NTNU – Trondheim
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Design for Alternative Production Methods

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NORGES TEKNISK-
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INSTITUTT FOR PRODUKTUTVIKLING
OG MATERIALER

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FOR
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DESIGN FOR ALTERNATIVE PRODUKSJONSMETODER

Design for alternative production methods

Tomra Collection Solutions er verdensledende leverandør av maskiner for retur av drikkevareemballasje. Maskinene deres er spredd over hele verden. Press fra konkurrenter er voksende, og de fleste av disse konkurrerer på pris.

Tomra ønsker å opprettholde sin kvalitetsprofil, og samtidig fokusere på kostnadsreduksjon. I den forbindelse ønsker de å se på alternative produksjonsmetoder for mekaniske deler og sammenstillinger i maskinene.

Produktene består i dag av deler produsert av tynnplate, maskinerte deler, vakuumtrukket plast og sprøytestøpt plast. Man ønsker nå å se nærmere på prosesser som dyptrekking av stål, samt bruk av plaststøpemetoder som RIM og liknende for å øke det kreative spillerommet samt redusere kost og optimalisere ytelse.

I denne oppgaven skal kandidaten se på hvilke muligheter alternative produksjonsmetoder gir for å redusere kostnader og tilføre nye egenskaper, samtidig som gode egenskaper ved produktene bibeholdes.

I oppgaven skal kandidaten:

- Identifisere potensielle metoder og se på hvor dette kan brukes i Tomras produkter som nå er under utvikling.
- Beskrive egenskaper ved de nye metodene, og se på hvordan dette kan bidra til å forbedre Tomras produkter.
- Valgte metoder må vurderes i med hensyn på egnet årlig produksjonsvolum, tilgjengelighet for prosessen i forhold til Tomras nåværende produksjonslokasjoner samt nødvendig verktøyinvestering etc.
- Vurdere miljøaspekt ved valgte metoder.
- Vurdere kost/nytte ved bruk av valgte metoder
- Identifisere konkret(e) modul(er) der metoden kan brukes samt konstruere et konkret eksempel og sannsynliggjøre at dette vil forbedre modulen. Med forbedring mener vi her at gode egenskaper beholdes, mens nye egenskaper i form av reduserte kostnader

- eller nye muligheter for formgiving tilføyes. Funksjonelle forbedringer er selvsagt også ønskelig.
- Hvis tida tillater det: Vurdere produksjon av prototype (i samarbeid med Tomra).

I tillegg til rapporten, skal det leveres en PU-journal i instituttets format.

Besvarelsen skal ha med signert oppgavetekst, og redigeres mest mulig som en forskningsrapport med et sammendrag på norsk og engelsk, konklusjon, litteraturliste, innholdsfortegnelse, etc. Ved utarbeidelse av teksten skal kandidaten legge vekt på å gjøre teksten oversiktlig og velskrevet. Med henblikk på lesning av besvarelsen er det viktig at de nødvendige henvisninger for korresponderende steder i tekst, tabeller og figurer anføres på begge steder. Ved bedømmelse legges det stor vekt på at resultater er grundig bearbeidet, at de oppstilles tabellarisk og/eller grafisk på en oversiktlig måte og diskuteres utførlig.

Senest 3 uker etter oppgavestart skal et A3 ark som illustrerer arbeidet leveres inn. En mal for dette arket finnes på instituttets hjemmeside under menyen undervisning. Arket skal også oppdateres ved innlevering av masteroppgaven.

Besvarelsen skal leveres i elektronisk format via DAIM, NTNUs system for Digital arkivering og innlevering av masteroppgaver.

Oppgaven er båndlagt i henhold til NTNUs standard vilkår i 3 år.

Kontaktperson ved Tomra: Katrin Jacobsen

Torgeir Welo
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Institutt for produktutvikling og materialer

Preface

Mass production is a fascinating phenomenon. While anyone can make a technical part, it takes thorough knowledge about a wide range of fields to develop a design that can easily be manufactured in the expected numbers, cheaply, still maintaining the functional requirements.

Not everyone see mass production as something prosperous. "The production of too many useful things results in too many useless people" Karl Marx writes in his Economic and Philosophical Manuscripts of 1844 [8]. And he points at a challenge with the modern manufacture; labour becomes an exposed post on the bill. Cost is important in a free trading world, making production in Norway and other high cost countries a hefty challenge.

The autumn 2011 and the following spring I spent at Universiät Stuttgart, Germany. The rumour says that car manufacturer Mercedes, and multi industry empire Bosch, employ about half the city's population of around 600 000. How do they manage to keep business profitable?

In most subjects something that had been improved through redesign, standardisation, part integration or use of a new production method, would be shown. The professor would with a face of utter joy, tell about how his or her team of workers improved something and thereby secured jobs.

To my delight I have been able to try implement these thoughts into parts provided by Reverse vendig machine developer and manufacturer Tomra.

Tomra has since accepting my request for a collaboration been a tremendous help, and source for endless learning. Without the help of all the employees in the mechanical department, and many other departments as well, this thesis would never have been possible. I am greatly thankful!

The work has been supervised by Knut Åsland, Kristian Hovde and Katrin Jacobsen. During the work Knut Åsland at NTNU has lead me with steady direction through the processes and methods of development, whereas Kristian Hovde and Katrin Jacobsen have provided the connections to all branches of Tomra required to redesign parts hugely integrated in their products. Their weekly meetings have, sitting at their headquarters far away from my academic friends, been a source for many a discussion and revelation.

Arne Olav Eide

Abstract

Design for alternative production methods
by Arne Olav Eide

The Norwegian university of science and technology
Faculty of product development and materials

Tomra provides reverse vending machines (RVMs) to markets all over the world. Since the start in 1972 many competitors, challenging Tomra have occurred. Despite being the technical leader and having a dominating position in the market, Tomra see it as a goal to cut costs, and make their products even more competitive. In this thesis single parts from Tomras machines will be examined and optimized for lower cost, better environmental properties and enhanced functionality.

The upper door of the Tomra multipac processing machine, and from the RVM; the cabinet, and in particular a tray placed inside it have been chosen as the parts for optimization. Concepts are presented, discussed and rated, before a conclusion is drawn. Several concepts are found to provide savings in terms of cost, some as well in terms of environmental impact and functionality. One concept for each of the parts are finally recommended for further investigation.

A rolled upper door concept provides savings of NOK 122 per door at 25000 produced units, while simplifying assembly.

A deep drawn tray concept vastly reduces part count in the RVM cabinet, and hence provides estimated savings of NOK 197 per cabinet at 25000 produced units.

Sammendrag

Design for alternative produksjonsmetoder
av Arne Olav Eide

Norges teknisk-naturvitenskaplige universitet
Fakultet for produktutvikling og materialer

Tomra leverer pantemaskiner til markeder verden over. Siden starten i 1972 har mange lavpris-fokuserte konkurrenter dukket opp. Til tross for at Tomra har store markedsandeler verden over, og et teknologisk forsprang, ser de det som et mål å gjøre produktene enda bedre rustet for framtiden.
Gjennom oppgaven vil Tomras maskiner analyseres. Deler vil utvelges og bli forsøkt forbedret med mål om lavere kostnader, lettere miljømessig fotavtrykk og økt funksjonalitet.
To deler ble valgt ut for redesign. Overdøra på Tomras multipac prosesseringsmaskin, og et trau inne i den nye utgaven av overkabinett i pantemaskinen. Konseptene vises, diskuteres og rangeres. Til sist konkluderes det, og det gis noen føringer på hva forfatteren mener er konsepter Tomra bør se videre på i fremtiden.
Det første anbefalte konseptet er en rulleformet dør, som gir besparelser på NOK 122 pr. stykk ved 25000 produserte enheter, og som forenkler montasjen.
Det andre konseptet er et trau som integrerer svært mange av kabinettets deler, og dermed gir en estimert besparelse på NOK 197 pr. stykk ved 25000 produserte enheter.

Contents

1 Introduction

Tomra has since the start in 1972 developed and produced reverse vending machines (RVM's). The company is no longer alone in the business and its position as market leader is continuously challenged. To find parts for optimization, a short introduction to Tomras machines and their functionality will be given.

1.1 Reverse vending machines

Tomras reverse vending machines (RVM's) can be categorized in to types:

- T-XXX type scans containers, and send them on to a separate processing machine, or a storage table.
- T-XX type scans containers, and processes and stores the container inside itself. This machine hence does not need any storage room, and is therefore ideal for smaller facilities with limited storage space.

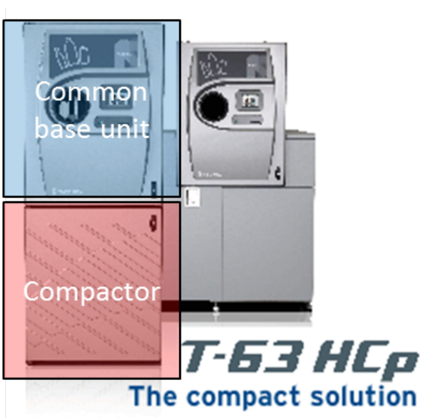
Figure 1: The Tomra RVM product family

The RVM, and the common base unit

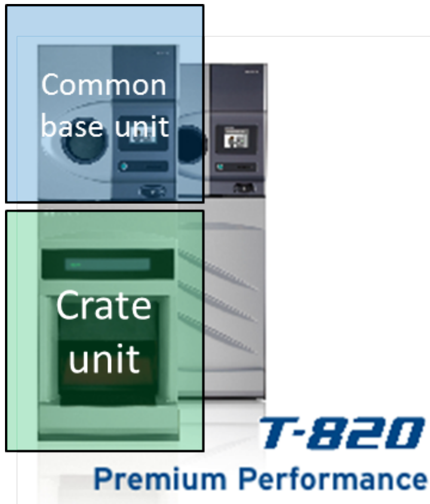
The machine with which the user interacts is divided into functional modules. The base unit, handles single containers, and is delivered with all RVM's.The T-XXX models can in addition contain a module for scanning of crates. The T-XX models contain compactors or shredders and storage modules.

The module for handling single containers - the base unit - is largely the same in all models, regardless of low-, or high range. The differences in the machines lies in the its sub-modules (software, electronics and scanning systems).

These days the next generation of base unit is launched. The new module is a total redesign. The previous model was launched in 1995, but has gone through many updates (mostly in software), including a thorough revision in 2005.



(a) A T-XX machine with its modules.



(b) A T-XXX machine with its modules.

Figure 2: The main modules of the two series of RVM's provided by Tomra.

The new common base unit will first be implemented in the most exclusive machines of the T-XXX type. As new versions of the less exclusive models are launched it will also here be included.

Looking into the future Tomra hopes to have implemented the next common base unit in all sold RVMs by 2016. With 5000 units sold yearly, a modest cost reduction could add up to a considerable saving.

As this module is a complete redesign, a lot of effort has been put into reducing the cost, limit use of material, to enhance functionality and make the module more attractive to the users.

Storage room machinery - Multipac

The T-xxx series RVM's do not store the containers. This is done in a storage room behind the machine. Multipac is such a machine.

The machine receives containers on two (or one) conveyors running above a series of storage bins. Upon arriving to the bin into which the container should be sorted, an arm tosses the bottle onto another conveyor. This second conveyor feeds the compactor/shredder with material. The processed container is left in the bin.

The number of bins varies but is usually four or five.

There are plans for selling around 500 multipac machines every year, each having 4-5 cabinets. The number of sold multipac machines is much lower than the amount of RVMs because multipac only is one of several storage room machines, and also as the T-XX series do not require external processing.

Figure 3: Multipac with four cabinets, connected two T-820 machines

1.2 Parts for optimization

Torma has pointed out that the number of base units sold is larger than the number of multipac machines, and that a saving in the common base unit therefore would be more profitable. Also due to the fact that the base unit is currently being launched, it will probably stay in production for a longer time.

1.2.1 The common base unit

To find candidates for optimization all parts of the new common base cabinet were examined. Fig. 4 and tab. 1 show an overview. As seen in tab. 1 a large number of parts are contained in the cabinet. This will therefore be examined closely.

The cabinet

The cabinet of the base unit consists of stamped and bent sheet metal parts. These are welded together into a stiff construction. The welding results in a need for corrosion protection. This is solved with a thin layer of sink, and some few micrometers of chrome for passivity. After this the assemblies are powder coated.

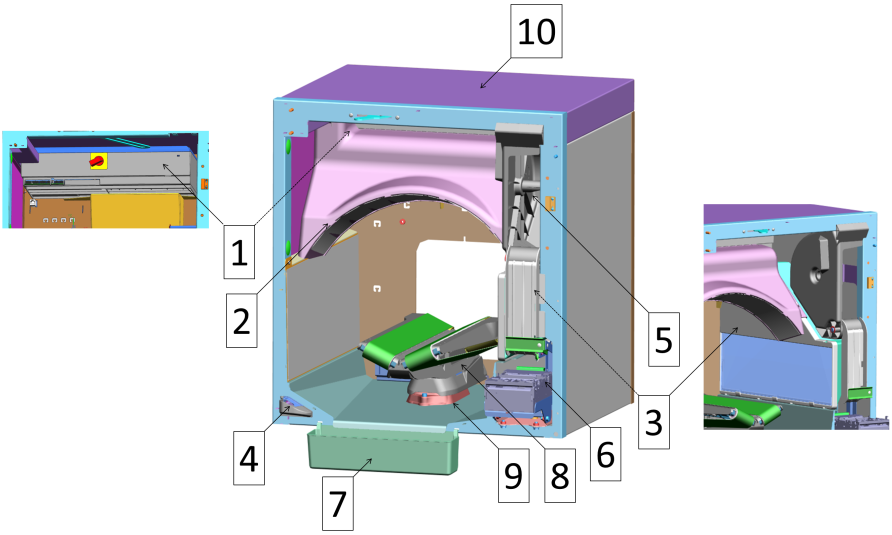


Figure 4: The base unit with all functional groups.

	Parts base unit	Number of parts	Manufacture method
1	Power supply	2	Injection molded
2	Reflector arch	1	Injection molded
3	Shape recognition box	2	Injection molded
4	Cable liner	2	Injection molded
5	Parts for printer roll holder	2	Injection molded
6	Mountings for printer and printer roll	4	Sheet metal
7	Collection tray	1	Injection molded
8	Conveyor - removable	4	Injection molded
9	Base conveyor	3	2x Injection molded 1x Aluminium cast
10	Cabinet	**10**	Sheet metal

Table 1: The base units functional groups.

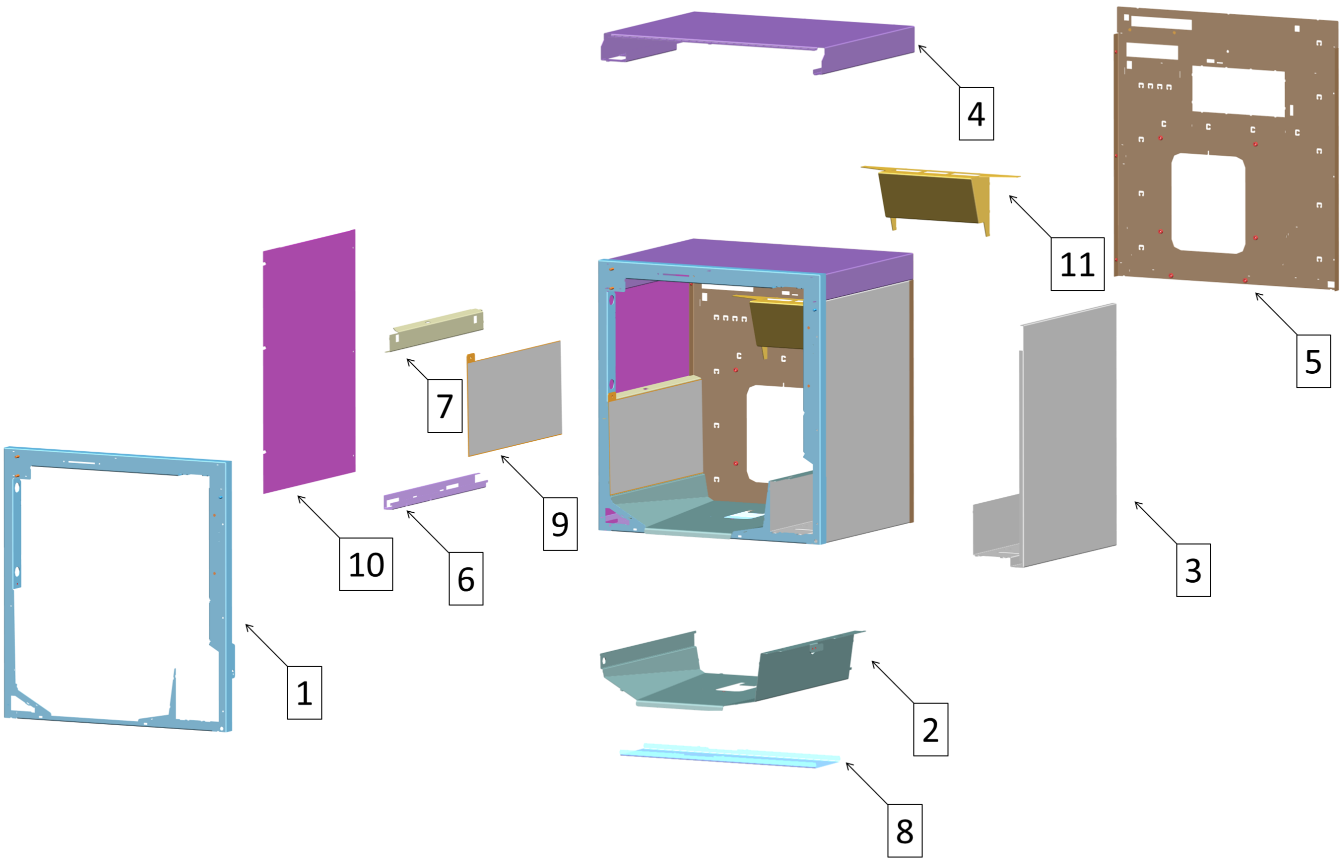


Figure 5: The common base unit and an explosion drawing of all parts.

		Function	Prod. complexity	Functional integration	Fold-out size (1-4)	Fulfils expectations (1-4)	Comment
1	Front frame	Positioning and fixing of receipt roll, positioning of all depth-going pieces.	Simple	High degree	4	4	
2	Spill tray	Positioning and contribution to stiffness of conveyor, surface for collection of fluids from machine use and during cleaning, mounts for reflex surface.	Moderate	High degree	3	2	The bending process limits the radii to given, small values. These corners can pose an obstacle when cleaning. Not stiff enough to fully fix the conveyor alone. Bending in unorthodox angles makes the part challenging to manufacture, and reduces the repeatability.
3	Right side and partly bottom.	Printer mount, covering of surface, stiffen structure	Simple	High degree	4	4	
4	Top surface	Covering and stiffening.	Simple	Some	4	4	
5	Back surface	Positioning of all depth going pieces, Positioning of shape recognition box and power supply, covering.	Simple	High degree	4	4	
6	Bottom beam left	Stiffen, Connect front and backplate, Mounting points for the bottom support beam.	Simple	Some	1	4	
7	Support beam left	Stiffen, Mounting point of reflex surface, and arc reflector.	Simple	Low degree	1	4	
8	Support beam bottom	Stiffen, contribute to stiff fixing of the conveyor.	Simple	Some	1	4	
9	Reflex surface	Reflect light from camera for shape recognition.	Simple	Low degree	2	4	
10	Left surface	Covering and stiffening.	Simple	Low degree	4	4	
11	Cable liner	Covering.	Simple	Low degree	4	4	

Table 2: The common base units parts and their purposes

The cabinets purpose is to separate the machine from the world outside (cover), and offer a steady and stiff basis for the functional modules on the inside. Effort has been put into integrating as many functions into a piece as possible. This though does not mean that there is no redundancy. In the lower left corner two separate beams connecting the front and the back surface can be found (part 6 and 7 in fig. 5). This in addition to the tray (part 2 in fig 5), welded to both surfaces. Without the removable left surface (part 10 in fig 5), the cabinet would be open. The reflex surface (part 9) is bolted on with a single bolt not providing any stiffness to the system. It seem there is a material build-up in the lower left corner, possibly avoidable.

As aforementioned the parts serve many purposes. The lower left beam (part 6) does e.g. also provide a fixing point for the support beam (part 8), and does therefore play and important role in fixing the conveyor in the current design.

Early base unit prototypes did not contain this support beam. Testing showed that loading the tip of the conveyor with a force downwards made the tray bulge in an unacceptable manor. The torsional stiffness of the conveyor support is important both for the accuracy of the bottle weight sensor placed inside the base (fig. 6), and because the conveyor is a component exposed to the user and hence should be able to withstand some rough handling. Tests of the weight's ability to give consistent results *with* the support beam has been conducted by Test Manager Håkon Haflan. Although having a different read-out than the former base unit, the results are consistent and through interpretation acceptable.

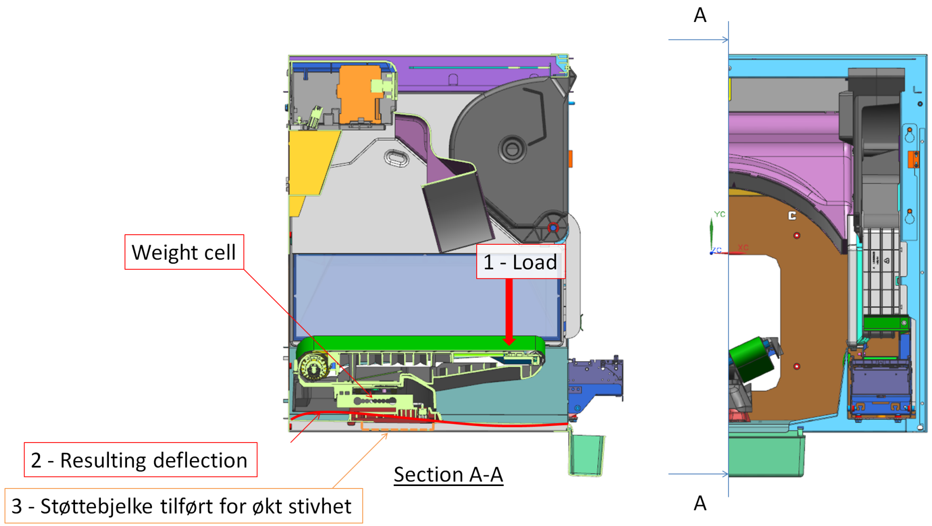


Figure 6: Section of the base unit. Shows the weight sensor inside the conveyor base. Sketched loadingpoint, resulting deformation in collection surface and added support beam for stiffness.

In early models the reflex surface was a part of the spill tray. This has been changed to enable the installation of cables.

A large number of cables enter the cabinet (through the cable liner, part 4 in fig. 4) from the door where a recognition module - the "onering" - is mounted. The onering is illustrated in fig. 11. After passing through the cable liner the cables are lead up along the left side of the front frame, and up behind the arc reflector up to the power supply. Another branch of cables stretches from the power supply down along the right side of the front frame, to provide the printer with data and power. A single cable is also led from the cable liner to the conveyor supported by the bottom left (6) and bottom support beam (8) fig. 5.

During assembly the left surface will be removed and hence enable the installation of the cables on the left side. The cables are laid out, and then fixed to the front frame. On the right side the installation of the cables is done from the inside of the cabinet.

When servicing the machine on cite the left surface will no longer be demountable as the machine is fitted through a wall. This leads to a requirement for access to the wires from the inside. This led to the splitting of the reflex surface from the tray. The access is still limited, and a change of cables would be crippled, but as this is not a likely occurrence it is seen as acceptable.

Cable installation requires access to the area around the cable liner, either from the inside, or from the outside. The current solution has come together as requirements have turned up. Learning from Tomra's findings during its design and development, this thesis will redesign parts centred around *the tray.*

1.2.2 Multipac

Multipac is a machine for processing and storage of containers. The user is mainly skilled personnel interacting with the machines during emptying, cleaning and maintenance. The unit contains a powerful shredding or compactor unit leading to noise and spills. To ensure safety multipac has magnetic locks shutting down the dangerous parts instantaniously when breached.

The large weight of the compactor/shredder has been the key factor influencing the design of the cabinets lower frame. It is designed for the purpose, and it seems sheet steel is well suited for this job. The large structure is covered with a shell of steel. This cover seems more interesting, as its only purpose is to cover the weight carrying structure within. Therefore the large surfaces and in particular the *upper door* solution will be looked at in the thesis. Tomra has previously done inquiries to improve these expensive covers, considering reaction injection molding as an alternative.

2 Development methodology

In the work a methodology derived from integrated product development has been used. The P2005 project, mentioned in the Product development compentium provided by the Institute of Product development and materials (IPM) [4] at the

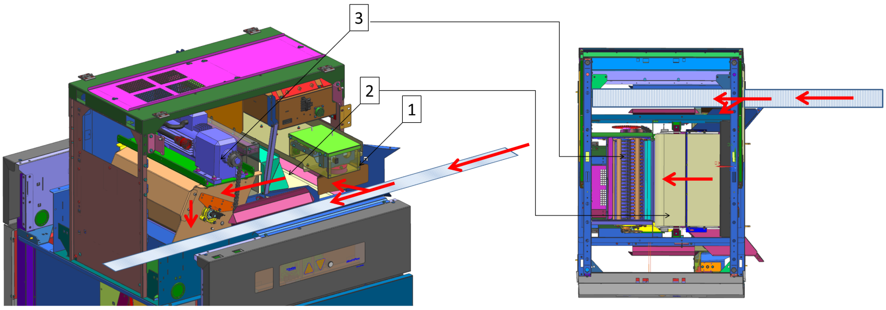


Figure 7: Multipac funktions. 1 - Guiding arm, 2 - conveyor feeding compactor, 3 - compactor.

Norwegian university of science and technology (NTNU). Integrated product development suggests to include all stakeholders in the project at an as early stage as possible. Also ideas from the IPM-model has been used as inspiration.

From the very beginning of the work, many sources for input was sought. Suppliers and manufacturers provided guidelines, and reviews on early concepts in order to make the finished product as manufacturable, cheap and functional as possible. The marketing department at Tomra provided updated information on the customers thoughts on the test-series base unit currently in selected stores.

The work has at many levels been conducted in iterations. In terms of the synthesis; finding the best solutions for all details in itself is a process of iteration alternating between creative and evaluating work, and in terms of the entire development process; starting with the vision and requirements, all the way through to the final shape and cost calculations.

During the entire work, weekly meetings - functioning as Workshops - were conducted. New concepts, or solutions to single features of concepts were discussed. Feedback and new ideas and angles were shared.

In terms of creative techniques several techniques were used throughout the work. Observation can be used as a powerful technique as described in the book Universal methods of design [7]. In the early stages observation played an important role in understanding the user and his/her interaction with the products. A visit to Tomras assembly plant in Lier gave insight in the assembly, a visit to Wermland Mechanics gave insight in the current production methods; limitations and benefits. Several new manufacturing methods were also observed enabling the use of the features special to the process, and avoiding its pitfalls.

The concepts were sought to be as creative and different as possible. Orthogonal

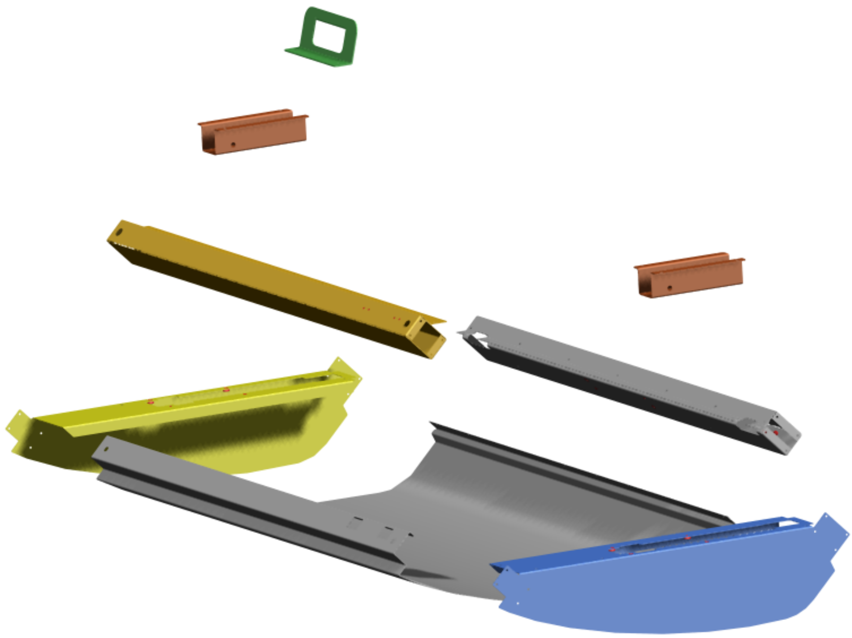


Figure 8: The upper door of the multipac cabinet.

concepts were sought. As an example, paper pulp molding was considered as an opposite to the everlasting steel.

The development was split into different phases by evaluation points. The first phase consisted of collecting data about the products, parts and their functions. By doing this an insight into which parts had potential for improvement, and which integrations were possible, was achieved.

The following phase consisted of synthesising a wide range of concepts, with a design for cost mentality. The idea of maximum part integration combined with design for manufacture was seen as means for achieving this. At the beginning, the widest possible range of concepts and manufacturing methods was sought, and investigated.

The final phases consisted of detailing of shape, features concurrent with cost and logistics estimations and ECO99-indicator analysis further explained in sec. 3.2.4.

3 The requirements

To have an idea of the expectations to the selected parts, data on user requirements were sought and extracted as product requirements.

3.1 The user requirement specification

Tomras machines interact with a large variety of different users or customers;

- The buyer of the machine - head of a grocery store, warehouse or recycling facility.
- His/her employees - doing daily maintenance on front end and storage room machines.
- The visitors to this facility - returning bottles and cans.
- The people assembling and servicing the machines.

As shown there are several stakeholders, and hence many considerations to be taken to not only make the part cheaper, but also better.

The buyer

Research conducted by Tomra has shown, not surprisingly, that the buyer is concerned about price. He wants the machine that over time is the cheapest. Therefore the machine needs to be durable, have a low need for maintenance (both from his employees, and service personnel), and be quick in order to serve as many customers as possible.

According to product manager Frank Lippert, a Sweedish survey has shown that a store with a well functioning machine will attract people returning more bottles than the average, and spending on average 50 % more than the average customer in the store.

The low need for maintenance has many aspects. For a front machine it includes the ability to recognize bottles at high speed, without mistake and without faulty bottle rejections. For the storage-room machines it involves storage capacity, and flexibility. Also other things like smell (washability), and looks are important.

The facility employee

The facility employees do the daily maintenance of the machines. They, as their bosses, want to minimize the number of unnecessary interactions with the machine. Necessary interaction should be as simple, understandable and ergonomic as possible, as well as safe.

The facility costumer

This user expects a quick, and bug free experience, without unexpected stops due to capacity problems.

The assembler

The installers want easy access to bolts and fasteners. To avoid accidents when using sheet metal, sharp edges and corners should be avoided.

Service

Service can consist of cleaning, but also changing of components. When the finished machine has been installed in facility, accessibility can be lower than during assembly. Attention should be given to provide sufficient access to critical components also when installed on cite.

3.2 Product requirement specification

The user requirements is a great input that needs interpretation to provide a base for development. To accommodate the users demand for a fully functional product, their requirements were translated into more specific product requirements.

3.2.1 Mechanical requirements - Tray

Stiffness

The weight cell placed within the base of the conveyor measures the weight of the object on the conveyor several times as the object moves along the conveyor. Testing mentioned in the final parts of section 1.2.1 states that the current setup preform acceptable. Simulations were therefore performed (see fig. 10 and app. A) to find numbers for the accepted, and not accepted stiffness.

As the illustrations and the deeper investigation in A show, the accepted solution achieves a deflection of 1,3 mm down in front of the base, and less than 0,5 mm up in the back. The setup without the supporting beam, tried at an early stage of development, did on the other hand show a deflection of 3,9 mm in the front with the same load. This was found unacceptable.

The wanted solution must provide similar properties as the accepted, but may vary slightly.

Position

The positioning of the "nose" of the conveyor is of the highest importance. The container is identified by two modules, the shape recognition camera (part 3 in fig. 4) placed within the base unit, and with the label scanner ("onering" see fig. 11) mounted on the inside of the cabinet door.

The onering has several cameras mounted around the chute into which the containers are placed by the costumers. The cameras are directed at the the bottle as it enters the machine. The view of the cameras must only contain one moving object namely the bottle. If the tip of the conveyor enters the picture, it will be recognized as fraud. Today the tolerances are modelled as 0 mm gap, but reality is different. The length of the conveyor bands differs from the model, and the pulley mount is flexible giving a gap of several millimetres.

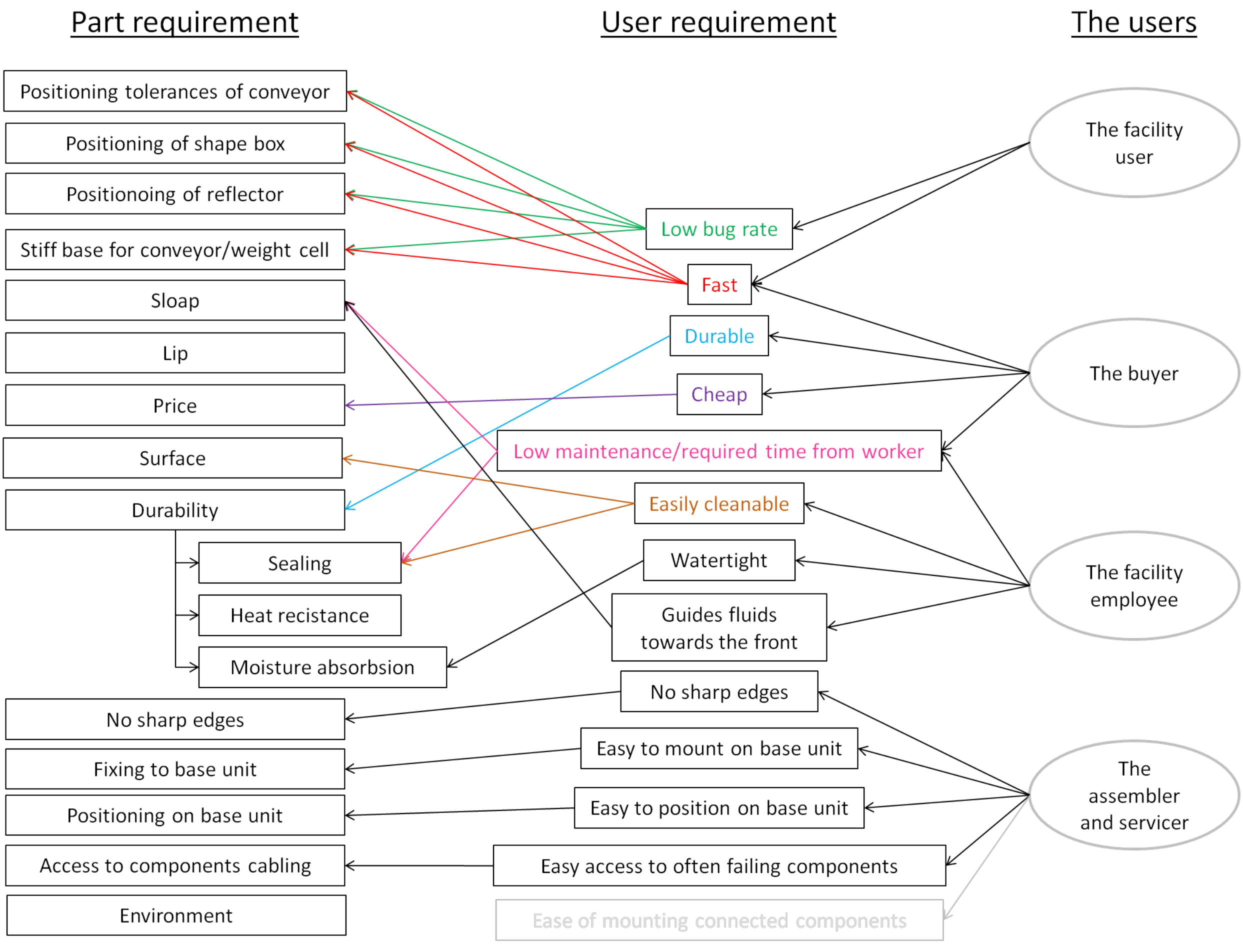
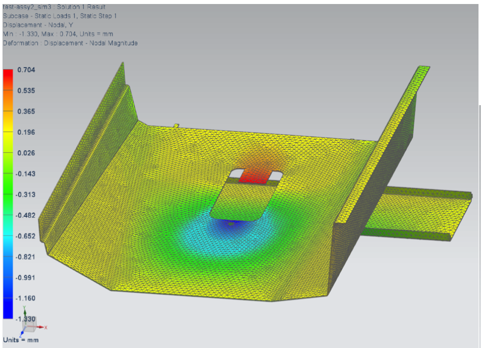
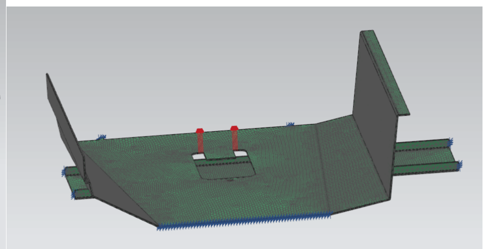


Figure 9: The transition from the users wishes to the requirements for the tray



(a) The maximum deflextion in z-direction (up and down) with a 10kg load on the tip of the conveyor.



(b) The boundary conditions

Figure 10: The simulation done to derive a requirement for stiffness of the tray. For more on the simulations see Appendix A

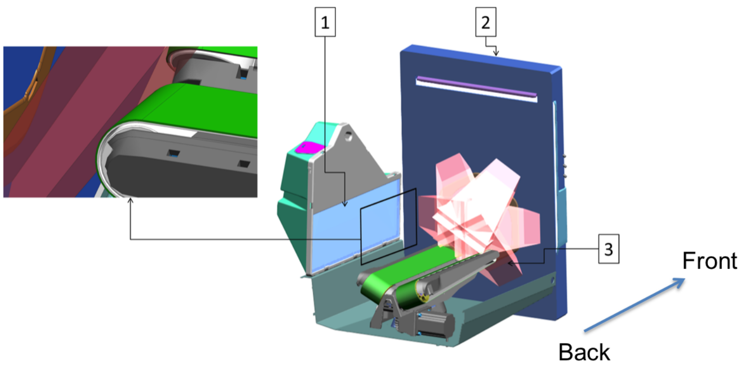


Figure 11: 1 - The shape recognition camera box, 2 - The onering, 3 - The one ring's field of view. The zoomed seciton shows the tight modelled tolerance between the field of view and the conveyor.

The shape box requires that as much as possible of the bottle is in its view, resulting in that the conveyor can not sink lower than the bottom of the view even when heavily loaded. This is solved with a 5 mm overlap.

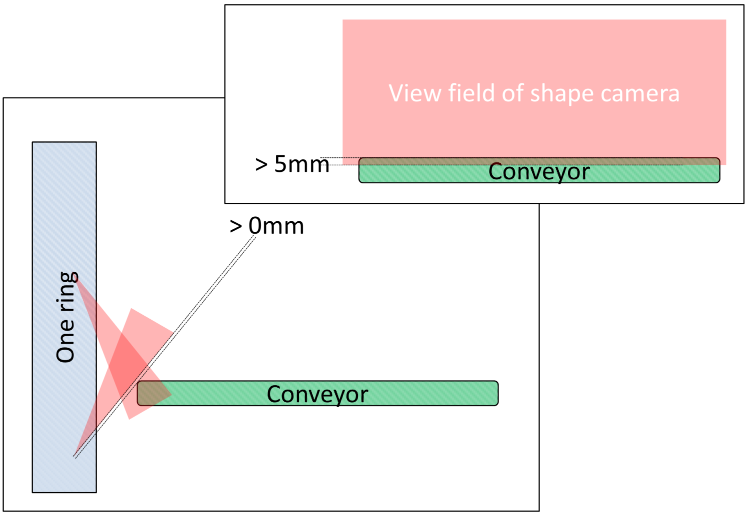


Figure 12: Tolerances for the conveyor.

Durability

In America machines made by Tomra in the 80's are still in operation. The machines are though not designed for such a long life. According to technical product manager Espen Lund, the machines are designed for 7 years of operation.

In order to keep the machine in operation the tray has to be able to withstand heat of up to 50 degrees over time, have a surface that does not absorb moisture or in any other way let moisture transmit through the tray and further down into the structure.

3.2.2 Mechanical requirements - Upper door

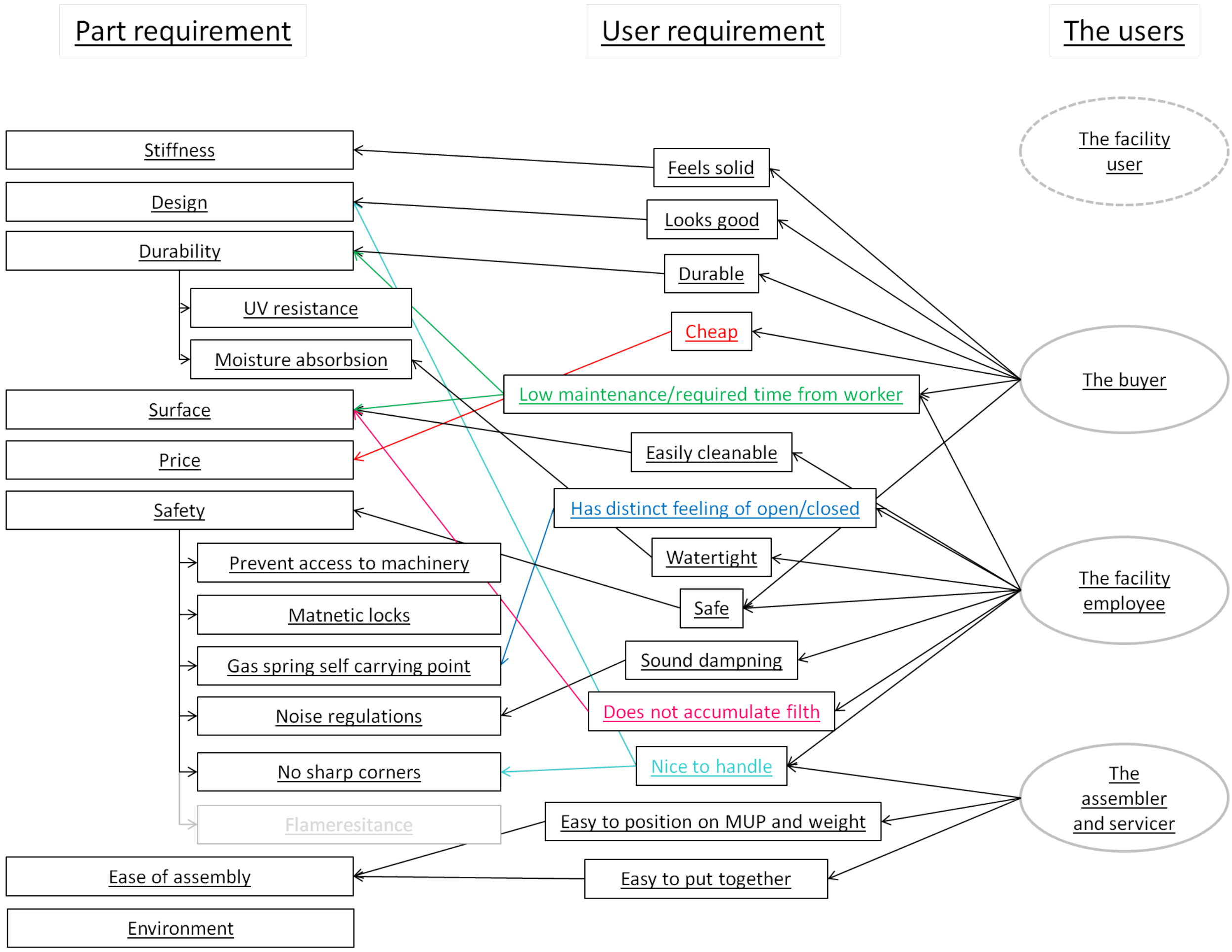


Figure 13: The transition from the users wishes to the requirements for the multipac upper door

Stiffness

Whereas the requirements for the stiffness in the tray originated from the demand for stiffness made by other connected systems, the requirement for the upper door is of a somewhat less concrete character. The door has no need for high stiffness to fulfil its main obligations, to cover and shield. The consideration for the costumers experience, still makes it and important requirement.

Product requirement spesification for the tray		
Positioning tolerances of conveyor (for recognition systems to function)	Depth: >0mm between field of view of onering and conveyor belt. Width: +/- ca. 3mm at tip of conveyor, Height: Overlap of conveyor in shape recognition camera field of view of >0mm.	Depth: Between the field of view of the two lower cameras on the "one ring", and the belts of the conveyor there has to be a gap. Modeled there is no such gap, but as the pulley is mounted on springs, and the conveyor bands them selves are shorter than in the model, there is a gap. This varies somewhat, as the bands are not precicely equally long. Width:Not as strict. Height: Today a 5mm overlap is built into the model due to the long chain of tolerances between the shapebox and the conveyor.
Positioning of shape box	Two cut-outs on far right flange.	
Positioning of reflektor	Loose toleranse, 1° + $<2^\circ$ / ->$0,3^\circ$	
Stiff enough to provide a steady base for conveyor weight cell	Tray deflection <1,4mm in front of base with 10kg load at conveyor tip.	Todays solution has 1,4mm deflection in front of base with 10kg load at the conveyor tip. Vibrations should be minimized.
Sloap	$0,8^\circ$ (or more) tilted towards front.	
Front-lip for controlled pouring	Lip is 10 mm deep, and should have edges to avoid spillage. Has to provide space for mounting of collection tray.	
Sealing for fluids	0 ml.	Electrical components for the crate unit will be placed below the tray, and hence it is an absolute requirement to keep the bottom of the common base unit sealed. During development decissions have been made to secure the crate unit from fluids from above. The tray should still seal well, as fluids over time can create smell.
Withstand heat from motor	Approx. 50° C.	Motor produces heat.
Moisture absorbsion	Corrosion protect/waterproof barrier	Humid environment
Durability	7 years of use.	The machines usually last much longer, but the design requirement is 7 years.
Surface	Smooth, enabling easy cleaning. No sharp bends.	
Edges	Avoid sharp edges and corners	To minimize personell damage during assembly
Price	SEK 950 for the entire base unit.	
Positioning on base unit	Guides, tabs, screw holes or similar for easy placement	The current setup has tabs for easy positioning of the tray.
Fixing to baseunit	Rigid connection to baseunit	The tray is welded to the base in the current setup.
Access to components	Cabling and worn out components must be accesable	Around 250 weight cells brake every year. The cell has to be accessable. This goes also for the cabling running up along the left, front side of the cabinet.
Enrvironment	Preferably as good as current setup	

Table 3: Product requirement specification for the tray

Design

The exterior of the multipac is award-winning. Large changes of the design is therefore unwanted. The inside though has potential for changes. The current design provides a lot of space inside the door. This is mostly not in use. The minimum distance to the outer wall of the door is 80 mm, where a box slightly enters the door frame. An explosion drawing of the door is presented in fig. 8.

Assembly

The current setup has as previously shown a complex build-up consisting of 7 parts, and a large amount of fasteners. For a complete list see 4.1.2. This is unfortunate, and should be reduced in the new designs.

The door is large and heavy, and to be mounted in at an unconveient height. Weight reductions should be sought.

Durability

The machine has to endure 7 years of use.

Product requirement spesification		
Stiffness	Subjective optinion	
Design	Keep todays exterior lines. Easy to open and close.	Todays exterior is award winning, and hence should not be tampered with. The profile acts as handle, and should provide sufficient grip to open.
Durability	7 years.	The part should withstand wear and tear of 7 years operation.
Surface	Smooth, no open up-facing U-profiles collecting moisture and dirt.	
Price	<570 NOK	
Safety	Prevent access to machinery	
	Contain 2 magnetic locks	
	2 gas springs carrying the door at horisontal opening	
	Noise level <80dB-A over rep. working day, <120dB-C peak	Current setup is approved. Measures to reduce noise has been tried, without luck. The noise escapes the cabinet at many points making the importance of the doors soundproofness questionable. Tests with sound damping mats inside doors showed unmentionable effect.
	No sharp corners	
	Flame resistance (?)	In America reqirements for flame resistance have been presented.
Ease of assembly	Lowest possible weight, minimum amount of parts and fastners.	
Environment	Preferably as good as current setup	

Table 4: Product requirement specification for the upper door

3.2.3 The production and cost requirements

The multipac machine is largely made from metal sheets to finished product in Poland. An alternative part should therefore preferably be produced near by.

Alternatively when production in other countries can reduce the price of the part, the cost of transport and storage will have to be estimated to give a compareable result.

The price of the multipac door unit has been given in detail in a confidential document. The total price of the upper door, inclusive the color coating, fastners and assembly sums up to NOK 577. Of this the actual door costs about NOK 482. This is illustrated in fig. 14.

The price of the common base units tray is a somewhat less exact science. The whole unit has a cost of SEK 950 in batches of 100 (for 1-series produced in Sweden). With a total weight of about 10 kg, and the tray weighing 3,5 kg, the tray should have a price around SEK 300. Assembly is thought to be a major cost source. A large portion of the assembly cost adds through the welding, surface treatment and coating, operations for which the removal of one single part from an assembly would have moderate effect.

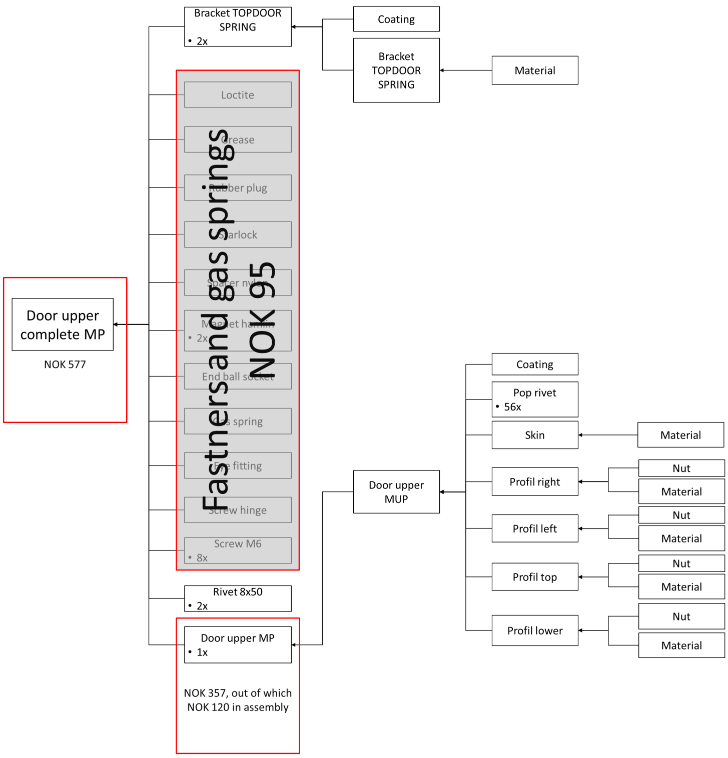


Figure 14: The structure of the upper door, and the prices assosiated with the parts.

A cost calculator provided by Norwegian supplier Moss jern og stanseindustri AS, showed that the prices of stamped and bent parts levelled out at orders of 50 parts.

To get an estimation of the tray cost, it was assumed that as both the tray and the upper door were produced in large amounts, equally large parts would cost approximately the same. A comparison using the detailed price sheet previously mentioned was therefore reasonable.

The sheet metal parts were sorted by weight. A plot showing the cost of sheet material, and the price of the finished sheet metal parts (with coating, inserts and other operations) over part weight, was graphed. When inserting a regression line the graph showed that the finished part would cost about three times the cost of a similarly weighing sheet, plus an additional start up cost.

According to Wermland Mechanics, a key supplier for Tomra, the sheet metal usage efficiency lies somewhere below 80 % (part material · 1,25), but the confidencial cost document suggested a modest 66 % (part material · 1,5). It must be considered that it was in the interest of the cost document provider, another supplier, to show a lower percentage than the actual value. Nevertheless, in cases where used, the efficiency is therefore set to 66 %.

$$\text{Part cost} = 3 \cdot \text{Steel cost} \cdot \text{Part weight} + \text{Start cost}$$
$$\text{Part material cost} = 1{,}51 \cdot \text{Part weight} \cdot \text{Steel cost}$$
$$\text{Part material weight} = 1{,}51 \cdot \text{Part weight}$$

Figure 15 shows that the material turned out with a cost of NOK 10 per kilo, while the part price ended up at NOK 27 per kilo plus an initial cost of NOK 15. The prices deviate with weight due to the differences in shape and processing. At 3,5 kg, the weight of the tray, this range spans from around NOK 60 to NOK 150 see fig. 15. The regression suggests the price of NOK 106. Judging by the total assembly price, the shape of the part and the required surface treatments, it is assumed that the part cost is closer to the upper limit.

Numbers provided by Kristian Hovde suggest a life run consisting of a three year product introduction, five years in market, and some years of market exit and service. Current sales numbers suggest that when fully introduced in 2016, 5000 base units will be sold each year. The total numbers could be assumed between 25000 and 40000.

Current sales suggest between 250 and 300 multipac machines a year. The goal is though 500 multipac machines each year. With four or five cabinets mounted on each machine, this ads up to eight or ten doors per machine, and up to 4000 doors a year. A similar lifetime as for the common base could be expected as for the multipac machine, released 2012.

3.2.4 The environmental requirement

A property seen as particularly important to Tomra has been the environmental impact of the part. Some way of comparing the current setup to the alterative concepts was sought. According the manual describing the ECO99 indicator [9], is exactly such a tool.

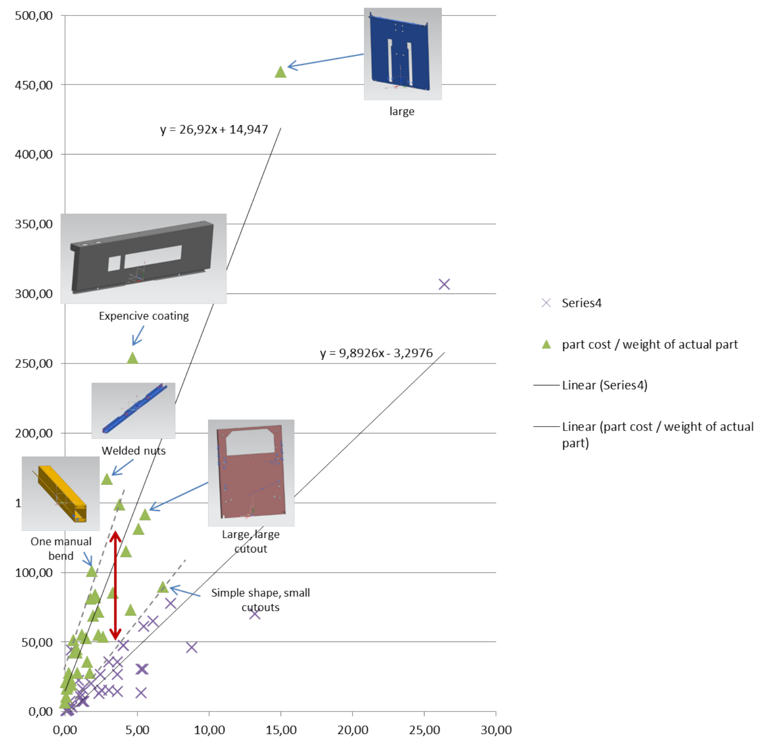


Figure 15: The cost of different parts from the multipac machine by weight. Tray weight inserted.

ECO indicator 99 has been applied to give a perspective on the life cycle impacts of the different material, processing and disposal options.

For some processes no indicator was available. Estimates, based on similar processes, were then used instead. This is in accordance with the actions proposed by the creaters of the method [9]. It is though found that the material production and the disposal pose the largest impacts on the indicator. The transport is also a factor which could be influenced through the part weight.

The waste treatment data were based on data from Statistics Norway (SSB).

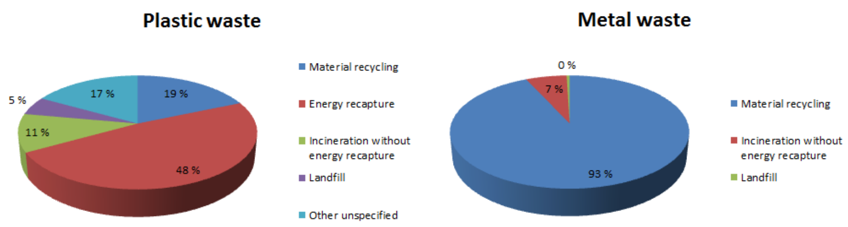


Figure 16: Waste treatment in Norway according to SSB numbers.

The data were not in all cases in accordance with European data found in the Eurostat database.

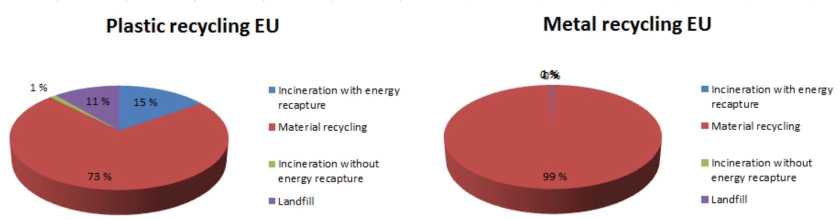


Figure 17: Waste treatment in Europe according to Eurostat numbers .

Kari Mellem an advisor at SSB, specialized in Environmental statistics also found the numbers strange.

Neither SSB, nor Eurostat do distinguish between thermosetting and thermoplastics, making the figures less exact. HÅG, a Norwegian office furniture manufacturer paying large attention to LCA and the environmental impact of their products, therefore simplifies the plastics disposal options to 50 % recycling, 50 % incineration without energy output fig. 18. This does give a slightly different score.

Metal production has a score 4-5 times lower than that of the most common plastics. Through weight savings made possible by the manufacturing processes of the less environmentally friendly alternative materials, the environmental impact could still turn out acceptable or even better. This will be discussed later for the different concepts.

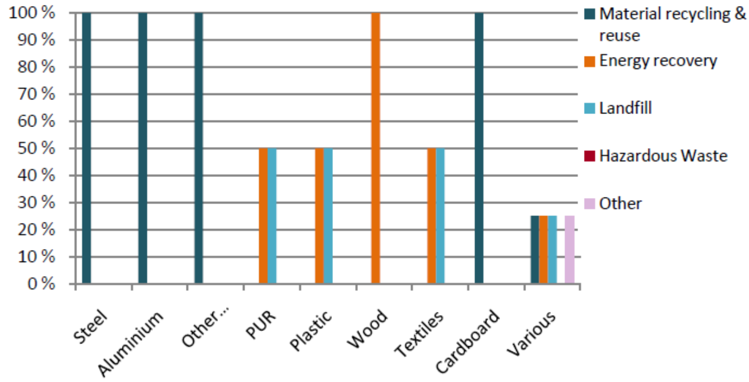


Figure 18: Adaptation from HÅG, the company distributes the plastic waste in a simplified way.

For both parts in question the system considered in the analysis was as shown in fig. 19.

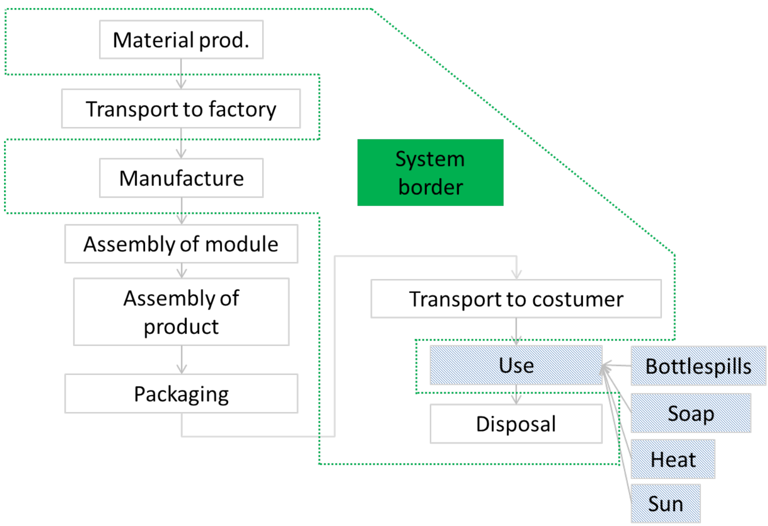


Figure 19: The system concidered in the ECO99-indicator analysis.

4 New concepts

Alternative production methods were sought to find alternatives fit for the requirements given. Cost can not only be cut through change in production method and material, but also through part integration. By different choice of material and process, other parts in the machine might become redundant. Studies were done to find potential redundancies.

4.1 Part integration

4.1.1 Base unit

The study showed that if the stiffness of the cabinet could be preserved, several parts could be merged. The stiffness simulations are shown in full in app. A.

For part overview study fig. 5 and the table related to it. Illustrations of the following options are presented in fig. 20.

- Option 1 - The support bracket below the tray became redundant when stiffness in tray was provided elsewhere.
- Option 2 - The reflex surface could be integrated in the tray when tray was made removable, providing the same or better access to cabling as the current setup. When chosen, this would also enable the merging of the removable left side lid with the lower left corner bracket, at the cost of access from the outside when mounting components into the cabinet.
- Option 3 - The base could be integrated in the tray when the tray is removable, providing access to bolts fixing weight cell. It could also be integrated in a fixed tray if mounting of the weight cell was made possible from the top side of the tray.

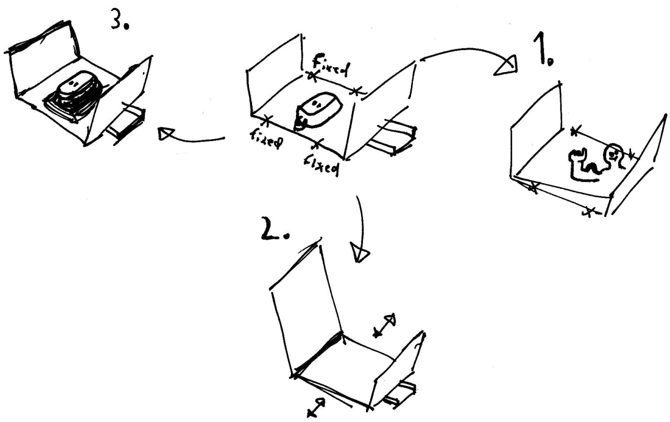


Figure 20: The tray part integration options as explained.

4.1.2 Upper door

The upper door today consists of a large amount of parts listed below and additional parts for installing the door on the cabinet.

- 2x2 screws for fixing and 2 magnetic locks
- 2x4 screws fixing the gas spring brackets and 2 brackets (2 bends)
- 1 profile low 8 bends, 1 handbend
- 1 profile top 8 bends, 1 handbend
- 1 profile left 2 bends
- 1 profile right 2 bends
- 1 skin 7 bends
- 1 handle innside 1 bend, 1 hem
- **58 pop-rivets**
- 20 self-clinching nuts

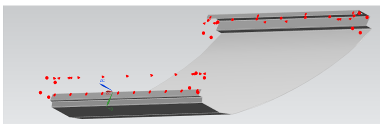


Figure 21: The 58 pop rivets in the multipac upper door

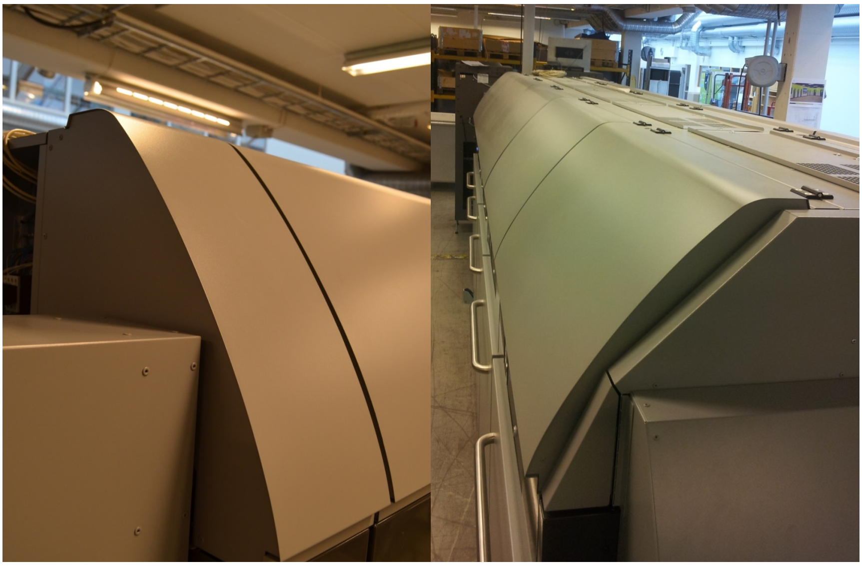
The door has no other purpose than covering and providing access discussed in sec 1.2.2. It is therefore questionable what stiffness the door requires 3.2.2. The current door has been characterized as over-dimensioned. The parts not contributing to the visible outer surface do largely only contribute to the stiffness and strength of the door.

Today the door shape is made up of a frame of four metal brackets, and a skin fixed to the frame with pop-rivets, see fig. 8.

The frame makes a closed side section. Opening the side of the door poses no safety issue, except at the end of the machine, where this would provide an unwanted gap. This end panel can easily be changed to accommodate a door without a side wall as seen if fig. 22.

The following tactics for reducing the door part count were planned:

- Option 1 - Reducing the door to a single skin with enough stiffness and strength to function on its own. Opening the side profiles does though trigger a need for redesign of the far end of the machine, where the door side profile has been used as the only barrier between the machine inside and the outside. Examples of this is shown in app. G.



(a) The end of the multipac cabinet closest to the RVM.

(b) The far end of the multipac cabinet

Figure 22: The end of the mult

- Option 2 - The brackets fixing the gas springs could be included in the door parts.

- Option 3 - Adding stiffness to the skin and hence merging the upper and lower horizontal brackets with the skin.

4.2 The processes and materials

None of the parts in question are high cost parts nor large scale mass production. Some materials, and processes are therefore unsuited. Large investment need (tooling) is an examples of factors influencing this.

The production methods were considered on the basis of cost, environmental impact and limitations to design.

As part of the thesis, a study on part-revisions on the old base unit cabinet was conducted. The study shows a large number of changes during just a part of that machines life. Most changes are small, like adding a hole or moving one, but some contained complete rework of the part's geometry. This kind of business would be inconvenient in processes dependent on expensive tools. Therefore tooling cost, and tool adaptability has an added importance in the selection. The mentioned revision study is provided in App. I.

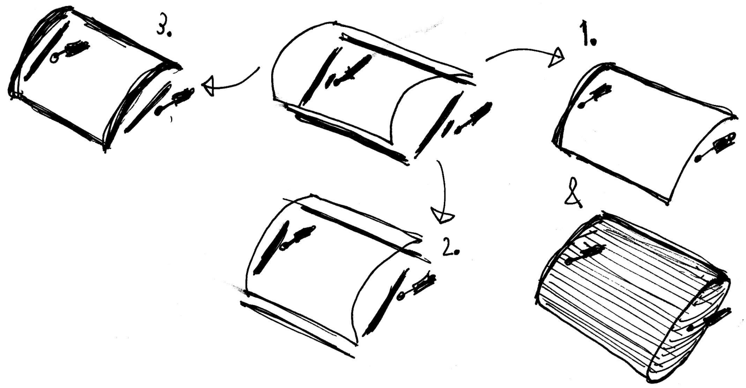


Figure 23: The door part integration options as explained.

4.2.1 Today's solution - stamping and bending of sheet metal

According to the main supplier of this type of machines Din Maskin AS, there has been a revolution during the last years. With new servo-electric actuators, the energy consumption has dropped from 35-40 kW to around 4 kW. Other suppliers confirm the former high consumption.

With a low power consumption, limited need for maintenance, large degree of automation and no start up cost (shaping-tool), the process seems ideal for a wide range of products. But, more than in e.g. the molding processes cost does vary with complexity. The part cost also stays flat from 50 units to eternity.

The process does though limit the shape of the part. With a revolver head punching machine, tools with 30-40 different shapes can be punched out at high speed. If the sought shape can not be found, the shape has to be built up from the available tools. If no combination results in wanted shape, a new tool can be made. If the cost is found to high (NOK 20000 and up), a laser cutter could be used (done with the front frame of the common base unit).

The bending also limits the shape. The bends are straight and the the design is limited to a small number of small radii giving the parts a square look. Due to the need for access to both sides of the material, the making of closed, or U-shaped profiles is limited as shown in fig. 25.

4.2.2 Vacuum forming

During vacuum forming sheet thermoplastic is fixed in a frame, heated and stretched around a shaping-tool. The tool can either have a male or a female shape, dependant on whether the inside or the outside of the part is of the largest importance. Twin-sheet forming is another option, where a hollow structure is made with two female tools. The vacuum is added through tiny holes in the tool-surface. Af-

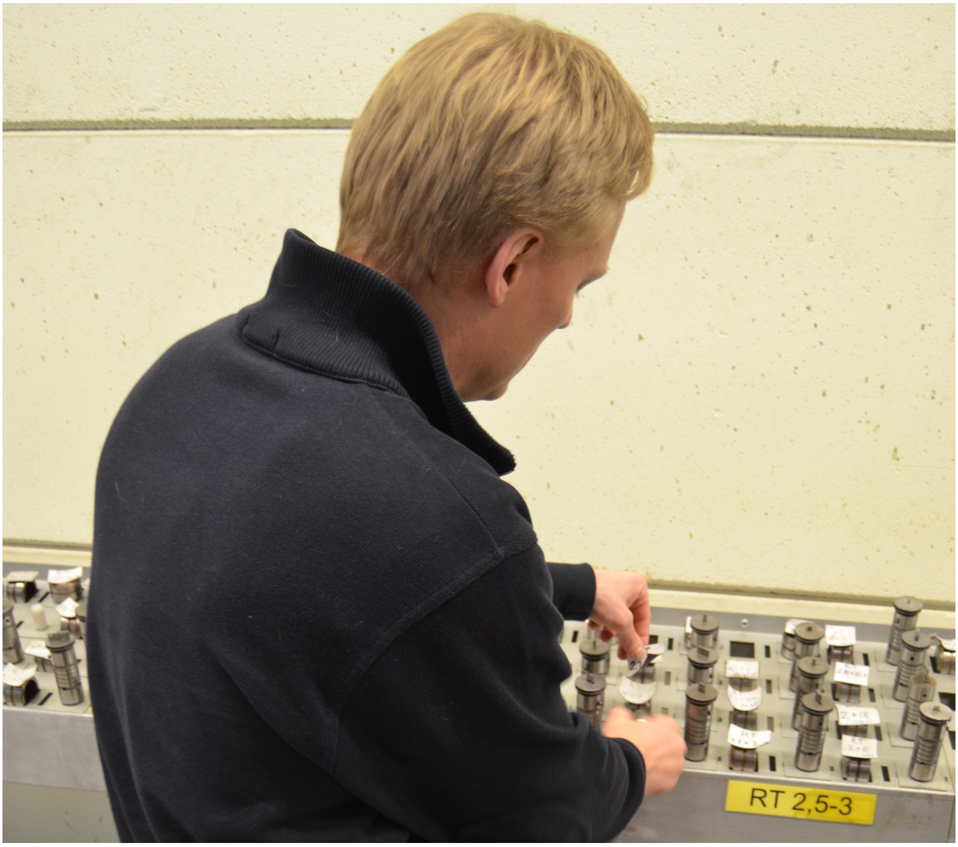


Figure 24: A presentation of different punching tools for revolver puncher at Wermland Mechanics Töcksfors AB.

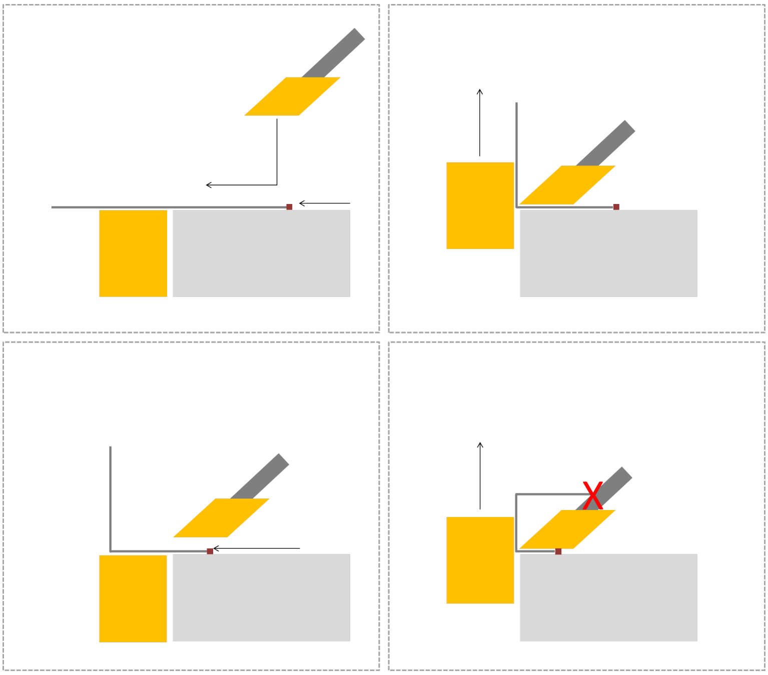


Figure 25: Clockwise from upper left corner. Example of the limitations when bending a U-profile from sheet metal

ter cooling the parts are trimmed in a mill to remove surplus material and add functionality.

Also this process appears highly automated. At Ny Plast AS, tall stacks of plastic sheets are piled up in front of the machine. The machine then moves, shapes and outputs the part. Personnel then move and fixed the parts to a mill, where the part automatically is trimmed.

The process' strength is the low pressure in the shaping, enabling tools made up from cheap materials. The process does not limit the shape. But as the part is shaped from one side with one tool, undercuts and areas without release angles should be avoided. During the shaping of deep parts the material is thoroughly plasticity deformed, resulting in a thinning of the material in these areas.

Functionality can be added through the milling.

4.2.3 Deep drawing and hard-tool shaping

Deep drawing of steel is a process of shaping the steel plastically. It requires a robust tool, powerful machine.

Shaping of sheet metal in tools is not new to Tomra. The division based in China has already delivered so called hard-tool made parts. These tools shape square parts with a large number of punched details. The process used to make medium-small sized parts with box-like appearance. The process has a much larger potential. The part is shaped through one, or more stages with different purposes.

Stepwise manufacture can be done in a so called progressive die, where a reel/sheet moves step by step forward adding bends and punched details. This is ideal for large scale mass production, as it requires advanced and expencive tools.

The current processing used by Tomra is much more manual. Different presses, with workers manually placing every single part are used, and hence separate tools are used for the different operations.

The tools are still expensive and the costs can be compared to the ones for injection molding. By adding empty slots in a progressive tool, additional steps can later be machined into the sequence of shaping steps, hence enabling minor changes. In the current Chinese production, the addition or replacement of one step is relatively simple as the steps are performed on separate tools, in separate machines.

4.2.4 Flexforming with Quintuspress

A metal shaping process previously explored by Tomra is so called flexforming. A process promoted in Norway by Prototal. The process involves shaping steel with a single sided tool, and a rubber membrane backed up by 1400 bars of pressure forcing the steel sheet into shape. The process is relatively cheap for small series of products due to only one half of the tooling of deep drawing, but seem unsuited for larger series due to a large cost of operation, and low availability of machines.

For large, very complex and more exclusive parts the process seems ideal. The process also has the advantage of being able of forming undercuts as the membrane is flexible.

The process is a single step forming process, and hence has limitations to corner angles. When compared to the traditional sheet metal punching and bending, this becomes visible.

Figure 26: The large radii required for a single step shaping of a closed corner. Left: A sheet metal door punched and bent. Right: A flexformed door concept.

4.2.5 Press forming of wood, laminate

Norwegian furniture pioneer Ekornes has given some clues on how this process can take place. The sliced wood arrives with a relative water density of 8-10 %, way to high for glueing. The wood is therefore dried under vacuum at 80 °C with radiators filled with water. When the wanted moisture is reached, the water is cooled to 30 °C, and the moisture in the heater condensates on the machine's surfaces. The wood is removed, tested (4-6 % is wanted).

The wood in the outer layer of the laminate is less moist than the inner layers to encourage the water to move out from the inside layers.

After this stage the laminates are painted with glue, either sprayed or rolled onto the surfaces. The layers are then stacked, with high quality slices on the surfaces and lower quality slices towards the middle (Quality class B-C are still acceptable providing a low amount of branch-marks and other potential cracking points, for more see [3]).

The press then is closed for around 1 minute when using Urea Formaldehyde (UF) glue, and high frequency heating. This can be used when the part wanted shaped is thick; 12 mm at absolute minimum. The process provides high speed glueing, but has issues when it comes to the evenness and control of the heat. For thinner parts regular hot-plates are used for heating the glue. These machines typically press more pieces at the same time, justifying the 8-10 minute gluing time.

The process of laying up a stack and removing the finished product from the tool, did after what could be seen while observing the process, not take more than 1 minute more.

After glueing the pieces were moved to a CNC mill with fixtures holding the wood in place using vacuum. After milling the product's edges were manually sanded, before getting painted by robots.

Ekornes also had, in their facilities developed systems to do all the material and process handling automatically. The glueing process had been the last development, and the new system, capable of processing 120 meters of slices per minute, was soon to be installed. The facility produced 1500 Stressless chair bases every day, proving the mass production potential of the process.

As wood in thin slices is a very flexible and soft material, the tools used for shaping the glued, but not hardened layers, can be made from similarly weak materials such as wood. At Ekornes this is the case, although plates of aluminium coat the tool to provide hardness, and add heat conduction on the surface. The German laminate gurus at Becker KG also suggest for advanced parts, to construct the tool from solid aluminium.

Both tooling and materials are cheap - comparable with vacuum forming. Costs add in the paint.

Laminated wood, using beech, scores good on environmental impact, even though the glue does produce formaldehydes when burned. Glues intended for indoor use has to fulfil strict requirements, and the amounts of formaldehyde released in burning are very low. For the record, the glue has not been calculated in the ECO99-indicator analysis as nothing comparable was found in the manual. It has been brought to the authors attention that future glues might even avoid formaldehyde entirely.

Durability can also be an issue with this type of material. Especially when it comes in contact with water. A thin film of plastic can in some cases be used as an outer surface to enhance this property.

When forming a laminate modern guidelines presented by Becker [3] as well as traditional handbooks [11] state that the minimum radius of the laminate should never go below 1/10-1/14 of the ply thickness. The standard thickness is 1,5 mm, but 0,8-3 mm seems within the usual. When the shape contains hefty multi-axial bends, a so called 3D-veneer could be used.

A less known, and used feature of laminate shaping is the use of inserts. Ekornes has in a new foldable table glued an aluminium profile in between the wooden layers. This is shown in fig. 27a.

4.2.6 Injection molding

An extruder heats and grinds plastic granule into a melt. The extruder screw winds back moving a given amount of material in front of it, before releasing it into a mold with large pressure.

The tool is a large investment due to the large pressures involved in the molding. It is not flexible in terms of changeability, but the process can produce the parts close to 2 times the price of material, which compared to other processes is very cheap. The share size of a part can quickly be used as a guidance for price. Thinner cross sections also lead to a need for higher pressure during the molding.

The process enables complex shapes, and stiffening fins making up for the weak materials usually involved in the process. Also technical materials such as PPS, a high temperature, high strength, fibre reinforcable material can be molded to a larger expense.

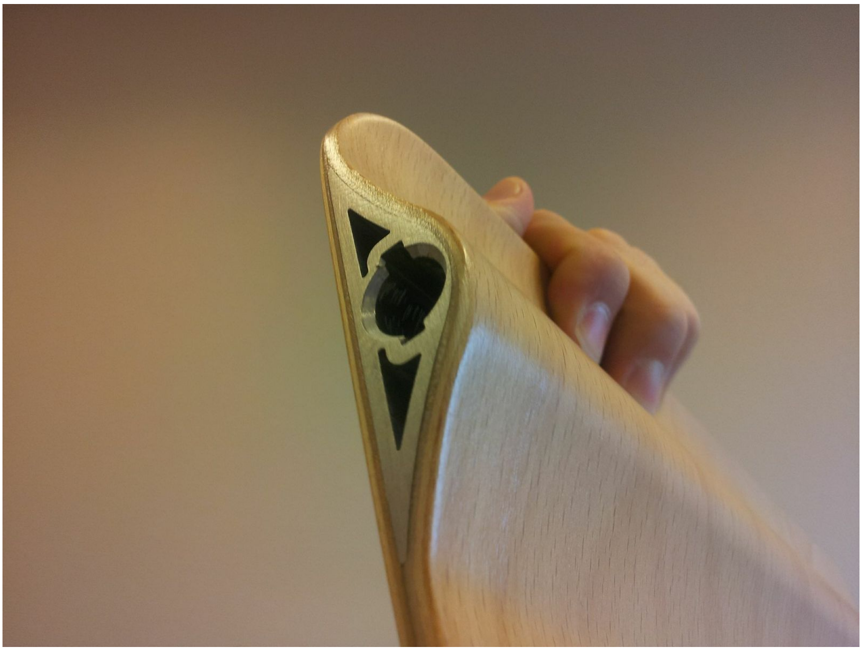
4.2.7 Paper based materials

Paper pulp molding

The classic paper pulp product is molded. A male tool, similar to the kind used for vacuum forming is dipped upside down into a pool of paper pulp slurry. Vacuum is applied through small holes on the surface making fibres build up. When the thickness of material is sufficient the mold is lifted and set to dry.

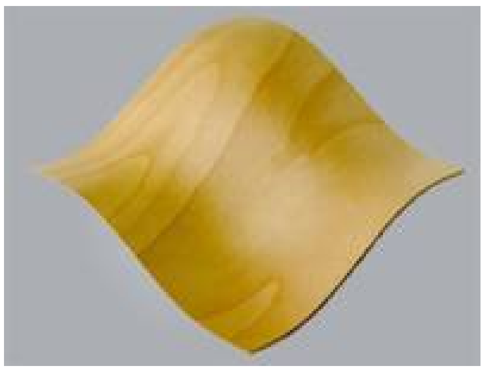
Paper pulp is usually associated with egg cartons, paper plates and packaging. The reasons why it has been seen as suitable for these jobs are probably environmental and due to the stiffness implementable through shaping. The Swedish forest-owner interest organisation Södra has through its paper pulp research lab [10] done studies to look at the challenges with paper pulp, and show how to work around these issues.

Durability is one of those. The lab is currently working on commercializing a product they call durapulp - a long fibre paper pulp and biodegradable polymer PLA hybrid material. During their studies and thesis done by Swedish designers, the material has been molded into the shape of a chair fig. 28a, and laminated to become a clothing hanger.



(a) Fold away table from Ekornes, implementing an aluminium profile into the 6mm laminate.

(b) Veneer laminated in three dimensions.



(c) Supplier Reholz 3d-veneer.

Figure 27: Possibilities within the field of wood laminates

By use of this hybrid the material increases its ability to withstand moisture. The general paper pulp material is though not. The DuraPulp material is still not mature enough for commercial use.

Paper-wood

Peugeot has in their new concept Onyx shown interest in Dutch design studio Vij5's newspaper-wood [14]. The material is made up of used paper, rolled and glued into logs, then cut or milled like a log of wood. The material has not got exceptional mechanical properties, but has low weight, and a bespoke look that might please the environmentally minded. Interestingly, the material consists of a high part adhesive/resin, which actually might not be very nice to the environment.

4.2.8 Extruded profile

With high volumes, extrusion becomes interesting. Moderate to high tooling cost, can be made up through low price per meter.

Plastic

Function integration is possible, and key to keeping part count, and cost down. The material is heated in the extruder, and pushed through a tool. The tool is usually expensive, but the part price is low if a sufficient length can be extruded at the same time.

The limitations lie in the maximum extruded profile size. Norwegian Primo, in conversation, expresses that its machines do not support cross sections larger than 30 cm. When it comes to design guidelines the material should not be thicker than 1-4 mm.

Aluminium

According to data available on the webpage of Norwegian aluminum company Hydro, profiles with cross sections of up to 52 cm can be provided.

4.2.9 Reaction injection molding

In the process two components (polyisocyanat and a polyol) are mixed and injected into the shape as illustrated in fig. 29. The two components flow easily and the injection can be done at a low pressure, or even in an open shape. The two components then harden to form a rubbery or hard, porous or solid part.

The process is in many ways ideal for a lot of products due to the low tooling costs. For larger, thinner parts the thin flowing components pose a valid challenger to ultra high pressure injection molding.

In order to reduce a part's density by 10 to 20 %, 1,5 to 2 parts CO_2 can be added to give a foamed porous structure. Through controlled cooling of the mold the density profile of the part can be controlled, described in [2] and illustrated in fig. 30.

(a) Durapulp childrens chair 25 % corn-based PLA [10].

(b) Durapulp laminate [10].

(c) Newspaper-wood in the Peugeot Onyx [14].

Figure 28: Production of technical character made from paperbased materials.

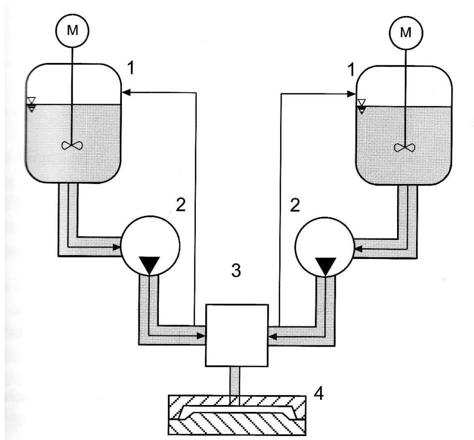


Figure 29: Illustration adapted from [2] showing the process of RIM - 1: Container 2: Flow regulator 3: Mixing unit 4: Mold

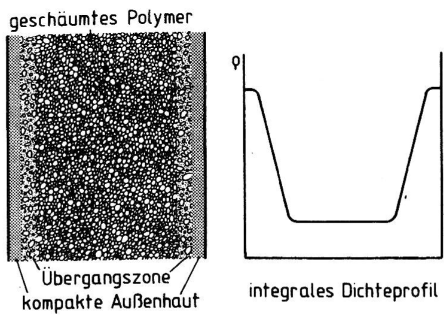


Figure 30: Illustration of foam an integral density profile, from [2].

As opposed to injection molding, and the other plastic shaping processes described, this process produces a thermosetting plastic. The part is in that sense not recycleable, nor reuseable (some foams are grinded down and reused in new foams). The only option is hence to burn the product with energy recovery. With the Norwegian recycling habits in mind, that is maybe not such a disadvantage for the thermosetting, as most of the plastic is burned anyway. This is discussed in sec. 3.2.4.

Requirements for turning the process less polluting has resulted in research on developing Biopolyols for Polyurethane production. A report by Li and Reeder [6] concludes that this yet is not competitive in terms of price, and also has technical barriers keeping the research from commercialization.

4.2.10 Long/endless fibre reinforced thermoplastics - "organoblech"

The latest years a new material has taken the stage in the automotive industry. Thermoplastic sheets with woven fabrics of glass- or carbon fibre, melted together into sheets with amazing properties. During manufacture these sheets are then heated and pressed into shape. In some uses, this part is afterwards put into a tool for injection molding and encapsulated into a new part with a large number of functional elements, yet retaining the superb properties of the reinforced sheets.

The manufacturers are not many and German/American company Bond-laminates does, upon request, answer that it does not know any company currently using their products in Norway, and that it doesn't not have the capacity to guide. This material will probably be more accessible in the future, and could maybe improve functionality through lower weight, and high functional integration with use of encapsulation in injection molded plastic.

4.2.11 Rotational molding

A closed mold is filled partly with finely grained plastic. The plastic is melted, and through multi axial rotation smeared onto the surfaces of the hollow tool.

Flat surfaces is a challenge, due to shrinkage during cool-down [13]. The process also limits the use of small radii to minimum 5 (to 10) mm, according to Norwegian manufacturer Cipax. Norner, a Norwegian independent industrial polymer institute, writes in a series of articles [12] about uncontrollable failure modes in rotational molding. Multiple problems are related to the centripetal acceleration during the process and its effect of moving heavier and smaller components to the surface of the part. This can be the case with contaminating particles and pigment.

The molds are often large, but do not need to withstand any inner pressure, and hence are moderately expensive.

Large parts (small boats etc.) are molded in single cavity machines. Smaller parts, in this process being below approximately 1 m^3, tools would be mounted on carousels with four arms biaxially turning. The mold on the arm would stop at four stations along a turn.

- Mold preparation, and material input.

- Heating, while being turned.
- Material distribution while turning.
- Cooling.

This way of manufacture poses one of the large challenges with the process. All molds on the same carousel are required to spend the same amount of time in each of the four stations. According to Cipax this implies that the wall thickness has to be similar for all products placed on the carousel.

4.2.12 Roll forming

Rolled profiles are made from sheets or reels of steel, through a series of rolls the profiles elements are shaped, and finally cut to length.

A large number of manufacturers limit the part size to 500 mm in material starting width, and 200 mm height, as the large numbers of profiles are smaller than this. Other suppliers (making roof panels e.g.) offer wider rolls, up to 800-1200 mm.

The number of bends and deformations, and the complexity - number of stages required to achieve wanted shape - define the tooling cost. Tool cost varies largely. Holes and punched details can be added before or after shaping. Closed profiles can be produced by shaping before continous welding joins the two outeredges of the profile.

4.3 Tray concepts

In the following sections the tray concepts are presented.

Some design features are the same in many tray concepts. The main shape of the tray was modelled with basis in the functional surfaces, and a mesh of lines were drawn between the surfaces to provide the best washability possible. For some models the mesh was altered, to give way for special features, but the initial model has been the same for all concepts.

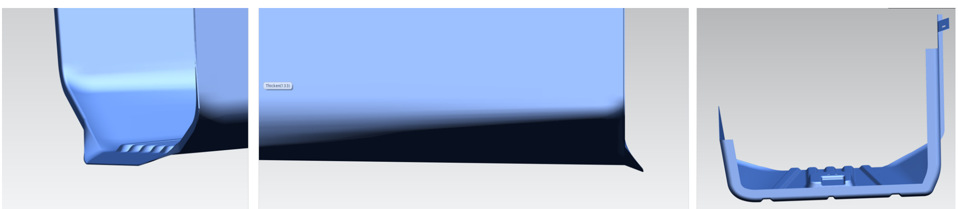


Figure 31: Towards the front of the tray a steep, yet softly blended, 8 mm tall edge forms, ensuring that fluids will not escape elsewhere than into the collection tray in the middle.

For the removable trays the policy has been to solve the issue of outer edge sealing in common. Through discussion with experienced mechanical designers at

Tomra's Asker office (for more read App. H), the idea of moving the right flange positioning the shape recognition box to the part called "right side and partly bottom" in fig. 5. This bracket was then shaped in a hook like fashion providing a "shelf" covering for fluids. The left flange of the tray has no need for a sealing as the reflex surface runs on top of it/is built in. Against the back wall several options were considered:

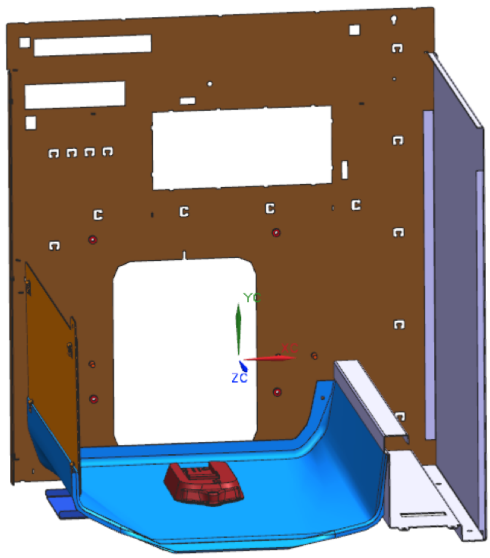


Figure 32: The final sealing of the right flange of the removable trays. The figure also illustrates how the left side is covered by the reflex surface.

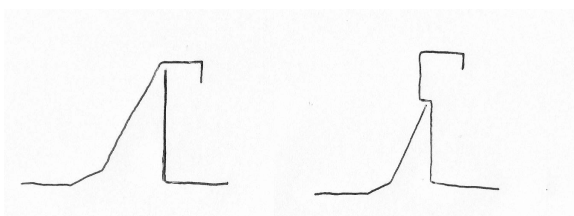
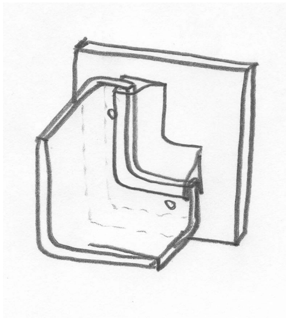
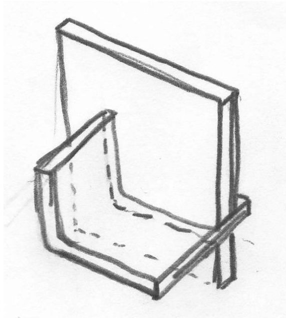


Figure 33: Left: the current right flange and connection to next part. Right: The preferred new solution.

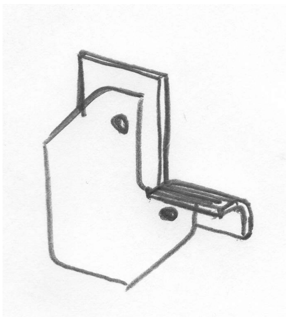
- Option 1 - A rubber profile that slides onto the edge of the tray. Either with top- or side- seal. A top seal was donated by Otto Olsen AS for testing. Before testing it became evident that the seal would not work, as the curvature needed was not supported by the seal. A side-seal might better do the job.

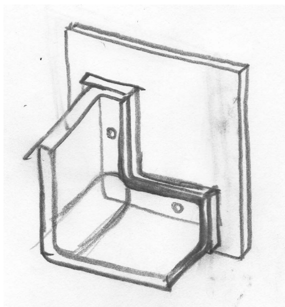




(a) Option 1 - A rubber profile is placed on the edge of the tray.

(b) Option 2 - The tray is guided through the back wall.





(c) Option 3 - Extra flange on back wall.

(d) Option 4 - Neoprene sealing.

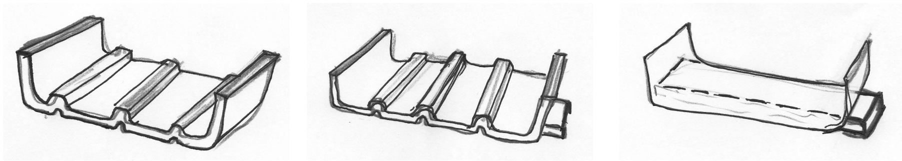
Figure 34: Different designs ideas for implementation of a vacuum formed tray.

- Option 2 - Letting the tray run through the back wall, enabling any fluids running down the back wall to drop onto the tray. This was not possible due to the fact that other modules are to be mounted on the back wall, and hence there can be nothing sticking out of it.

- Option 3 - Bolting the tray straight onto the back wall. Bending an extra flange on the lower edge of the large hole in the back wall, would provide perfect cover for the midsection of the join; the area where it is most likely to drip.

- Option 4 - Using a water jet cut neoprene mat, compressed 30-40 % between the two surfaces. Tests were conducted, showing no sign of leakage after 35 minutes, for more see app. B.

The prefered choice was therefore option 4, the neoprene seal.



(a) Design idea 1 - Stiff, with high wall thickness.

(b) Design idea 2 - Semi-stiff tray with support bracket.

(c) Design idea 3 - Thin tray with stiffened support bracket.

Figure 35: Different options for sealing the join between the back wall and the tray.

4.3.1 Concept 1 - Vacuum formed tray

Development and functionality

Due to the trays open shape vacuum forming was considered an ideal method of manufacture. The shape could easily be adapted to give good release angles, and the shaping should - according to Svein Fagereng at NyPlast be problem free.

Early concepts consisted of three main thoughts:

- A stiff tray, enabling the removal of the support beam below the tray.
- A semi-stiff tray, contributing to the stiffness of the tray, but still requireing the stiffness of the support beam.
- A weak, thin shell with excellent non-mechanical functionality (washability, aesthetics, durability), but assisted by a beefed up support beam, providing the system with the required stiffness and stability.

In colaboration with NyPlast the decission to go forth with the weak concept was made. Even when shaped cleverly (highest possible second moment of area) the poor mechanical properties of the ABS would overshadow the clever shape, making some additional bracket necessary. A semi-stiff solution would in any case not be the best option, and hence the decision was made to work on the weak tray.

Considerations about integration of the conveyor base and the reflex plate were also done. The base could easily be integrated, providing a waterproof seal between the former two parts. The idea came to a halt due to the difficulty of providing support structure below the tray providing sufficient stiffness without adding numerous parts, and unwanted cost.

The integration of the base in this way would also involve removing access to the bolts fastening the weight cell. This could be solved through a replaced weight cell without threads. This is possible according to the manufacturer, but according to Tomra not a wanted outcome. Tomra argues that the number of variations of a part in use in their machines, should be kept to a minimum.

Other alternative solutions to this have been sought in later concepts where base integration was found more reasonable (high integrated stiffness).

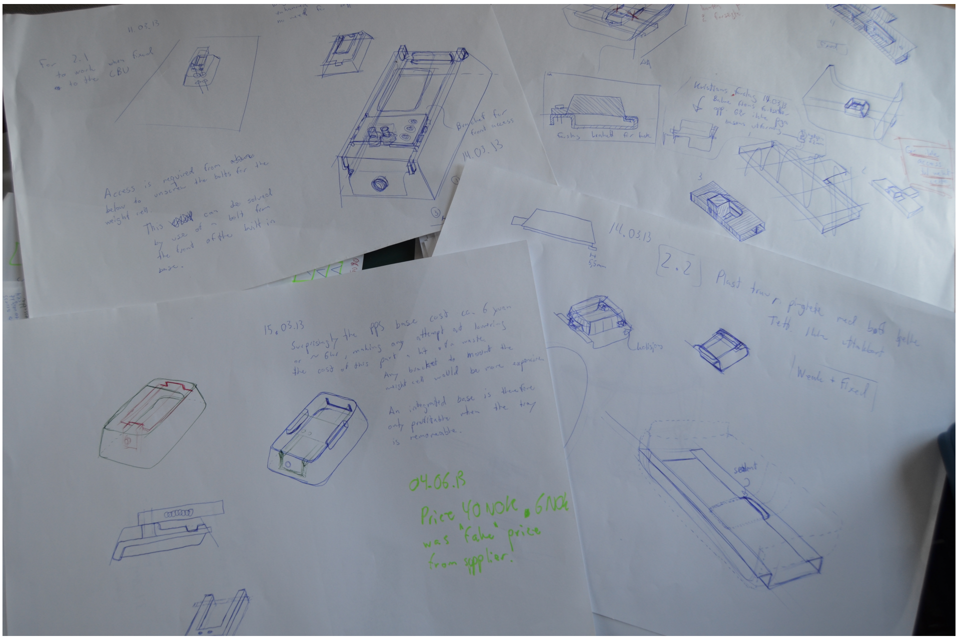


Figure 36: Different concepts for implementing the base into the tray, still enabling the mounting of the weight cell. For a close look see the PU-journal.

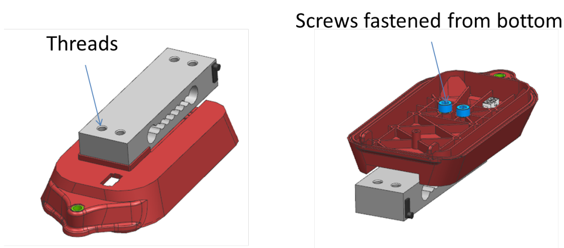
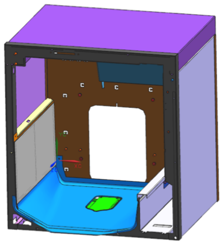
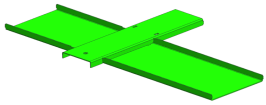


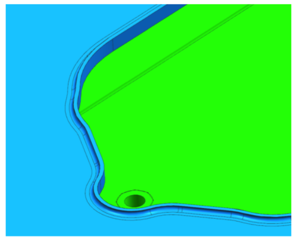
Figure 37: The weight cell and how it is fixed to the current base.



(a) Vacuum shaped tray concept mounted in base unit



(b) The supporting bracket for the vacuum tray



(c) The edge of the tray, prohibiting fluids from flowing out

Figure 38: Illustrations of the vacuum formed concept

An integrated reflex plate would increase the drawing depth of the tool significantly, resulting in added thinning of the vertical walls, and large amounts of surplus material only to later on be milled away.

In phase two the issues of water sealing was addressed. The edge between the base and the tray was found to be a challenge. An already inbuilt grove in the base gave space for a stopping flange in the tray.

The thickness was chosen in consultation with NyPlast. The company also provided an offer for cost of tooling and parts. This is found in the next section.

Cost

Ny Plast has previously been a large subcontractor of vacuum formed parts to Tomra. It has long experience and has offered guidance in the course of this development.

Production in Norway has its disadvantages if the assembly is taking place in Poland. Because of the fairly good stackability of the part the cost of transport can be kept low.

The tray itself has also been found cheap, at NOK 42, at a shared best price. For the production volumes in question a multi cavity tool probably would be beneficial. Ny Plast has suggested that a dual cavity tool would cost around 75 % more than a tool with a single cavity. This could decrease the cost of the part through less manual handling (halved number of fixing operations in the CNC mill for surplus material removal).

The requirement for additional massive brackets (NOK 74) in order to maintain the required stiffness sky-rocketed the price. The fixing of the brackets has also become a dilemma; whilst the tray itself is the easiest to remove of all the concepts, the extra bracket increases the total assembly time.

The total price of the concept ends up at NOK 258 with a production of 25000 units. The current setup has a cost of NOK 272.

Environment

The original setup contained a 3,5 kg tray, and a 1,35 kg support bracket. In this concept the tray weight was reduced to 0,87 kg. The bracket on the other hand had to be reinforced, resulting in a new weight of 1,675 kg.

In the ECO99-indicator manual the indicator [millipoints/kg] of plastic generally is 4-5 times higher than that of steel. The tray itself did show considerable weight savings, but the strengthening of the support bracket added metal weight and increased the indicator above the current setup.

Due to the increased number of suppliers the damage done through transportation also adds to the total score.

Product or component	**Project**
Tray	T-9 - base unit
Date	**Author**
03.jun	Arne Olav Eide

Notes and conclusions
Sheet metal usage efficiency of 66% see sec. 3.2.3

Production
Materials, processing, transport and extra energy

material or process	**amount**		**indicator**		**result**	**assumption**
ABS	0,87	kg	400,0	mPt/kg	348	
Vacuumforming	0,87	kg	9,1	mPt/kg	7,917	
Steel added	2,030303	kg	86	mPt/kg	174,606	
Sheet production	2,030303	kg	30	mPt/kg	60,9091	Stamping and bending is neglected
Transport Tanker	6,96	tkm	0,8	mPt/tkm	5,568	
Transport Trailer	0,261	tkm	15	mPt/tkm	3,915	
Total					600,9152	

Use
Transport, energy and any auxiliary materials

process	**amount**		**indicator**		**result**	**assumption**
Transport Tanker	*5,22*	*tkm*	*0,8*	*mPt/tkm*	*4,176*	*25% of all transport*
Transport Trailer 40t	*1,74*	*tkm*	*15*	*mPt/tkm*	*26,1*	*25% of all transport*
				Sum	*30,276*	
				Sum x 25%	7,569	
Transport Trailer 28t	*0,9135*	*tkm*	*22*	*mPt/tkm*	*20,097*	*75% of all transport, 1000km*
				Sum x 75%	15,07275	
Total					22,64175	

Disposal
Disposal processes per type of material

material and type of processing	**amount**		**indicator**		**result**	**assumption**
Recycling PP	0,16199	kg	-210	mPt/kg	-34,017	19 %
Deponering	0,0455	kg	3,5	mPt/kg	0,15926	5 %
Incineration w. energycapture	0,42044	kg	-13	mPt/kg	-5,4657	48 %
Municipal waste PP	0,14743	kg	-0,13	mPt/kg	-0,0192	17 %
Incineration wo. Energycapture	0,09464	kg	0	mPt/kg	0	11 %
Recycling of ferro metals	1,88818	kg	-70	mPt/kg	-132,17	93 %
Incineration without energycapture	0,14212	kg	-32	mPt/kg	-	7 %
Landfill	0	kg	1,4	mPt/kg	0	0 %
Total					-137,658	
Total (all phases)					485,8993	

Table 5: ECO99-analysis for the vacuum formed tray concept.

4.3.2 Concept 2 - Injection molded tray

Development and functionality

Compared to vacuum forming, injection molding provided an additional shaping dimension. Where vacuum forming produced sheets with varying thickness, injection molding provided the option of adding ribs and functional elements to the surface.

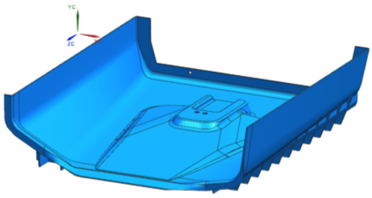
To produce a simple part would never be beneficial with injection molding, as the part complexity does not impact the cost largely. The part cost was given by the amount of material in the part. The cost of tooling varied with tool material usage (volume), hence it was a goal to keep it at a minimum. Thin structures also drive costs as mold pressure rises with thinner cross sections. The reflex was therefore not integrated in the concept; volumious mold, thin surface. Functional elements were tried incorporated in the concept through use of ribs for stiffness and domes intended for use with high strength bushings. The base was integrated in the part without risk of compromising access to cables, as the concept was designed to be removeable. This decission was again made as the base unit is made from steel and a fixed tray would not in any way be better interconnected with the base unit (metal-plastic welding ie. was not available at assembly location).

Through a series of simulations a shape providing sufficient stiffness was found. Doubling the number of ribs only slightly increased stiffness, while a doubling in rib height led to more than halfing the deflection. Illustraions are shown in app. A. The second moment of area is proporsional to h^3 showing the important role the rib height plays in the stiffness question. All ribs were placed on the lower side of the tray, ensuring easy cleanability. The space below the initial tray's upper surface was not sufficient for providing enough stiffness to the part. Below the base unit, in the crate unit/cabinet, there is an additional 30 mm of height available, providing more than enough room for sufficient stiffness to be acchieved (less than 5 mm needed). Through discussion with Kristian Hovde and Katrin Jacobsen, the decision to not proceed with such a design was made, based on the thought of future compatability issues with future crate units, cabinets and uses. Further simulations were in a second phase conducted in order to make a sufficiently stiff tray fit within the required space. The floor was lifted in the area of stress, and iterations were made until sufficient stiffness was provided.

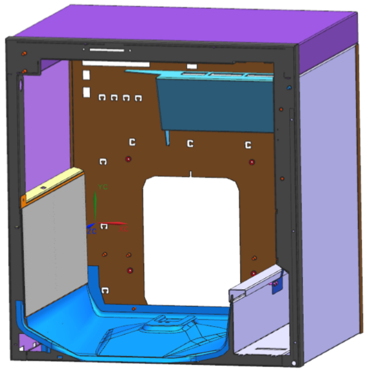
The same solutions of sealing the side and rear edges were used as for the vacuum formed tray. This solution was found best fitted for all removable trays.

Cost

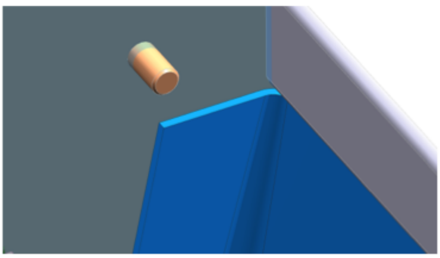
In previous years injection molding has played a role in Tomra. For many machines (T-600 e.g.) the front door was made in this manner. Large, thin cross sectioned parts require large, high pressurized, costly tools that hence made the solution, though ever so cleverly made, less profitable. Tomra developers have guessed the cost of a front door tool to staggering NOK 500 000, and that being some years ago it would probably be even higher today.



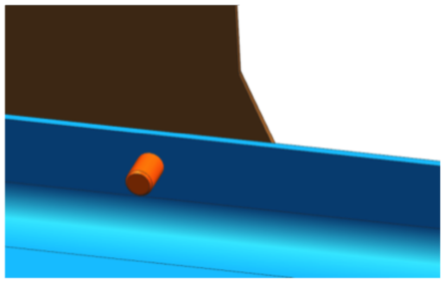
(a) Injection molded tray by it self



(b) Injection molded tray concept mounted in base unit

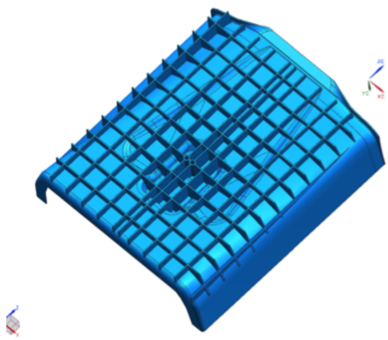


(c) The right edge of the tray, covered by a slightly changed right side wall. This change has been adapted for all concepts



(d) The fixing of the tray will on the back wall consist of studs standing out of the back wall, and nuts fixing the tray onto these

(e) As d), used for testing neoprene seal between a 1,5mm "back plate" and a 1mm "tray"



(f) The rib structure below the tray floor, enabling the removal of the support bracket

Figure 39: Illustrations of the injection molded concept

With a slightly smaller size, the tray might turn out more profitable to make. With the China department of Tomra, new opportunities have arisen. The tooling cost in China is remarkably cheaper than in Scandinavia.

An offer was given through Tomra mechanical engineer Tom Veble, and the China department, for a ABS molded tray of NOK 58. The tooling would cost rather high NOK 353 000.

With a rather low stackability, an additional NOK 55 had to be added for transport, and logistics. In terms of assembly, the stiffening ribs enabled the removal of the support beam, and the mounting to the cabinet also was made less extensive. This shaved some 10 % of the total assembly time.

The sealing solution chosen added a rather moderate NOK 16.

The total cost per unit of the concept at 25000 units was NOK 234, as opposed to current equivalent at NOK 312.

Environment

Using Norwegian numbers for recycling the tray scored 385 in the ECO99-indicator analysis. The indicator is as aforementioned (see section 3.2.4), higher per weight than for steel. Using the advantages given by the process, stiffness has been given the part through stiffening ribs drastically increasing the bending stiffness of the tray.

Additional environmental damage had to be added through transport from China. The ECO99-indicator analysis does though not differentiate between the easily stackable and non stackable parts. For the injection molded tray, this was an advantage.

Product or component				**Project**		
Tray				T-9 - base unit		
Date				**Author**		
03.jun				Arne Olav Eide		
Notes and conclusions						
Production						
Materials, processing, transport and extra energy						
material or process	**amount**		**indicator**		**result**	**assumption**
ABS	1,056	kg	400,0	mPt/kg	422,4	
Injection molding	1,056	kg	21,0	mPt/kg	22,176	
Transport Tanker	8,448	tkm	0,8	mPt/tkm	6,7584	
Transport Trailer	0,3168	tkm	15	mPt/tkm	4,752	
Total					451,3344	
Use						
Transport, energy and any auxiliary materials						
process	**amount**		**indicator**		**result**	**assumption**
Transport Tanker	*6,336*	*tkm*	*0,8*	*mPt/tkm*	*5,0688*	*25% of all transport*
Transport Trailer 40t	*2,112*	*tkm*	*15*	*mPt/tkm*	*31,68*	*25% of all transport*
				Sum	*36,7488*	
				Sum x 25%	9,1872	
Transport Trailer 28t	*1,1088*	*tkm*	*22*	*mPt/tkm*	*24,3936*	*75% of all transport, 1000km*
				Sum x 75%	18,2952	
Total					27,4824	
Disposal						
Disposal processes per type of material						
material and type of processing	**amount**		**indicator**		**result**	**assumption**
Recycling PP	0,19662	kg	-210	mPt/kg	-41,29	19 %
Deponering	0,05523	kg	3,5	mPt/kg	0,19331	5 %
Incineration w. energycapture	4,08261	kg	-13	mPt/kg	-53,074	48 %
Municipal waste PP	0,05368	kg	-0,13	mPt/kg	-0,007	17 %
Incineration wo. Energycapture	0	kg	0	mPt/kg	0	11 %
Total					-94,1777	
Total (all phases)					384,6391	

Table 6: ECO99-analysis for the injection molded tray concept.

4.3.3 Concepts 3-4 - Deep drawing

The China department of Tomra has already used what they call "hard-tool" forming of metal for shaping simple sheet metal parts. A series of tools punch and force the metal into shape. The process is a shaping process, but does not seem to utilize the plastic deformation of deep drawing for more than bending the metal.

Not knowing the abilities of the Chinese suppliers, concepts were at an early stage provided for review.

The Chinese suppliers did not utter any requirements for change in the concepts, its revisions, detailing and tolerance constraints. Production is hence, to the authors knowledge possible.

Early concepts only consisted of the basic shape. Two concepts were brought forward:

- Concept 3 - fixed - A welded concept, with sufficient stiffness, but without base and reflex (due to accessibility issues). At a later stage Tomra suggested that the base was included, and the accessibility issues had to be solved.

- Concept 4 - removable - Fully integrated tray with sufficient stiffness to remove the support beam, built in reflex and with the base built in. For access purposes with these parts integrated, the tray had to be removeable.

Simulations were conducted for both concepts showing sufficient stiffness with as little as 0,7 mm sheet metal. Rumour has it that the material received from China has varying quality, and hence an extra margin was added giving a final thickness of 1 mm, still 0,5 mm below the current tray.

4.3.4 Concept 3 - Deep drawing - Fixed

Development and functionality

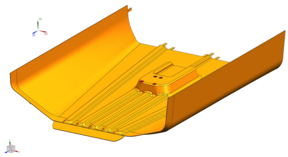
After consultation with Tomra supervisors the concept was changed to include the base (see fig. 37 and fig. 32). The base was easily integrated in the part design, and distanced the concept from the current setup.

Integrating the base brought with it some challenges as well. A base fixed to a welded tray, would not give the required access to the weight cell screws, mounted from below.

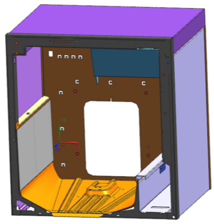
An innovative, though not too practical solution was found with use of a new bracket mounted below the bolt holes in the tray, illustrated in fig. 40d.

The new bracket enabled installation of the weight cell from above with an allan-head screwdriver fitted through the threaded hole into a set-screw already fitted with a locking nut.

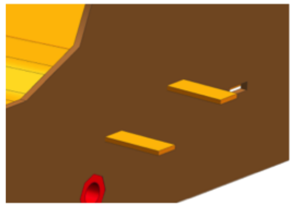
A spring fitted to each of the two screws would push the screws up through the floor of the tray, but flexibly sink into floor while e.g. the first screw was tightened. When the second bolt was to be tightened the screwdriver would again be inserted through the threaded hole in the weight cell, finding the set-screw being pushed up against the weight cell, ready to be tightened up.



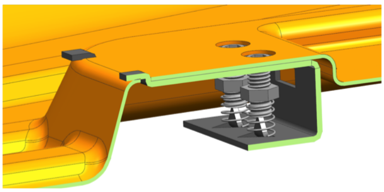
(a) Fixed steel tray by it self



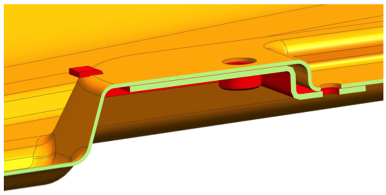
(b) Fixed steel tray concept mounted in base unit



(c) Long tabs are guided through the back wall ensuring correct placement.



(d) Section view of Bracket 1 - Using springs, two set-screws with locking nuts on, a bracket enabling mounting of the weight cell from the upper side of the tray (for an illustration of the weightcell and its fixing see fig. 37.



(e) Section view of Bracket 2 - Altering the weight cell to having one end without threads, the bracket can be simplified a lot. The large surface ensures good distribution of moment

(f) The fixing of the tray will on the back wall consist of studs standing out of the back wall, and nuts fixing the tray onto these

Figure 40: Illustrations of the fixed steel concept

This might sound unpractial, but in reality this process should not be difficult. There are though some issues with the manufacture of this bracket. The way the bracket has been designed, the bracket either needs to contain one hand bend, or the set-screw and the locking-nut have to be fitted after the screw has been inserted through the bracket. The bracket is by itself an extensive assembly.

An alternative would have been to use a weight cell without threads, although in conflict with Tomra's policy of using as few different types of one module in their machines as possible. This solution would also require a bracket on the lower side of the tray, though less complex. This bracket is shown in fig. 40e.

The tray was to be welded to the common base, as the current solution.

Cost

A high degree of stackability resulted, despite a single yearly delivery and additional storage requirements, in low logistics costs of NOK 12. The part cost had to be based on an earlier and more complex concept, and should hence be higher than the final part. The part cost was set to NOK 42, and the tool cost to NOK 170 000. At NOK 42, the tray was as cheap as the vacuum formed tray, still stiff enough to make a support bracket redundant. The cabinet total assembly cost also sunk, making this concept a serious contestant in this thesis.

At 25 000 units the total cost of a unit of the concept added up to NOK 170, nearly half the price of the original concept at NOK 312.

Environment

With an estimated total part weight reduction from 6,1 kg, to 2,3 kg, the tray scores highly in the ECO99-indicator analysis. The additional transportation, counterweights some of the effect, leaving the concept with a reduction in indicator of 33,7%.

Product or component				**Project**		
Tray				T-9 - base unit		
Date				**Author**		
03.jun				Arne Olav Eide		
Notes and conclusions						
Production						
Materials, processing, transport and extra energy						
material or process	**amount**		**indicator**		**result**	**assumption**
Steel	3,5	kg	86	mPt/kg	298,39	
Sheet production	3,5	kg	30	mPt/kg	104,09	
Zink coating , ink zink	0,347	m2̂	49	mPt/kg	17,0015	
Pressing	2,3	kg	23	mPt/kg	52,67	
Transport Trailer 40t	18,32	ton*km	0,8	millipoints/tonkm	14,656	
Transport trailer	0,687	ton*km	15	millipoints/tonkm	10,305	
Total					497,117	
Use						
Transport, energy and any auxiliary materials						
process	**amount**		**indicator**		**result**	**assumption**
Transport Tanker	*20,8*	*tkm*	*0,8*	*mPt/tkm*	*16,655*	*25% of all transport*
Transport Trailer 40t	*6,94*	*tkm*	*15*	*mPt/tkm*	*104,09*	*25% of all transport*
				Sum	*120,745*	
				Sum x 25%	30,1864	
Transport Trailer 28t	*3,64*	*tkm*	*22*	*mPt/tkm*	*80,15*	*75% of all transport, 1000km*
				Sum x 75%	60,1125	
Total					90,2989	
Disposal						
Disposal processes per type of material						
material and type of processing	**amount**		**indicator**		**result**	**assumption**
Recycling of ferro metals	3,227	kg	-70	mPt/kg	-225,88	93 %
Incineration without energycapture	0,243	kg	-32	mPt/kg	-	7 %
Landfill	0	kg	1,4	mPt/kg	0	0 %
Total					-225,877	
Total (all phases)					361,539	

Table 7: ECO99-analysis for the Fixed deep drawn tray concept.

4.3.5 Concept 4 - Deep drawing - Removeable

Development and functionality

The reflex surface was incorporated into the tray. This was expected to become a disadvantage in terms of cost. That was though not the case, as discussed further in the next section.

The tray efficiently integrated the base, the reflex surface, upper left beam and enabled the merging of the lower left beam and the left side plate.

With all this integration the question of the cabinets stability when the tray would be removed, arose. Simulations were conducted on the cabinet with, and without the removable tray fitted. The loading condition was: the door at 45 ° open, with 60 kg added to the 30 kg weight at the middle of the door width. All the weight and half the moment was added at the upper hinge. This did show a radical increase in deflection without the tray mounted, but a decrease in deflection with the removable tray fitted compared to the original. The values were in all cases within 1 mm at the hinge. The full series of simulations can be found in app. A.

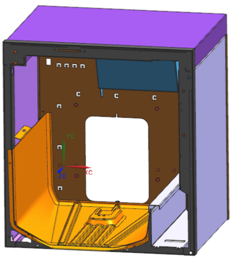
Cost

Despite expextations of a high cost, due to the large flange, this did not influence the cost largely. The part cost ended up at NOK 55, with a rather moderate tooling cost of NOK 200 000. The thin walled tray also provided impeccable stackability making the logistics cost as low as NOK 20 included the additional storage requirements due to the single yearly shipment. Assembly also benefited in this concept. Although the assembly might contain more work per part, but as the number of parts has been reduced significantly, the cost of assembly of the cabinet is reduced with more than 20 %.

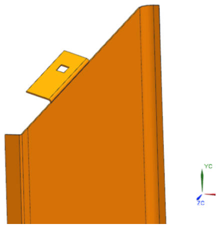
In totalt the concept could be produced with a total cost per unit based on 25 000 units of NOK 197, compared to the NOK 375 of the current setup.

Environment

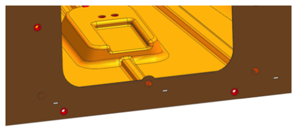
As for the fixed concept the reduction is significant. With an even higher degree of integration, replacing more heavy parts with a single, lighter part, the indicator reduction ends up at fascinating 35,3 %.



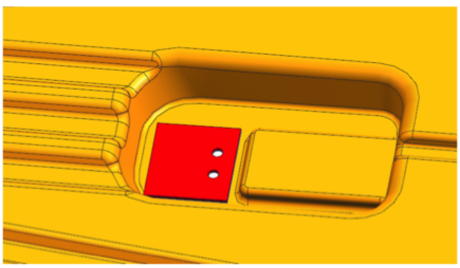
(a) Removable steel tray concept mounted in base unit



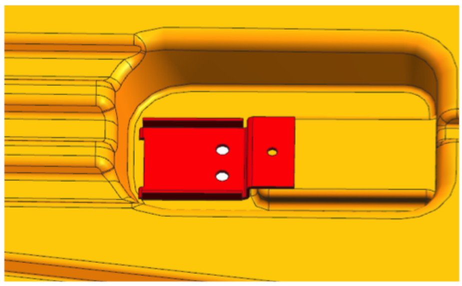
(b) The left flange of the tray, the reflex surface.



(c) Vaguely visible orange studs for fixing of the tray.



(d) Simple bracket for distribution of forces.



(e) Bracket 2 as for previous steel concept - In this setup without self-clinching nuts, as the threads in the weight cell is still present. Screws are entered from below.

Figure 41: Illustrations of the removable steel concept

Product or component				**Project**		
Tray				T-9 - base unit		
Date				**Author**		
03.jun				Arne Olav Eide		
Notes and conclusions						
Sheet metal usage efficiency of 66%						
Production						
Materials, processing, transport and extra energy						
material or process	**amount**		**indicator**		**result**	**assumption**
Steel	4,7	kg	86	mPt/kg	403,94	
Sheet production	4,7	kg	30	mPt/kg	140,91	
Zink coating , ink zink	0,4697	m2̂	49	mPt/kg	23,0152	
Pressing	3,1	kg	23	mPt/kg	71,3	
Transport Trailer 40t	24,8	ton*km	0,8	millipoints/tonkm	19,84	
Transport trailer	0,93	ton*km	15	millipoints/tonkm	13,95	
Total					672,954	
Use						
Transport, energy and any auxiliary materials						
process	**amount**		**indicator**		**result**	**assumption**
Transport Tanker	*28,2*	*tkm*	*0,8*	*mPt/tkm*	*22,545*	*25% of all transport*
Transport Trailer 40t	*9,39*	*tkm*	*15*	*mPt/tkm*	*140,91*	*25% of all transport*
				Sum	*163,455*	
				Sum x 25%	40,8636	
Transport Trailer 28t	*4,93*	*tkm*	*22*	*mPt/tkm*	*108,5*	*75% of all transport, 1000km*
				Sum x 75%	81,375	
Total					122,239	
Disposal						
Disposal processes per type of material						
material and type of processing	**amount**		**indicator**		**result**	**assumption**
Recycling of ferro metals	4,368	kg	-70	mPt/kg	-305,77	93 %
Incineration without energycapture	0,329	kg	-32	mPt/kg	-	7 %
Landfill	0	kg	1,4	mPt/kg	0	0 %
Total					-305,773	
Total (all phases)					489,42	

Table 8: ECO99-analysis for the Removable deep drawn tray concept.

4.4 Upper door concepts

The different upper door concepts will in the following section be introduced and presented.

As for the tray, some properties are found in all concepts. The hinges are fastened in the same way in all concepts, and the gas springs are, although with varying strength, the same. The magnet locks is also something that to some extent has been implemented in a similar way in all concepts. The variations are shown for the different concepts.

Differences in price of gas springs of different load were found minimal.

4.4.1 Concept 1 - Wooden laminate

Development and functionality

Wood has a good stiffness to weight ratio, and is, when laminated, easy shapeable. The tools are cheap, compared to other processes, and the environmental aspect is also positive. Hence this alternative was found to be interesting, although somewhat radical.

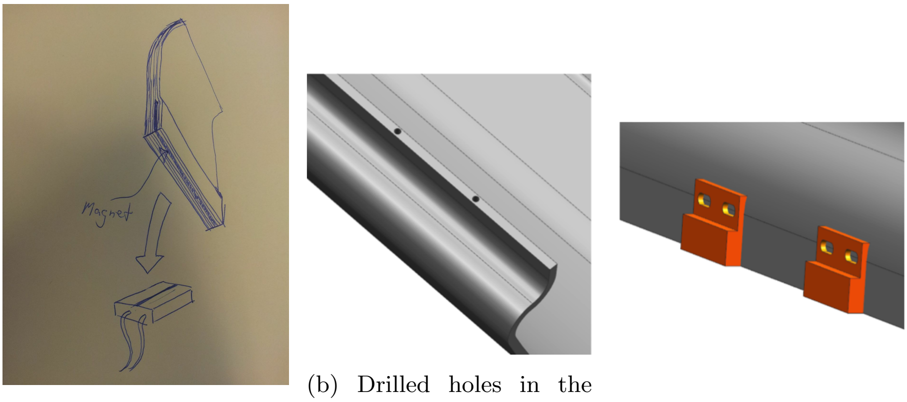
In collaboration with Chief-constructor at Ekornes Laminat Knut Tore Fausa, a concept for a door came together. From the beginning the aim was to create a simple, lean laminate, with low requirement for milling.

In consultation with Knut Tore Fausa, a question of manufacturability was raised. The process of making wood laminates demands experience and is of long tradition. According to Fausa, a thin laminate like the one proposed (6-8 mm), would need hot-plate heating, instead of the more cost efficient high-frequency glueing. Even using this method, which spreads the heat out more evenly, the risk of getting warpage in the final product was present. Keeping an eye on this from an early stage, tweaking the production to work flawlessly, this would not be a problem. Ekornes has below 1 % wrecked parts in their production.

A screw should have at least 5 mm of material to grip onto, and an additional 2-3 mm on the other side, in order to not leave any marks on the opposite surface. This led to some complications.

The issue of fastening the gas springs was solved through use of casted sink brackets fastened with a clamp-like shape, with screws on the back fitting into pre-made dimples in the laminate. Alternatives were using wooden side wall, additionally closing the open end surfaces, or a bar from one end of the profile to the other. The sink brackets have been offered from China, and turn out to be cheap.

Fixing the magnetic locks was not simple. Several ideas were investigated. The possibility of building in a magnetic strip in the laminate might be the sleekest solution, but needs further testing before chosen. A compromise would be to use the magnet of the lock, without its housing, as shown in app. C. The manufacturer works closely with Tomra, and such a solution should be possible according to Tom Veble, with experience from the China department of Tomra. Glueing the current locks into a grove made in the laminate should work, and has therefore for now been selected as the best option.



(a) Magnetic strip laminated inbetween the veneer layers.

(b) Drilled holes in the lower edge of the laminate for insertion of lock activating magnets.

(c) The existing magnetic lock with housing, glued into grove in laminate.

Figure 42: Magnetic locks concepts for the wooden door

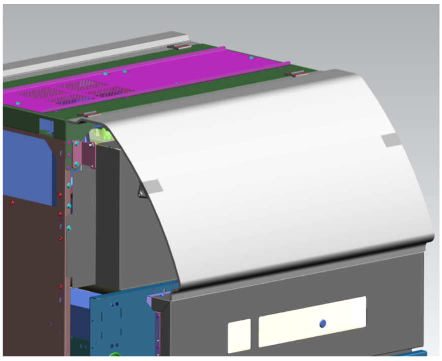
Also the issue of mosture is important when working with wood. Both in the production and as a final product the part is sensitive to water. Ekornes did explain this, but the compendium Der Becker, by Becker AG [3]. laminate company states this even clearer. Keeping in mind that they have patented technology to improve wooden laminate lifetime expectancy, they describe the expected life of a normally treated beech laminate to last 3 years. This can again be increased with surface treatment, or tougher, more durable surface materials.

Cost

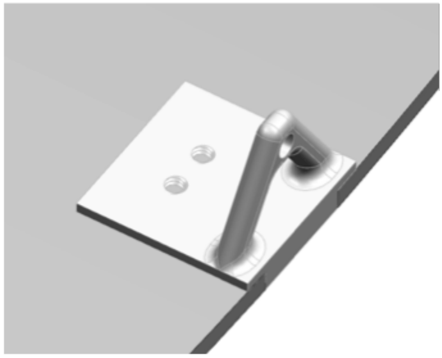
The cost of the wooden laminate was sought from several sources. Initial development was conducted in association with Ekornes. Ekornes also presented a way of guessing the price of the laminate:

- Wood cost - NOK 7000 per m^3 for B-C quality beech, in 1,5 mm layers.
- Glue cost - 100 x thickness [mm] = grams of glue per m^2 laminate.
- Cost of laminate press and worker - Worker is payed NOK 180-200 per hour.
- Cost of running mill
- Sanding and worker
- Cost of coating - Equivalent to the cost of all the previous posts.

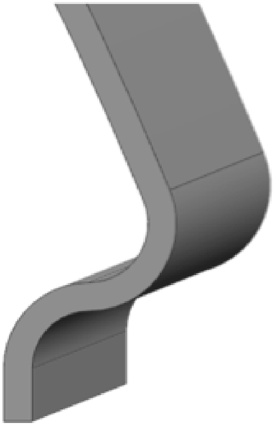
Using this highly theoretical estimate the cost of the laminate should be around NOK 324 per unit (to be found in the PU-journal dated 6.3.13). Ekornes did not have the capacity to produce the laminate, forcing a search for other suppliers.



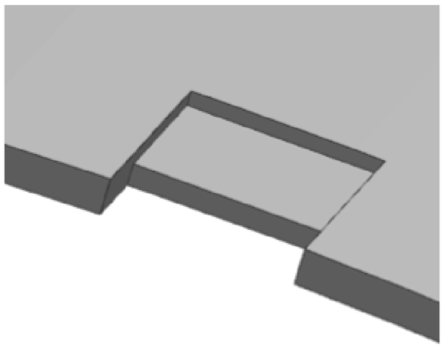
(a) The wooden laminate concept.



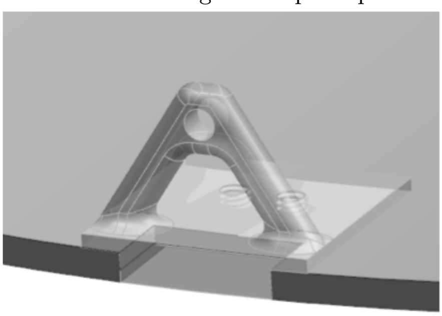
(b) The clamp bracket for gas spring mounting.



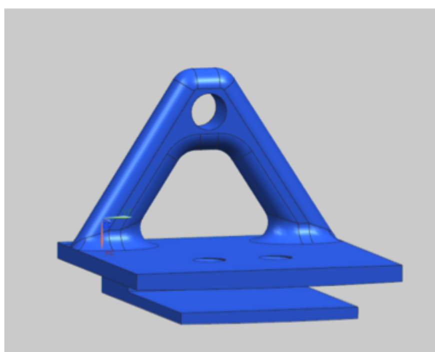
(c) The profile of the laminate, keeping as close to the original shape as possible.



(d) The slot in the laminate into which the clamp is fitted.



(e) The clamp bracket for gas spring mounting.



(f) The clamp bracket for gas spring mounting.

Figure 43: Illustrations of the vacuum formed concept

Måndalen laminates, a part of Danish laminate specialist Kvist, gave an offer for production in the Baltic region, with a pure wooden laminate either from beech or birch, coated with an suited coating at NOK 435. Tooling would add additionally NOK 100 000. The reason for the "high" tool cost was based on that the supplier found that a full aluminium tool was required to secure correct shaping of the small radii. A simpler laminate would be shaped using an aluminium coated wooden tool.

Realizing this would fall short of the cost of the current concept, another offer was sought. Laminate specialists Becker AG, which at an early stage was brought in for their competence, was asked, resulting in a offer for a CPL (continuously pressed laminate) coated laminate. With CPL a paper film is covered in a thermosetting resin, making the coating incredibly durable. This coating can be found on most office desks, door panels and similar. The price of this laminate was NOK 331, tooling at NOK 28800.

Offers for the brackets was given through Tom Veble and the China department of Tomra. Each bracket would in zinc cost NOK 25.

The cost per unit at 25 000 units ended up at NOK 411, a slight reduction from the 482 of the current door.

Environment

The wooden laminate was difficult to implement in the ECO99-indicator system. For the fine sheets of wood, and the laminate production the indicator values had to be chosen from similar materials and processes. The aluminum/zinc brackets also turned out a big question. The zinc findable in the ECO99-manual [9] has and indicator of 3200, rather a lot more than the other metals (steel 86, aluminium 312). To the writers understanding the material mentioned must be a coating material, or a somehow high grade material. zinc has its disadvantages for the environment; it is not particularly good for creatures living in water, and it also is toxic in large amounts, but to the writer the indicator value of 3200 seems unrealistic. Whether the bracket is made from zinc or aluminium plays a smaller role in this setting. The advantages of zinc, making it the choice favoured in the thesis was its good casting properties; requires small release angles and shrinks less. Also in terms of the casting process no value is presented in the manual. Guidelines suggest using indicator calculated from the energy required for energy consuming processes like casting. This has been done (see tab. 9).

The effects of the CPL coating has been neglected as the thickness is 0,5-0,8 mm, and hence the volume, is small. Disposal will in any case hopefully be incineration with energy recapture as described by HÅG in fig. 18.

The concept, using woodboard, plastic pressure forming, aluminium as material, and energy required as a value for the casting process, ends up with a value of 832,3. A conciderable 31,3 % below the current door.

Product or component
Upper door
Date
29.jan

Project
Multipac
Author
Arne Olav

Notes and conclusions
Based on the assumption that the distribution of multipac machines is similar to that of the front end machines
Wood board is valid substitude for plywood
Pressure forming of plastics and wood is equivalent

Production
Materials, processing, transport and extra energy

material or process	**amount**		**indicator**		**result**	**assumption**
Wood board	7,0	kg	39	mPt/kg	273	Building cite material
Pressure forming	7,0	kg	6,4	mPt/kg	44,8	Same value as for plastic
Zink cast brackets	0,4	kg	3200	mPt/kg	1280	
Aluminum cast brackets	0,4	kg	780	mPt/kg	312	Only new material
Energy needed for casting	0,5596	kWh	46	mPt/kWh	25,7416	Double of European High Voltage
Total					655,5416	

Use
Transport, energy and any auxiliary materials

process	**amount**		**indicator**		**result**	**assumption**
Transport Tanker	*42*	*tkm*	*0,8*	*mPt/tkm*	*33,6*	*25% of all transport*
Transport Trailer 40t	*14*	*tkm*	*15*	*mPt/tkm*	*210*	*25% of all transport*
				Sum	*243,6*	
				Sum x 25%	60,9	
Transport Trailer 28t	*7,35*	*tkm*	*22*	*mPt/tkm*	*161,7*	*75% of all transport, 1000km*
				Sum x 75%	121,275	
Total					182,175	

Disposal
Disposal processes per type of material

material and type of processing	**amount**		**indicator**		**result**	**assumption**
Average of paper/cardboard	7	kg	-4,75	mPt/kg	-33,25	
Total					-33,25	
Total (all phases)					832,2916	

Table 9: ECO99-analysis for the Wooden upper door concept.

4.4.2 Concept 2 - Reaction injection molding (RIM)

Development and functionality

Tomra has also previously made attempts at exploring RIM, but without taking the final step. Also this time the process has turned out problematic. The production itself is by far the most versatile considered, the troubles arise considering environmental properties, and in connection with the Chinese suppliers. The China department at Tomra played an important role in finding a supplier for the RIM concept. Their attempts finally terminated without success.

Using reaction injection molding integration all of the brackets were made possible, resulting in a single part.

Transverse stiffness was added using ribs on the inside surface of the door. During development the manufacturability of the part got more detailed. The final result had a somewhat compromised handle, enabling a two-piece tool (see how the handle is only an edge in fig. 44c).

Cost

A similar concept, designed by Tom Veble, also including the display panel below the door, was priced at $ 100 using RIM and manufacture in China. In search of prices for the concept, the same suppliers were contacted by the China department of Tomra. Their work lasted for months, and finally broke down. To get an indication of the price range, a Norwegian supplier was sought. An offer was though never given.

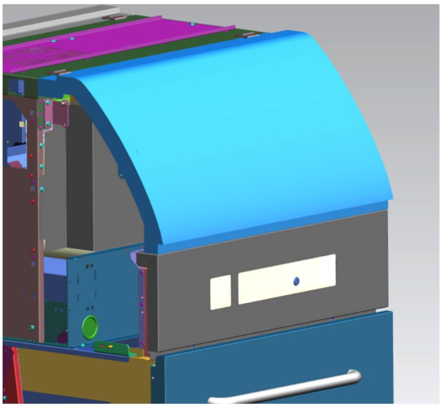
Environment

From the beginning of the work, RIM was a process seen as interesting to Tomra. In many ways RIM, and molded polyurethane (PUR) is an ideal process/material for large thin parts. The fact that the material formed when the two components cure was a thermosetting plastic could though be seen as an incentive for exclusion.

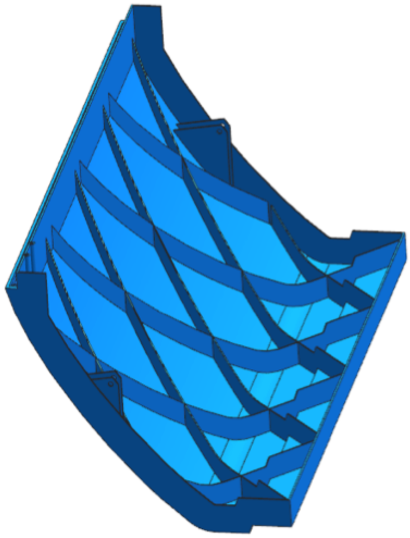
The material can not be recycled with profit, and only to some extent be shredded and reused. According to an article by G. Behrendt and B. W. Naber [1], recycling of PUR until today has made no sense. The issues have been related to the large variations in content in polyurethanes, and the solveability of the mostly unknown components.

If the question was only about how to dispose of the PUR, incineration with energy recapture would not be such a bad idea. Thinking of reuse and recycling of the material, the issues build up.

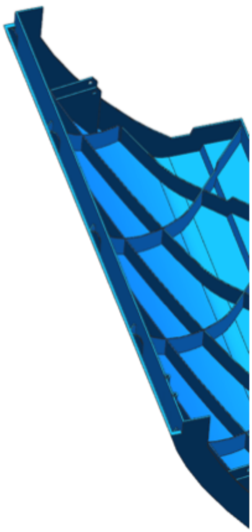
This became evident in the ECO99-indicator analysis. Material production (the two components) was by itself less environmentally friendly than the production of ABS or similar thermoplastics. The shaping required no energy. It was first in the state of disposal the materials separated. Where as reuse and recycling was an option for the thermoplastic, only (or close to it) incineration can be done to the thermosetting plastic.



(a) The RIM concept.



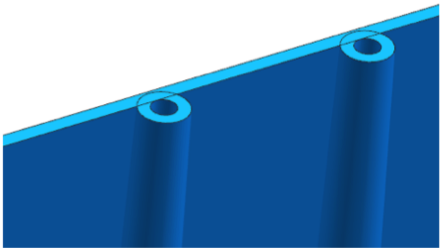
(b) The "waffle" ribs for torsional stiffness.



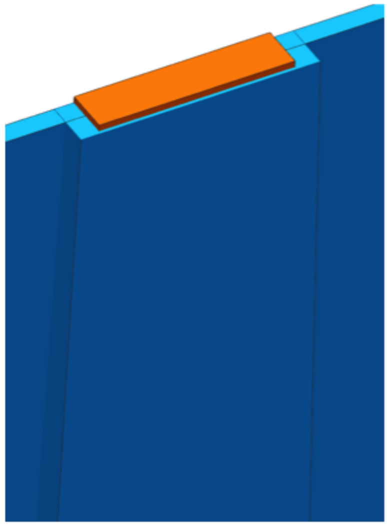
(c) The hollow handle, due to the simple two part mold.

(d) The RIM door profile.

Figure 44: Illustrations of the reaction injected concept.



(a) Magnet implementation in RIM part. Magnet without casing is melted into the part.



(b) Magnet implementation in RIM part, Magnet with casing is melted into the part.

Figure 45: Illustrations of magnet implementation in the reaction injected concept

Because Norway according to SSB, incinerate 48% of all plastic, RIM scores quite good from a Norwegian perspective. Looking at numbers from Europe, Eurostat numbers, only Sweden (65 %) matches the Norwegian numbers for incineration. The other European countries, and the countries in which Tomra operate (e.g. Germany (16 %)), the numbers are much lower (average of Europe w. Croatia 15 %).

Using Norwegain numbers for waste treatment the RIM concept scores a not too unpleasant 1409, an increase of moderate 16 %, comparing to the current door.

When using European numbers, the score becomes increasingly ugly at 1756, an increase of 45 %.

Product or component	**Project**
Upper door	Multipac
Date	**Author**
29.jan	Arne Olav

Notes and conclusions

Based on the assumption that the distribution of multipac machines is similar to that of the front end machines

Production

Materials, processing, transport and extra energy

material or process	**amount**		**indicator**		**result**	**assumption**
PUR	4	kg	420,0	mPt/kg	1680	Antar ca 6mm tykk
Reaction injection molding	4	kg	12,0	mPt/kg	48	
Transport to ass. (China-Poland)	80	tkm	0,8	mPt/tkm	64	20 000 km by sea to china?
Total					1792	

Use

Transport, energy and any auxiliary materials

process	**amount**		**indicator**		**result**	**assumption**
Transport Tanker	*24*	*tkm*	*0,8*	*mPt/tkm*	*19,2*	*25% of all transport*
Transport Trailer 40t	*8*	*tkm*	*15*	*mPt/tkm*	*120*	*25% of all transport*
				Sum	*139,2*	
				Sum x 25%	34,8	
Transport Trailer 28t	*4,2*	*tkm*	*22*	*mPt/tkm*	*92,4*	*75% of all transport, 1000km*
				Sum x 75%	69,3	
Total					104,1	

Disposal

Disposal processes per type of material

material and type of processing	**amount**		**indicator**		**result**	**assumption**
Incineration w. energycapture	38,6611	kg	-13	mPt/kg	-502,59	48 %
Total					-502,594	
Total (all phases)					1409,406	

Table 10: ECO99-analysis for the Reaction injection molded upper door concept.

4.4.3 Concept 3 - Rotational molded

Development and functionality

With guidelines from Norwegian rotational molding company Cipax AS, a door was designed; the outer profile being kept as close to the current design as possible. Due to the process of manufacture the door needed to contain radii on all corners, resulting in a lower degree of continuity between the cabinet doors. The process though also enabled the implementation of stiffening ribs, and a closed, hollow structure, giving impeccable stiffness, and low weight.

Nuts and liners could be mounted in the mold before the insertion of the platic granule ensuring correct positioning and easy assembly on to the cabinet. As RIM, rotational molding proved itself truly flexible enabling a single part door, with all functional elements built in.

Cost

Cipax was early interested in a collaboration, and a meeting was arranged. The results were two concepts, one being the door now in question. The intention was from the start to use a production facility recently set up in Poland by Cipax. The final part production offer was for production in Norway, as the Polish factory still did not have capacity to deliver an offer. The part would cost NOK 357, with a tool priced at NOK 180 000.

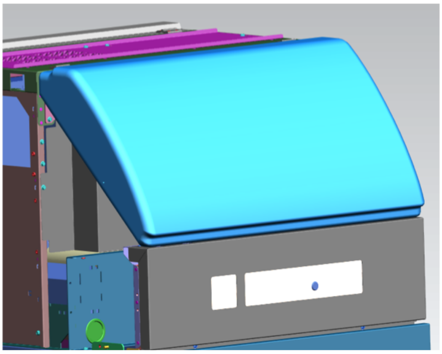
Logistics was therefore calculated from Poland. The stackability of the doors is not the strongest feature of the concept. The logistics of the concept has been estimated to NOK 40.

The door has a strong advantage because all holes, fastners and similar is molded into the door, and hence no assembly is required.

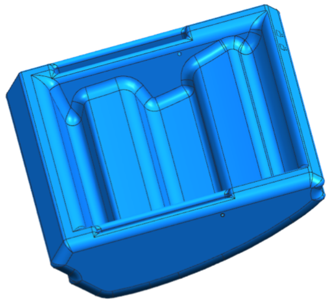
The door total cost therefore ends up at NOK 404 at 25000 units, up against the NOK 482 of the original.

Environment

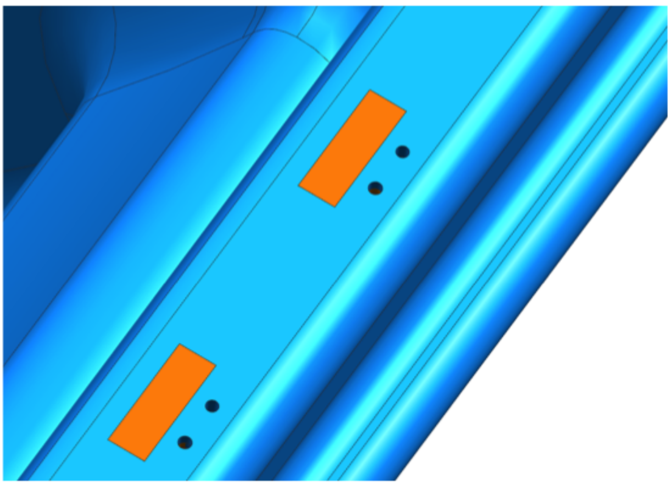
The concept scores by far worst in the ECO99-indicator analysis, with a high material consumption and following high score. The blame can easily be put on the supplier's requirement for wall thickness, 5-6 mm, in order to have similar heating time as their other product to be produced on the same mold carousel. The door can be completely recycled, but using Norwegain numbers for waste treatment, this is not the case and the reduction in total indicator is moderate. The total sum of 3395 is by far the worst.



(a) Rotational molded door on Multipac cabinet



(b) Stiffeneing ribs.



(c) Magnets implemented in the part.

Figure 46: Illustrations of the rotational molded concept

Product or component				**Project**		
Upper door				Multipac		
Date				**Author**		
29.jan				Arne Olav		

Notes and conclusions

Based on the assumption that the distribution of multipac machines is similar to that of the front end machines
Sheet metal usage efficiency of 66%

Production

Materials, processing, transport and extra energy

material or process	**amount**		**indicator**		**result**	**assumption**
ABS	8,5	kg	400,0	mPt/kg	3400	Antar ca 6mm tykk
Rot. molding (Vacuum-forming indicator)	8,5	kg	9,1	mPt/kg	77,35	
Milling	1	dm3̂	6,4	mPt/kg	6,4	
Total					3477,35	

Use

Transport, energy and any auxiliary materials

process	**amount**		**indicator**		**result**	**assumption**
Transport Tanker	*51*	*tkm*	*0,8*	*mPt/tkm*	*40,8*	*25% of all transport*
Transport Trailer 40t	*17*	*tkm*	*15*	*mPt/tkm*	*255*	*25% of all transport*
				Sum	*295,8*	
				Sum x 25%	73,95	
Transport Trailer 28t	*8,925*	*tkm*	*22*	*mPt/tkm*	*196,35*	*75% of all transport, 1000km*
				Sum x 75%	147,2625	
Total					221,2125	

Disposal

Disposal processes per type of material

material and type of processing	**amount**		**indicator**		**result**	**assumption**
Recycling PP	1,58264	kg	-210	mPt/kg	-332,35	19 %
Deponering	0,44456	kg	3,5	mPt/kg	1,55596	5 %
Incineration w. energycapture	0,48326	kg	-13	mPt/kg	-6,2824	48 %
Municipal waste PP	0	kg	-0,13	mPt/kg	0	17 %
Incineration wo. Energycapture	0	kg	0	mPt/kg	0	11 %
Total					-337,08	
Total (all phases)					3395,27	

Table 11: ECO99-analysis for the Rotational molded upper door concept.

4.4.4 Concept 4 - Rolled profile

Development and functionality

Having discovered the size limitations in extrusion the attention was turned to shaping of profiles. Rolling of profiles has for long been big business, but only a limited number of manufacturers provide machinery for manufacturing profiles larger than 350 mm reeled metal starting width. After consulting Danish IB Andressen and Sweedish Bendiro Profile Tech, hints were given that Austrian Welser Profile AG provided such services. In consultation with Camilla Wallin at the Sweedish office of Welser, a new design keeping within the 800 mm width limit was constructed.

The design possibilities were discussed and discovered while making an early prototype with Tomra mechanic Tore Torvbråten. The design sticks largely to the current profile, adding flanges at the top and bottom for assembly to stiffening brackets.

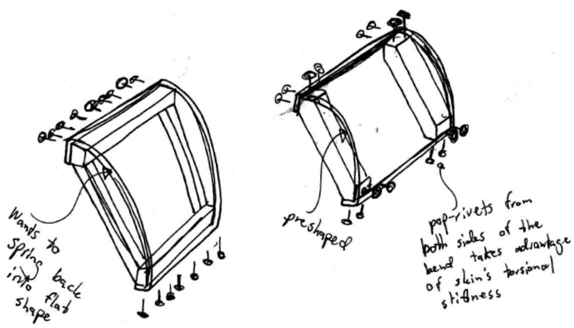


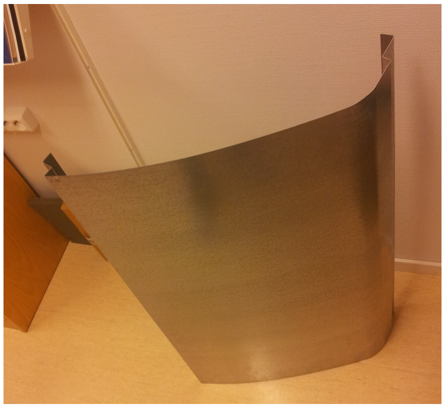
Figure 47: Left: the current connection between the skin and the frame. Right: A shaped skin, and brackets using the torsional strength created by the bends by fixing both sides of the bends to a connecting bracket.

Cleverly fastning the brackets to the profile on two sides provided a similar stiff "frame" as seen in the current design, while not having to mount the skin to it afterwards.

The brackets were initially designed for stiffness, without consideration to manufacturability. The multi-axial fastning to the profile led to a rather complex part. A concept based on Tomra favourite; sheet metal, was constructed. The design kept close to the bracket assembled for the prototype shown in fig. 49c and fig. 48a. The bracket consisted of a single U-profile, with additional bends with tabs in the ends, for mounting of the profile.

Seen as a minus to many, the design did not provide the door with a closed end surface. As discussed previously in sec. 4.1.2 this was found not to be essensial, but looks unprofessional according to consulted Tomra employees. The reason for the design lies in the manufacturability of the bracket, and the wish for a stiff U-profile. In app. G and the PU-journal an illustration of a way to solve this is

(a) First upper door prototype 2mm aluminium. Not stiff enough.

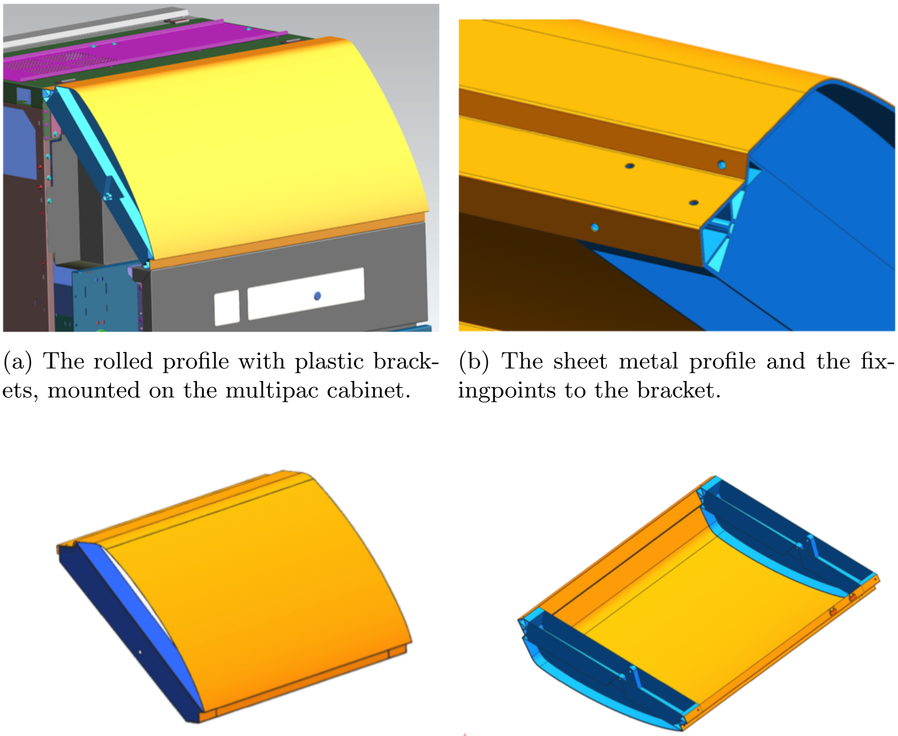


(b) Second upper door prototype 1,25 mm steel. Almost stiff enough even without brackets.

(c) Prototype mounted on multipac cabinet, open.

(d) Prototype mounted on multipac cabinet, closed.

Figure 48: Illustration shownig the protoypes of the rolled upper door.



(a) The rolled profile with plastic brackets, mounted on the multipac cabinet.

(b) The sheet metal profile and the fixingpoints to the bracket.

(c) The alternative brackets in punched and bent steel.

(d) The door from the inside, with the magnets built into the shell.

Figure 49: Illustrations of the Rolled door. concept

provided.

An additional bracket was therefore constructed with injection molding (but possibly also with RIM). Keeping the brackets symmetrical was kept in mind during the design, in order to avoid double tooling. Thought was also given to keeping the number of sliders and tool parts low. The final design enabled a three-part tool.

Cost

The rolled concept has one key component, the skin. Welser gave an offer for a 1,5 mm rolled skin at 5000 units, of NOK 88. Tooling would cost NOK 121 680.

Stiffness was ensured through brackets connected at allmost 45° angle to the bent flanges of the skin, providing great torsional stiffness. The brackets were selected to be produced using injection molding. Production was sought by the China department of Tomra. The cost was estimated to NOK 73, with an additional tooling cost of NOK 277 777. The material selected was PA66+30%GF. A cheaper and weaker material should be considered. The tool itself increases the investment cost drasticly. A non-technical plastic would maybe also enable a lower in-mold pressure, and hence lower the tooling cost.

Assembly was estimated to a significantly lower NOK 57.

The price of the concept at 25000 units would be NOK 360, up against the NOK 482 of today.

Environment

Much like today the concept uses steel as main material. The reduction in metal used, is counterweighted by an addition of somewhat less plastic (with higher impact value). Transport from China for the brackets, and from Austria for the skins has been estimated to add some to the indicator, still not changing the result mentionably.

The total sum ends up closely to the current setup at 1268, only 56 millipoints above the current door.

Product or component | **Project**
Upper door | Multipac
Date | **Author**
29.jan | Arne Olav

Notes and conclusions

Based on the assumption that the distribution of multipac machines is similar to that of the front end machines

Sheet metal usage efficiency of 66%

Production

Materials, processing, transport and extra energy

material or process	**amount**		**indicator**		**result**	**assumption**
Transport to ass. Steel (Austria-Poland)	3,6	tkm	15	mPt/tkm	54	600 km from austria to poland?
Transport to ass. Plastic (China-Poland)	120	tkm	0,8	mPt/tkm	96	20 000 km by sea to china?
Steel	6,0	kg	86	mPt/kg	516	
Sheet production	6,0	kg	30	mPt/kg	180	
Zink coating , ink zink	1,5	m$\hat{2}$	49	mPt/kg	73,5	
PA6.6 GF30 (ABS indicator, real weight)	1,7	kg	400	mPt/kg	680	2x 0,65kg w ABS (1,04g/cm$\hat{3}$), 2x 0,85kg w PA GF (1,36)
Injection molding	1,7	kg	21,0	mPt/kg	35,7	
Transport Tanker	13,6	tkm	0,8	mPt/tkm	10,88	
Transport Trailer	0,51	tkm	15	mPt/tkm	7,65	
Total					1653,73	

Use

Transport, energy and any auxiliary materials

process	**amount**		**indicator**		**result**	**assumption**
Transport Tanker	36	tkm	0,8	mPt/tkm	28,8	*25% of all transport*
Transport Trailer 40t	12	tkm	15	mPt/tkm	180	*25% of all transport*
				Sum	208,8	
				Sum x 25%	52,2	
Transport Trailer 28t	6,3	tkm	22	mPt/tkm	138,6	*75% of all transport, 1000km*
				Sum x 75%	103,95	
Total					156,15	

Disposal

Disposal processes per type of material

material and type of processing	**amount**		**indicator**		**result**	**assumption**
Recycling of ferro metals	5,58	kg	-70	mPt/kg	-390,6	93 %
Incineration without energycapture	0,42	kg	-32	mPt/kg	-	7 %
Landfill	0	kg	1,4	mPt/kg	0	0 %
Recycling PP	0,317	kg	-210	mPt/kg	-66,471	19 %
Deponering	0,089	kg	3,5	mPt/kg	0,3112	5 %
Incineration w. energycapture	6,572	kg	-13	mPt/kg	-85,441	48 %
Municipal waste PP	0,086	kg	-0,13	mPt/kg	-0,0112	17 %
Incineration wo. Energycapture	0	kg	0	mPt/kg	0	11 %
Total					-542,212	
Total (all phases)					1267,67	

Table 12: ECO99-analysis for the Rolled upper door concept.

5 Concept rating

In the following section an introduction to the rating system will be given. Then cost and environmental impact will be calculated, before presenting the total rating.

From the data collected, and the virtual models made of the concepts, a rating system was set up. The rating system was based on the product specification requirements. Some requirements were left out of the rating as they were equally well solved by all concepts.

The rating of a feature was set up to be determined by two subjectively selected parameters for each rated feature. The *fulfilment of the requirement* was rated within a given range, and then given a second rating for *risk*. For example when it comes to manufacture in China, claims have been made that "it should work", but cultural differences and long distances stand between the two parties, the potential for a misunderstanding is seemingly present.

The weight of the requirement was again selected based on a subjective thought of what was more important.

The score each requirement was given was calculated using a linear interpolation based on the maximum score possible for the given requirement:

$$Points = \frac{\frac{evaluation}{risk}}{\frac{evaluation_{max}}{risk_{min}}}$$

Each requirement was rated for all concepts before moving on to the next requirement.

For cost the concept providing the largest saving was given the best grade. The other concepts were rated relative to this.

As for cost, the points were given judged relative to the score of the best alternative.

For alternative concepts scoring below the current setup in terms of cost and environmental impact, the points would be given in negatives.

The results are given in table 21, and table 22.

5.1 Cost estimation and rating

The cost of a concept has been estimated through three factors: cost of parts, cost of assembly and cost of logistics.

The estimates are not always detailed, but are done on basis of the information available.

The cost of door parts were taken from an internal document. For the tray a formula for cost estimation, based on the internal document was created. This is further described in sec. 3.2.3.

Assembly time was estimated using the technique of MTM-UAS. The technique did not prove itself truly valid, but by tweaking the method by adding subjective time consumption values for advanced processes impossible/impractical to break down into smaller segments, the technique gave data comparable for the different concepts. The time was then translated into cost using a estimate of labour cost of NOK 350 in Poland.

Comparing the total price of a base unit, and the estimated cost of the parts gave a difference that was somewhat comparable to the previously estimated values (see tab. 13 and tab. 14). The cost of the assembly of the upper door has been given to be NOK 120 from the internal cost sheet. The numbers are though not thought to be exact and therefore compared to the labour cost based estimates.

	Total base unit cost	950	SEK	836	NOK
-	Total part cost using formula			551	NOK
-	30% added for size and surf. treatment (sec. 3.2.3)			165	NOK
=	Total assembly cost			119	NOK

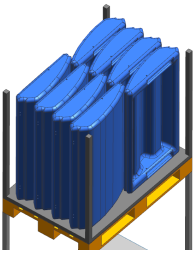
Table 13: Estimate of original assembly cost, based on formula for part cost estimation

	Time [min]	Reduction [%]	Assembly costs based on original cost of NOK 119, using percentage	Assembly cost, assuming labour cost of NOK 350/hour
Current base unit	16,9		119,375	98,5
Vacuum	17,7	-5 %	124,8472508	103,0
Injection molded	15,4	9 %	108,922386	89,9
Steel fixed	15,3	10 %	107,8771246	89,0
Steel removable	13,0	23 %	92,10597476	76,0
			Assembly costs based on original cost of NOK 120, using percentage	Assembly cost, assuming labour cost of NOK 350/hour
Current upper door	17,9		120,0	104,2
Wooden door	1,1	94 %	7,5	6,5
RIM door	0,0	100 %	0,0	0,0
Rotational molded door	0,0	100 %	0,0	0,0
Rolled door	8,6	52 %	57,5	49,9

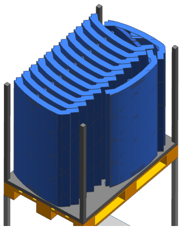
Table 14: Estimated time and cost of assembly.

According to the Norwegian institute of transport economics (Transportøkonomisk institutt) [5] logistics costs consist of grossly 40 % transport cost, 40 % storage cost and 20 % other costs. In the simplification 2 months of storage, the average in Norway is put down as basis. Any added storage was therefore added. The cost of storage was found through communication with Norwegian transport and storage company Bring, to be NOK 70 per pallet pr month. To the long distance transports (China) it was thought that the capital cost, the cost of organization and other auxiliary costs would be higher. The "other costs" was therefore increased by 50 % for the relevant concepts.

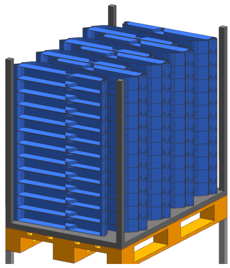
The stackability of the concepts can be viewed in fig. 50.



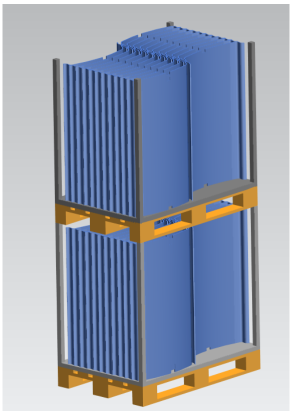
(a) Rotational molded door - 8 per pallet.



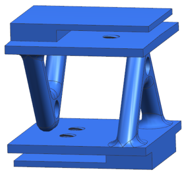
(b) Rotational molded door - 13 per pallet.



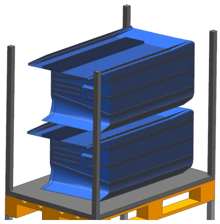
(c) Bracket for the rolled door concept - 96 per pallet.



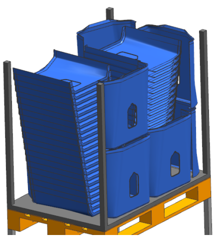
(d) Wooden door - 22 per pallet. Two pallets fits on top of each other in transport and storage, within normal height regulations.



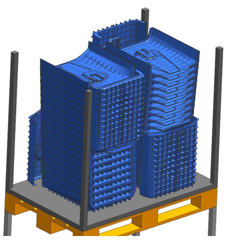
(e) Brackets for the wooden door concept - 7296 per pallet.



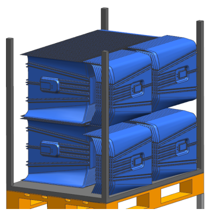
(f) Removable steel tray - 112 pr pallet.



(g) Vacuum formed tray - 52 per pallet.



(h) Injection molded concept - 40 per pallet.



(i) Fixed steel tray - 188 per pallet.

Figure 50: Illustrations of part stacking for transport.

Stackability of parts on EUR pallet (1200x800x1200mm)				
Wooden laminate	22	parts/pallet		
Rolled profile	20	parts/pallet		
Rotational molded	8	parts/pallet		
Tray Vacuum	52	parts/pallet		
Required number of pallets for yearly part volume				
	Volume		Number of pallets	
Wooden laminate	4000	181,818182	182	
Rolled profile	4000	200	200	
Rotational molded	4000	500	500	
Tray Vacuum	5000	96,1538462	97	
Required number of trailers (loading 33 pallets in two levels)				
Wooden laminate	2,757576	3		
Rolled profile	3,030303	4		
Rotational molded	7,575758	8		
Tray Vacuum	1,94	2		
Cost of transport (NOK 8000 within central europe)				
	Total	Cost/piece		
Wooden laminate	24000	6		
Rolled profile	32000	8		
Rotational molded	64000	16	*Assumed manufacture in Poland, not Norway*	
Tray Vacuum	40000	8		
Cost of logistics (40% transport, 40% storage (2 months), 20% other)				
		Delivery	Added storage cost	Total log cost
Wooden laminate	15	Evenly	0	**15**
Rolled profile	20	Single	17,5	**37,5**
Rotational molded	40	Evenly	0	**40**
Tray Vacuum	20	Evenly	0	**20**

Table 15: Cost of logistics of parts manufactured within europe.

Stackability of parts on EUR pallet (1200x800x1200mm)

RIM door	13	parts/pallet
Bracket for rolled	96	parts/pallet
Bracket for lam.	7296	parts/pallet - 2x pr 62x60x60 mm with margins
Tray Steel removable.	112	parts/pallet
Tray Injection molded	40	parts/pallet
Tray Steel fixed	188	parts/pallet

Required number of pallets for yearly part volume

	Volume		Number of pallets
RIM door	4000	307,6923077	308
Bracket for rolled	8000	83,33333333	84
Bracket for lam.	8000	1,096491228	2
Tray Steel all incl.	5000	44,64285714	45
Tray Injection molded	5000	125	125
Tray Steel split	5000	26,59574468	27

Required number of 40' containers (25 pallets in two levels)

RIM door	6,16
Bracket for rolled	1,68
Bracket for lam.	0,04
Tray Steel all incl.	0,9
Tray Injection molded	2,5
Tray Steel split	0,54

Cost of transport (NOK 20000, though varying with season pr container)

	Total	Cost/piece
RIM door	123200	30,8
Bracket for rolled	33600	4,2
Bracket for lam.	800	0,1
Tray Steel all incl.	18000	3,6
Tray Injection molded	50000	10
Tray Steel split	10800	2,16

Cost of logistics (transport cost + storage cost + 30% other)

	Delivery	Added storage cost	Other costs	Total log cost
RIM door	Monthly	5,39	15,65667	**51,8**
Bracket for rolled	Monthly	0,735	2,135	**7,1**
Bracket for lam.	Monthly	0,0175	0,050833	**0,2**
Tray Steel all incl.	Single	7,56	8,76	**19,9**
Tray Injection molded	Single	21	24,33333	**55,3**
Tray Steel split	Single	4,536	5,256	**12,0**

Table 16: Cost of logistics of parts manufactured in China.

	Production	Company	Part price	Tooling cost	at production volume	Logistics cost	Assembly	Total cost	Cost at 5000 units	Cost at 25000 units
1 - Vacuum formed							103	257,8	261,2	258,48
Tray	Norway	NyPlast	42	17000	-	20				
Bracket	Poland	PartnerTech	76	0	50+	0				
Seal	Germany/Norway	OttoOlsen	16,8		1500	-				
			22,5		500	-				
2 - Injection molded							90	220,2	290,7983	234,31966
Tray	China		58,4	352991,5	-	55				
Seal	Germany/Norway	OttoOlsen	16,8		1500	-				
			22,5		500	-				
3- Steel - removeable							76	188,8	228,8	196,8
Tray	China		55	200000	5000	20				
			65		1000					
Bracket	Poland	PartnerTech	21		50+	0				
Seal	Germany/Norway	OttoOlsen	16,8		1500	-				
			22,5		500	-				
4 - Steel - fixed							89	164	198	170,8
Tray	China		42	170000	5000	12				
			50		1000					
Bracket	Poland	PartnerTech	21		50+					
Rotaional molded						-		290,8	314,8	295,6
Tray	Norway/Poland	Cipax	198	120000						
Bracket	Poland	PartnerTech	76							
Seal	Germany/Norway	OttoOlsen	16,8		1500	-				
			22,5		500	-				

	Production	Company	Part price	Tooling cost	at production volume	Logistics cost	Assembly	Total cost	Cost at 5000 units	Cost at 25000 units
1 - Wood laminate							7,5	403,7	442,18	411,396
Laminate	Germany	Becker AG	331,2	28800	250	15				
	Baltic	Kvist / Mndalen laminat	435	107000						
Bracket	China		25	56600	1000	0				
2 - RIM							0			
Molded part	China/Norway	Mjsplast				52				
3 -Rotational molded							0	397	433	404,2
Molded part	Norway/Poland	Cipax	357	180000		40				
4 - Roll forming							57,5	343,78	423,6714	359,75828
Profile	Austria	Welser	88,2	121680	5000	37,5				
			99,576	121680	3000					
Molded part	China		73,19	277777		7,1				

Table 17: The total cost of the concepts

Part replacement	Weight	Cost	Assembly	Cost of original	Savings at 5000	Saving at 25000	Rating
1 - Tray, support bracket	4,8	174	98,5	272,5	*11*	*14*	**0,3923**
2 - Tray, support bracket	4,8	174	98,5	312,5	*22*	*78*	**2,1875**
Base		40					
3 - Tray, support bracket, high left, reflex	5,9	237	98,5	375,5	*147*	*179*	**5**
4 - Tray, support bracket	4,8	174	98,5	312,5	*115*	*142*	**3,9647**
Base		40					
Base		40					
5 - Tray, support bracket	4,8	174	98,5	272,5	*-42*	*-23*	**-0,646**

Part replacement	Weight	Cost	Assembly	Cost of original	Savings at 5000	Saving at 25000	
1- Upper door without hinges and gas springs				482	*40*	*71*	**2,8879**
2 - Upper door without hinges and gas springs				482	*0*	*0*	**0**
3 - Upper door without hinges and gas springs				482	*49*	*78*	**3,1822**
4 - Upper door without hinges and gas springs				482	*58*	*122*	**5**

Table 18: The original parts the concepts correspond to, cost difference, and cost rating.

As seen in table 18, the tray concept 3, the removable deep drawn concept, and door concept 5, the rolled profile with plastic brackets scores the best in terms of total concept cost and savings.

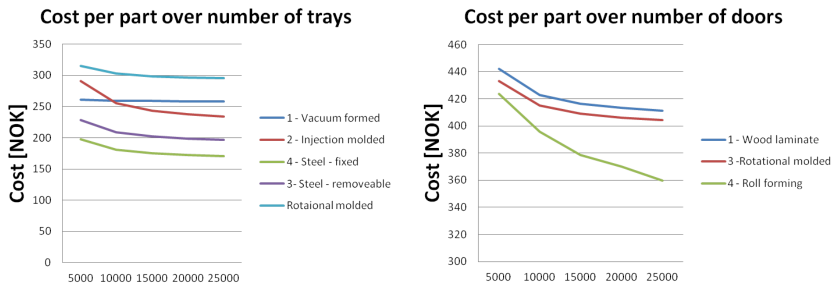


Figure 51: Cost of the concepts at different total production volumes.

From fig. 51 it can be seen that all the part cost of all the processes, except roll forming level out before reaching the 25 000 unit upper limit. The graph is in direct correlation with the tooling cost of each concept, clearly showing the unfortunate double tooling (NOK 400 000) for the roll forming concept; injection mold and metal forming rolls. The cost of the injection mold should though be possible to lower through use of a material requiring a lower pressure, or by using a sheet metal bracket as previously described 4.4.4. The injection molded tray also has a rather significant tooling cost of NOK 350 000.

25 000 units is about the volume reachable with a yearly production of 4-5000 for 5-6 years. This has been estimated to be the aim of the products in question. See section 3.2.3 for more on this.

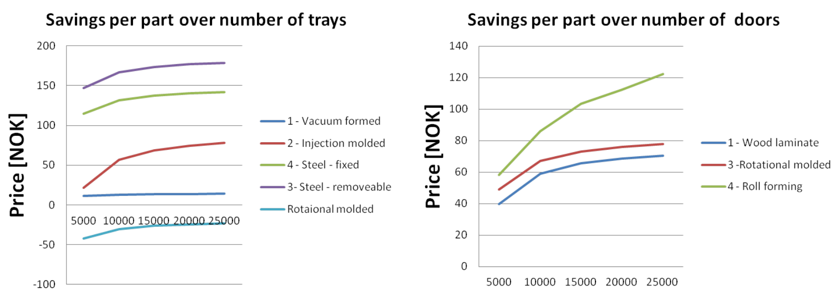


Figure 52: Savings of the concepts at different total production volumes.

Looking at the numbers from another angle in fig. 52, the savings quickly become significant. The roll formed concept, and to some extent also the injection molded has potential for even larger savings at higher volumes.

5.2 Environmental impact rating

The environmental impact of the different concepts have been discussed during the presentation of the new concepts in section 4. A summary of the results, and a comparison to the corresponding current solution will be presented here.

Tray only	*434*			Rating
Vacuum	486	*-52*	*-12,0 %*	-1,7
Tray inc sup. beam	*546*			
Injection molding	385	*161*	*29,5 %*	4,2
Steel split	362	*184*	*33,7 %*	4,8
Tray inc sup. beam + high left + reflex plate	*756*			
Steel all inclusive	489	*267*	*35,3 %*	5,0

Table 19: Eco99 indicator values, comparisons and ratings for the tray concepts.

Original upper door	*1212*			Rating
Wooden laminate	832	*380*	*31,3 %*	0,9
Rotational molded	3395	*-2183*	*-180,1 %*	-5,0
Rolled profile w. plastic bracket	1268	*-56*	*-4,6 %*	-0,1
Reaction injection molding	1409	*-197*	*-16,3 %*	-0,5

Table 20: Eco99 indicator values, comparisons and ratings for the upper door concepts.

The ratings vary largely from large reductions for most of the tray concepts, but only slightly better for the door concepts. This could be related to the fact that the tray today is a single, highly technical part, into which it through the development has been possible to integrate more parts, hence making it more complex and still easily manufacturable with alternative manufacturingmethods. Although the door has many parts, the complexity of the final part is rather low. The main purpose is to cover, and hence a certain amount of material is required independant of clever shape.

The rotational molded concepts sticks out as the black sheep, with a staggering, bad score. As previously mentioned in section 4.4.3, the large required wall thickness, and hence material usage is to blame.

5.3 Total rating

As described in section 5 the concepts were rated on basis of the calculated and estimated fullfillment of the requirements of stiffness, cost and environment. Other requirements, like durability, were subjectively rated with basis in experience, knowledge aquired in conversation with manufacturers, or so called "common sense". In many cases an explanation of a rating can be found in section 4.2

	eval. range	uncertainty	weight	MAXIMUM eval.	uncert.	points
Position tolerances	1-3	1-3	8 %	3	1	3
Stiffness	1-3	1-3	8 %	3	1	3
Sealing for fluids	1-5	1-3	5 %	5	1	2
Durability	1-2	1-3	5 %	2	1	2
Surface	1-3	1	8 %	3	1	3
Edges	1-2	1	3 %	2	1	1
Fixing to baseunit	1-3	1	8 %	3	1	3
Access to components	1-5	1	5 %	5	1	2
Price	-5-5	1-3	26 %	5	1	10
Environment	-5-5	1-3	26 %	5	1	10
					Score	39

	vacuum eval.	uncert.	points	steel fixed eval.	uncert.	points
Position tolerances	3	1	3	3	2	1,5
Stiffness	2	1	2	3	1	3
Sealing for fluids	3	3	0,4	4	1	1,6
Durability	1	2	0,5	2	2	1
Surface	3	1	3	2	1	2
Edges	2	1	1	1	1	0,5
Fixing to baseunit	3	1	3	3	1	3
Access to components	3,00	1	1,20	2	1	0,8
Price	0,39	1	0,78	3,96	1	7,93
Environment	-1,69748	1	-3,4	4,78	2	4,78
		Score	11,4896		Score	26,1

	injection molded eval.	uncert.	points	steel removable eval.	uncert.	points
Position tolerances	3	1	3	3	2	1,5
Stiffness	1	1	1	3	2	1,5
Sealing for fluids	2	1	0,8	4	2	0,8
Durability	1	2	0,5	2	1	2
Surface	2	1	2	2	1	2
Edges	2	1	1	1	1	0,5
Fixing to baseunit	3	2	1,5	3	2	1,5
Access to components	3	1	1,2	4	1	1,6
Price	2,19	1	4,37	5	1	10
Environment	4,18	1	8,36	5	2	5
		Score	23,7		Score	26,4

Table 21: Rating of tray concepts

	eval. range	uncertainty	weight	MAXIMUM eval.	uncert.	points
Stiffness	1-5	1-3	17 %	5	1	5
Production tolerances	1	1-3	10 %	1	1	3
Design	1-5	1	17 %	5	1	5
Surface	1-3	1	7 %	3	1	2
Safety	1	1-3	7 %	1	1	2
Ergonomics of assembly	1-3	1	10 %	3	1	3
Price	-5-5	1-3	17 %	5	1	5
Environment	-5-5	1-3	17 %	5	1	5
					Score	30

	Rolled profile eval.	uncert.	points	Wood laminate eval.	uncert.	points
Stiffness	4	2	2	4	2	2
Production tolerances	1	1	3	1	3	1
Design	3	1	3	5	1	5
Surface	3	1	2	3	1	2
Safety	1	1	2	1	3	0,666667
Ergonomics of assembly	1	1	1	2	1	2
Price	5	1	5	2,89	2	1,44
Environment	-0,13	1	-0,13	0,87	3	0,29
		Score	17,9		Score	14,4

	RIM eval.	uncert.	points	Rotational molded eval.	uncert.	points
Stiffness	3	3	1	5	1	5
Production tolerances	1	1	3	1	3	1
Design	4	1	4	1	1	1
Surface	3	1	2	2	1	1,333333
Safety	1	1	2	1	1	2
Ergonomics of assembly	3	1	3	3	1	3
Price				3,18	1	3,18
Environment	-0,45	1	-0,45	-5,00	3	-1,67
		Score	14,5		Score	14,8

Table 22: Rating of door concepts

6 Discussion

Tomra requested an investigation of potential production processes, with possible implementation in their newest, and future products. Based on findings in the thesis it has become evident that new processes can provide savings and better the products.

The tray of the base unit is a rather technical part, with many requirements to it. To implement such a part made in a process new to the company, would seem a huge risk. The less technical upper door could though be a good place to start the implementation of new processes.

There will always be a risk of quality issues, hiccups or even failure when dealing with unknown processes and manufacturers. If the cost of a potential failure is considered acceptable, there is no reason not to take the chance. The thesis has estimated that the savings potentially can be considerable. With production volumes of 4-5000 units, and savings of NOK 200-250 for each this adds up to more than NOK 800 000 yearly. A start up investment of up to NOK 600 000, with a production horizon of 6-7 years should not be too frightening.

As for any estimation it is clear that the numbers put down also contains various sources of error. The cost, not to mention environmental estimates must be seen as just what they are; estimates.

The fact that the production locations considered are placed in both high cost Norway, and ultra low price China suggest a rather unfair comparison of production method prices. Tomra does already buy parts from China, and has even got an office there. It has therefore been convenient to use companies with which Tomra already do business, although maybe for different production methods. On the other hand Austrian Welser has provided the cheapest concept for the upper door (though supported with brackets from China), a suggestion that at least large parts can be priced competitively also with manufacture in Europe.

7 Conclusion

For Tomra to continue being the market leader in the field of RVM machine it has through the run of this work become evident that knowledge and use of alternative production methods may provide an edge in terms of cost, functionality and environment.

The factor influencing the environment the most in accordance with the eco99-indicator is the use of material. When the eco-indicator score from the raw material can be reduced through the use of an alternative production process, this will most likely also reduce the total environmental impact of the part. Through integration of more parts and functions this has been possible especially for the tray concepts shown in the thesis.

The functionality of a part can definitely be enhanced through use of new production methods. The processes explored in the thesis are all very unlike, and offer different properties, advantages and disadvantages. The choice of process is an art refined through experience. The thesis does give some examples and show how they do fulfil the requirement.

Risks are present when exploring new grounds, and can seem overwhelming. Looking at the savings and benefits of the concepts explored in the thesis, it still seems right to recommend the forth-taking of the concepts of the removable deep drawn tray and the roll formed door. The tray ensures functionality, saves material and almost NOK 900 000 yearly, with production volumes of 5 000 units. The door provides a yearly saving of NOK 122, additional simplifies the assembly and keeps the award-winning outer surface design.

8 Further work

In order to set these concepts into life, final detailing, production, assembly and service drawings will have to be made. More specific cost estimates for cost and logistics must also be made. Prototypes will be required, and tests of stiffness and e.g. weight cell readouts must be tested.

The field of long/continuous-fiber-reinforced-thermoplastic should be kept an eye on in the future. The process has a great potential for large surface panels with needs for high stiffness. If/when the availability of the process becomes better, it should be reinvestigated.

Paper pulp, and paper based materials have unknown possibilities and will probably be introduced to larger extent in the future.

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A Stiffness

A.1 Cabinet

The cabinet was simulated in Siemens Unigraphics NX 8.5 to see the influence of removing the components that in the case of a removable tray would be removed e.g. in order to to service on the machine.

The parts were fused together using united linked bodies. The bodies were tried connected in the points where they in reality would be welded together. This was not always the case, adding uncertainty to the simulations.

Simulations were set up to test the deflection of the upper left corner of the front frame. In a worst case scenario all the load weight of the door is put on one of the two hinges. A weight of three times the 30 kg heavy door was applied to the hinge. The moment created by the weight of the door was assumed to work at the center of the door, resulting in a pulling force at the top hinge.

The four holes at the bottom of the cabinet, used for securing the cabinet to the bottom half of the cabinet (crate or empty cabinet), were set as fully fixed.

A mesh of 10 nodal tetragonal elements with was applied in the size suggested by NX.

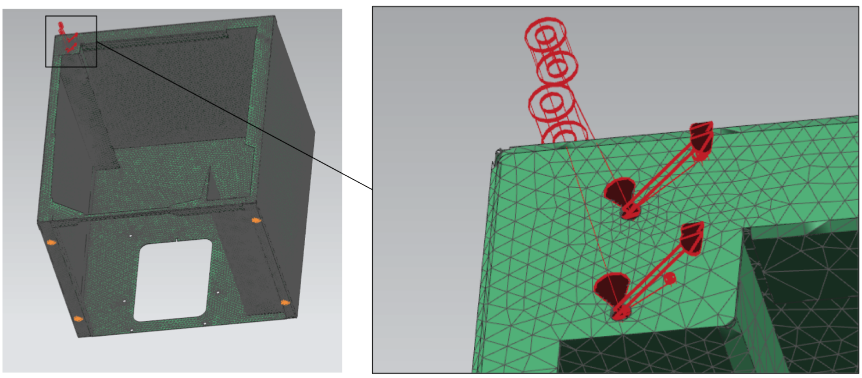


Figure A.1: The boundary conditions of the simulations.

Simulations were conducted with force directions resembling the door at three angles: straight out, half way open, or closed. The results can be seen in fig. A.2.

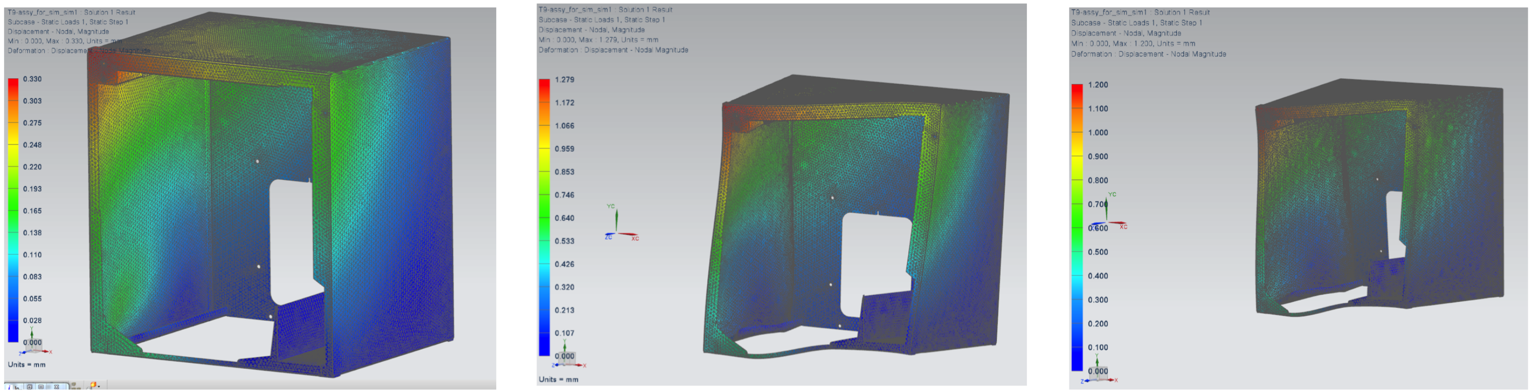


Figure A.2: The results of the simulations of the cabinet at different angles - Left: Door open, 0,33mm. Middle: Door half open, 1,279mm. Right: Door closed, 1,2mm. Deflection shown 10x exagurated.

As seen the deflection was largest at the half open position. This was therefore used in the other simulations.

What effect the removal of single parts would have on the cabinets stiffness was then examined.

Removing the tray and the upper left beam increased the maximum deflection from 0,47 mm to 1,2 8mm.

A deflection of 1,28 mm is still not a threat to the structures integrity, and accepted. Weather the actual deflection would be 1,29 mm is though questionable. A better conclusion might be that the removal of these parts would result in a deflection around 3 times larger than the of the current cabinet.

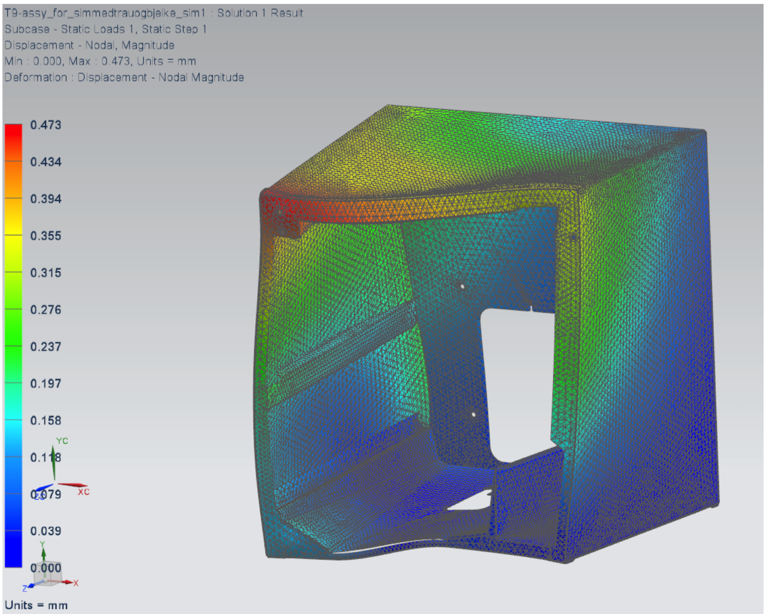


Figure A.3: The results of the simulations of the cabinet with tray, with a maximum deflection of 0.47 mm. Deflection shown 10x exagurated.

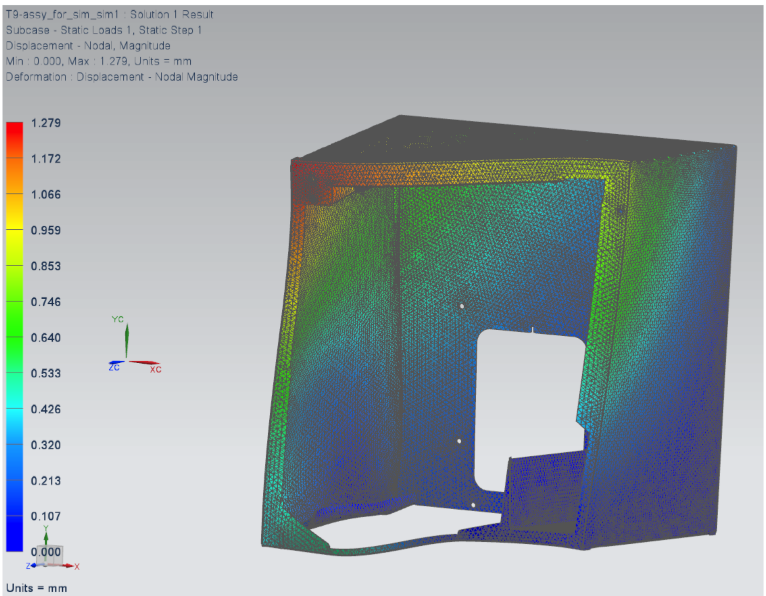


Figure A.4: The results of the simulations of the cabinet without tray and high left beam. Maximum deflection: 1,279 mm. Deflection shown 10x exagurated.

A.2 Original Tray

An alternative tray needed to be as stiff as the current setup. As no numbers for stiffness of the tray were defined, a simulation of a worst case scenario was set up.

The tray was simulated with a load of 10 kg at the tip of the conveyor. Resulting in a force of 101,43 N up in the back of the base mount hole, and 199,42 down in the front.

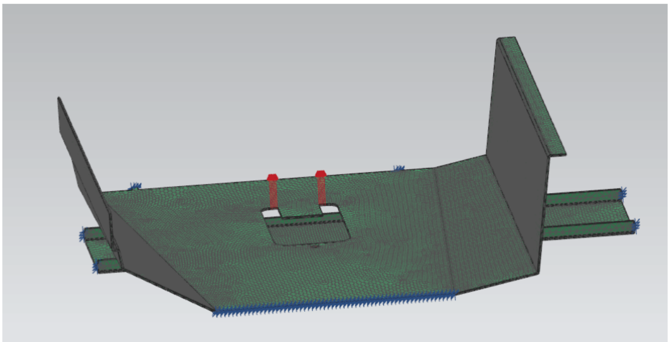


Figure A.5: The results of the simulations of the cabinet without tray and high left beam. Maximum deflection: 1,279 mm. Deflection shown 10x exagurated.

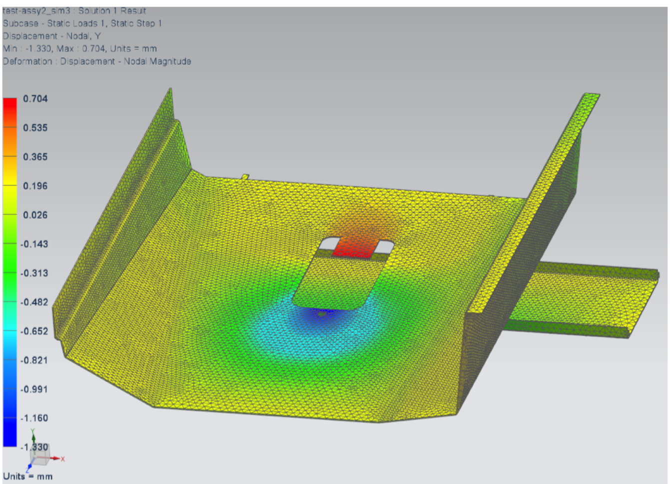


Figure A.6: The results of the simulations of the cabinet without tray and high left beam. Maximum deflection: 1,279 mm. Deflection shown 10x exagurated.

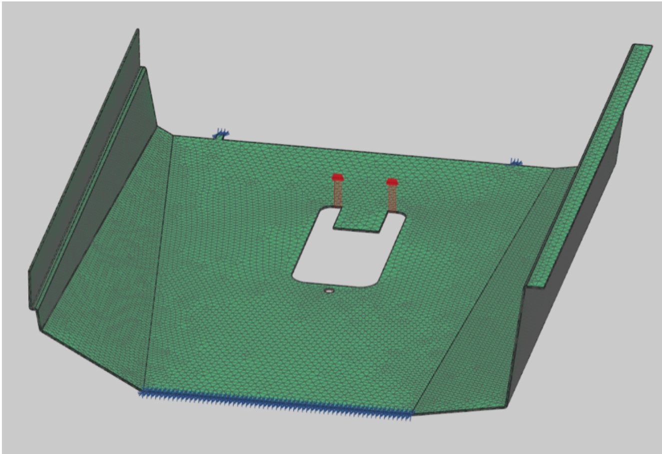


Figure A.7: The results of the simulations of the cabinet without tray and high left beam. Maximum deflection: 1,279 mm. Deflection shown 10x exagurated.

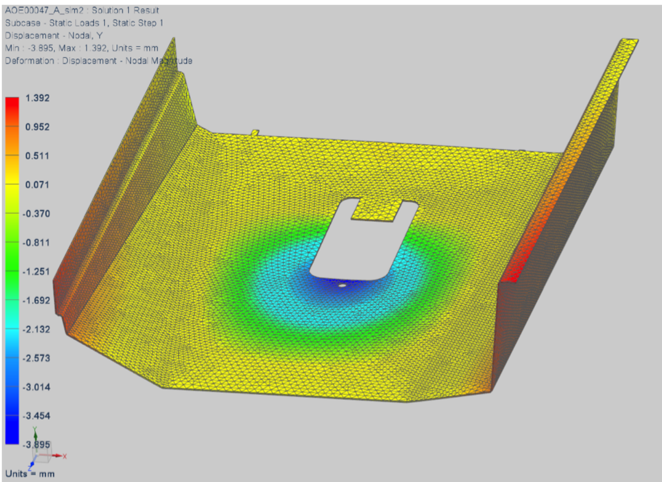


Figure A.8: The results of the simulations of the cabinet without tray and high left beam. Maximum deflection: 1,279 mm. Deflection shown 10x exagurated.

A.3 Alternative Trays

The tray concepts were also simulated to ensure that they fulfilled the requirements for stiffness. In the process several iterations were made before achieving the goal were attempted. An example can be seen for the Injection molded tray below:

The vacuum shaped tray was simulated similarly to the current setup. With forces up in the back, and down in the front (see A.2). The boundary conditions and results can be seen in fig. A.10. Maximum deflection 0,95 mm.

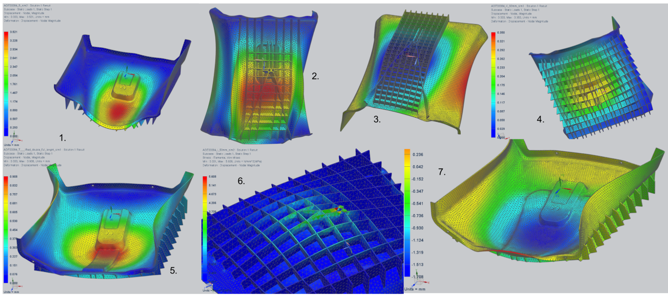
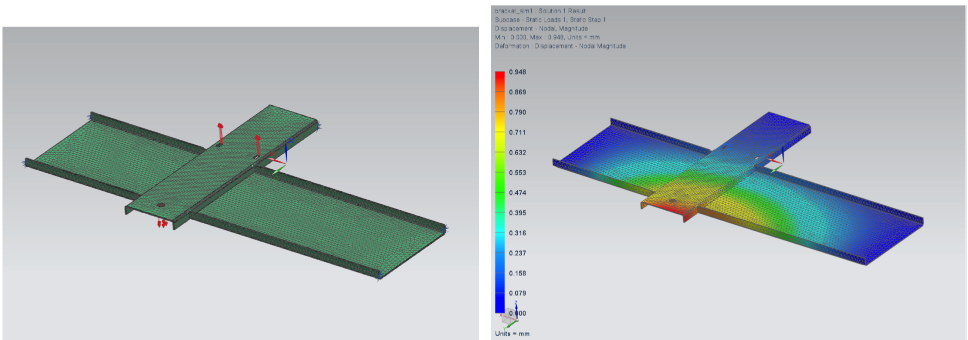


Figure A.9: The process of improving the injection molded tray to an acceptable stiffness. 1 - A startingpoint is simulated, resulting in the tray closing up. 2 - Additional cross ribs are added. 3 - Even more ribs are added. 4- To increase stiffness a double amount of ribs in the length direction is added. The doubling does little to the stiffness. Experiemtns with higher ribs is also conducted. 5 - The floor is lifted in order to increae stiffness without lowering the ribs below the floor of the base unit. 6 - The stress concentrations is used as guideline for where to rise the floor. 7 - The final concept, with a stiffness allmost inside the requirements.



(a) The boundary conditions.

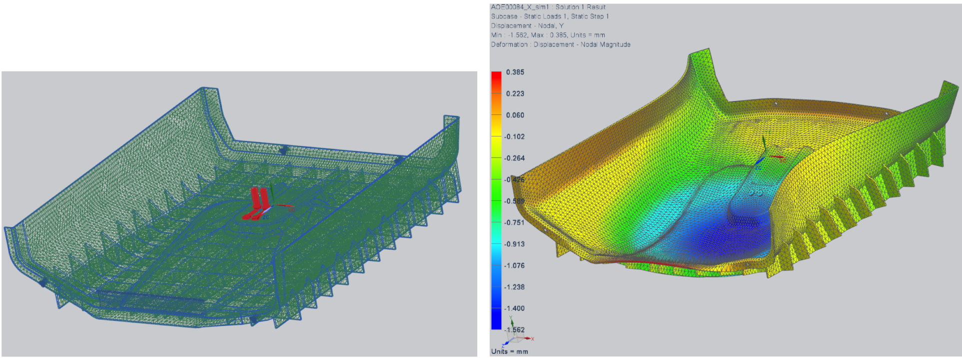
(b) The resulting deflection.

Figure A.10: Simulation done to the support bracket of the vacuum formed concept

The injection molded concept proved itself hard to fit within the space and stiffness requirements. A solution might be to use a stiffer material to a potential higher cost, or simply selecting another concept. The steps before arriving to the final part can be seen in A.9. The maximum deflection ended up at 1,5 mm.

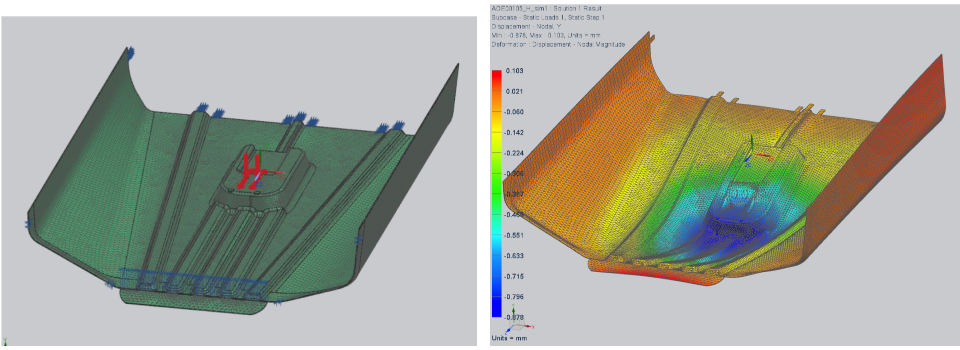
The fixed steel tray was also simulated. The simulation was conducted with support brackets mounted distributing the forces. The forces were translated into a moment of 22 Nm and a force of 98 N downwards. Final deflection ended up at 0.87 mm, see fig. A.12. As the value is far below the requirement, removal of some of the tabs towards the back wall might be reasonable.

The removable tray was also assessed with a stiffness analysis. During the development several ways of rising the stiffness of the bottom surface were tried



(a) The boundary conditions. (b) The resulting deflection.

Figure A.11: Simulation done to the injection molded concept.



(a) The boundary conditions. (b) The resulting deflection.

Figure A.12: Simulation done to the fixed steel concept.

e.g. fig. A.13.

The final removable steel tray concept provided more than sufficient stiffness at a maximum deflection of 1 mm, see fig. A.14.

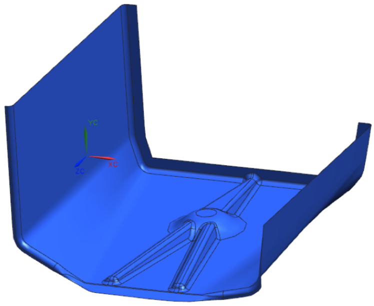
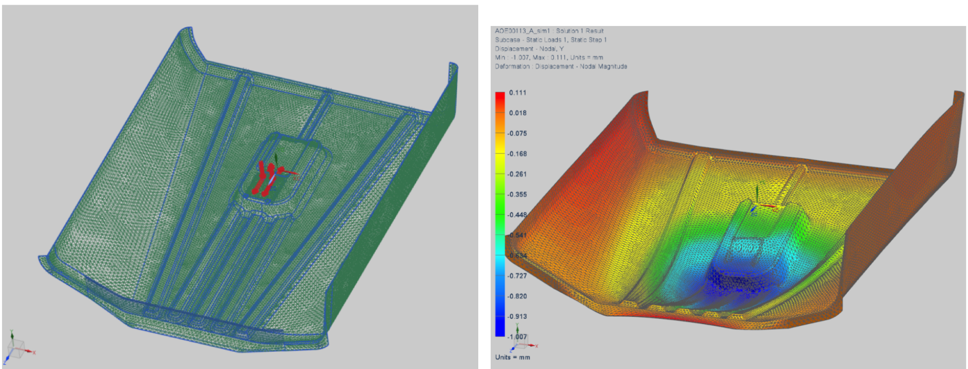


Figure A.13: Experimental stiffness integration in the tray.



(a) The boundary conditions.

(b) The resulting deflection.

Figure A.14: Simulation done to the removable steel concept.

B Neoprene sealing test

The neoprene seal was found best suited for sealing between the tray and the back wall. Otto Olsen AS would not guarantee that the seal would be tight with the suggested setup. A test was therefore set up. Two similarly sized sheet metal pieces were sought out. A 90° bend was made in the 1 mm sheet, and holes were punched out through both sheets, and a 5 mm neoprene material. The holes were placed some 160 mm apart. The setup was bolted together using screws, and tightened to 30-40 % compression of the seal. The ends of the joint were sealed with tape. The whole setup was then placed in a bucket, tilted to the side, and the grove filled with water, as seen in fig. A.15.

After 35 minutes there still was no water below the seal. Some water did though pass through the bolt holes. This could be an issue, but should then be a larger problem with the current setup - having a screw securing the base to the tray at the middle of the tray floor.

Figure A.15: The neoprene seal test setup.

Figure A.16: The neoprene seal test setup after 35min with water.

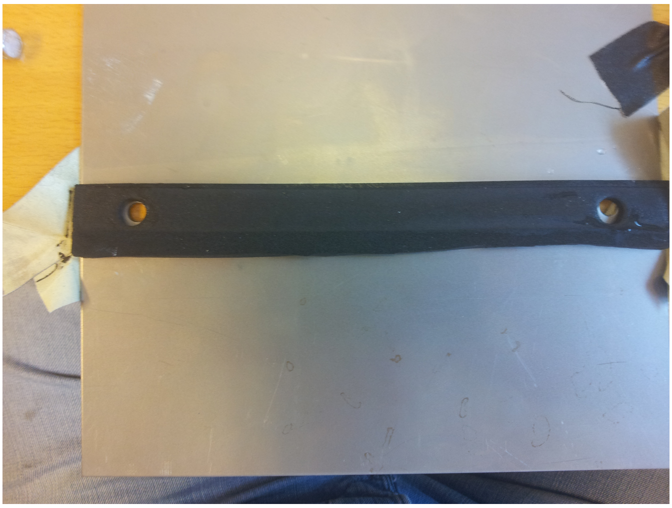


Figure A.17: The neoprene seal after testing, water on the top face and around screw hole.

Figure A.18: The neoprene seal after testing, water on the top face.

Using this setup spacers should be placed onto the studs securing the tray, enabling correct compression of the sealing, and a fixed mounting point for the tray. If not done, the tray could move through compression of the seal.

C Magnet locks

Tomra uses Magnetic locks as a safety barrier, shutting down the machinery when the lock is breached. The locks have an active part, in the case of the Multipac upper door built into the cabinet, and a passive part, built into the door. The passive part is a plastic capsule with two holes for fixing.

The capsule was tested at many angles, and does seem to function at any angle, as long as some part is within about 5 mm of the active part.

(a) The safety barrier is breached

(b) The magnet is placed upon the active sensor, and the machine returns to work.

Figure A.19: A test of the position tolerances of the magnet lock

After a closer look it was apparent that something had bin inserted into the plastic part.

Crushing the part, led to the discovery of the fact that inside a humble 30 mm magnetic cylinder was placed.

In discussion with Tom Veble, formerly employed at the Chinese department of Tomra, it was discovered the relation between the lock provider; Hamlin and Tomra is close, and that delivery of magnets without encapsulation probably would be possible. A shorter magnet, better suited for the wooden laminate might also be possible to get.

Attempts at using a magnetic strip for activation failed. No reaction was achieved from the system during testing.

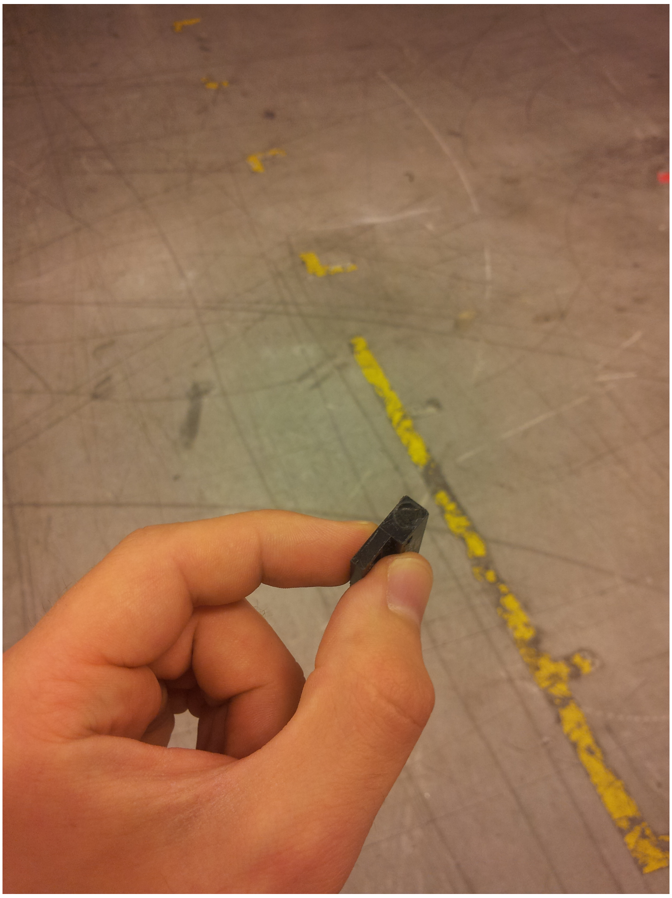


Figure A.20: The passiv magnet lock.

Figure A.21: The actual magnet.

D Results of the first design review

A design review was conducted, with representatives from the Mechanical department at Tomra Asker; Tom Lunde working with system design, Hans Georg Onstad mechanical designer on the T-9 project and supervisors Katrin Jacobsen and Kristian Hovde. The review gave many new views and enlightened aspects unconsidered priorly.

Upper door

	Stiffness	Design	Cost	Assembly	Durability	Environment
Wood	5	4	3	4	4	4
Rotational	3	1	5	5	5	5
RIM	3	5	?	5	5	1
Rolled	2	4	4	5	5	5
Tom:	Prefers wood, thinks it is new and doable.					
Kristian:	Rollforming, easy to do, easy to adapt to future models.					
Katrin:	Wood is most exciting					
Hans Georg:	Not rotational molding, looks cheap. Not RIM, is bad to the environment.					

Tray

	Position	Stiffness	Sealability	Cost	Access	Washability	
Vacuum	4	3	3	3	5	5	Stiffness: must consider if stiffness has to be added in other components than beam.
Steel fixed	0	0	0	0	0	0	Joins into new concept below
Steel rem.	0	0	0	0	0	0	Joins into new concept below
Injection molding	5	3	5	4	5	5	Stiffness: The cabinet has to maintain acceptable stiffness when tray is out. Very low cost will be required to consider implementation.
Steel all incl.	5	5	5	4,5	5	4	Position must be good enough. Cost: must be low as well.
*Steel fixed incl. base	5	5	5	4	5	4	If to be considered: must include base, be welded to the cabinet. New solutions for weight cell assembly must be considered. Position: must be good. Cost: must be low.

Table 23: Results from design review

E MTM-UAS analysis

MTM-UAS analysis were done to provide an estimate of assembly time, time saving and give a guidance on what the assembly cost would change.

For some of the door concepts; the reaction injection molded, and rotationally molded concepts assembly is not required.

For all door concepts additional assembly in terms of hinges, gas springs, and magnetic locks has to be concidered. The assembly, although beeing of varying character, has been seen as similarly time consuming and is therefore not calculated in table 29.

	Distance	Repeated	Code	Time [TMU]	Time [sec]
Pickup and placing of rear plate			AH1	25	0,9
Walk to storage pallet	2,5m		KA	62,5	2,25
Pick up and place on table - lower and higher left bracket, right sidewall and support bracket			AH2	45	1,62
Walk back to table	2,5m		KA	62,5	2,25
Placing of right wall			PC1	30	1,08
Twist tabs for secure position right wall		2	ZB1	20	0,72
Placing of high left			PC1	30	1,08
Twist tabs for secure position high left		2	ZB1	20	0,72
Placing of supportbeam			PC1	30	1,08
Twist tabs for secure position support beam		4	ZB1	40	1,44
Placing of lower left			PC1	30	1,08
Twist tabs for secure position lower left		2	ZB1	20	0,72
Pick up and place on table - top wall, cable support and tray	2,5m		AH2	45	1,62
Placing of top wall			PC1	30	1,08
Twist tabs for secure position of top wall		2	ZB1	20	0,72
Placing of cable support			PC1	30	1,08
Twist tabs for secure position of top wall		4	ZB2	40	1,44
Placing of tray			PC1	30	1,08
Twist tabs for secure position of tray		6	ZB1	60	2,16
Pick up and place on structure - front surface			AK2	75	2,7
Twist tabs for secure position of front surface		8	ZB1	80	2,88
Placement in jig for correct angles	1m		AK1	50	1,8
Visual control			VA	15	0,54
Spot-welding		41		12300	442,8
Grinding of welds and tabs		41		6150	221,4
Pick up and place on structure - left side plate			AK2	75	2,7
SUM					698,9
Technical stop (15%)					104,8
Operator slack (5%)					34,9
Operator rest (25%)					174,7
Total time [s]					1013,5
Total time [min]					**16,9**

Table 24: Assembly of the current base unit

	Distance	Repeated	Code	Time [TMU]	Time [sec]
Pickup and placing of rear plate			AH1	25	0,9
Walk to storage pallet	2,5m		KA	62,5	2,25
Pick up and place on table - lower and higher left bracket, right sidewall and support bracket			AH2	45	1,62
Walk back to table	2,5m		KA	62,5	2,25
Placing of right wall			PC1	30	1,08
Twist tabs for secure position right wall		2	ZB1	20	0,72
Placing of high left			PC1	30	1,08
Twist tabs for secure position high left		2	ZB1	20	0,72
Placing of supportbeam			PC1	30	1,08
Twist tabs for secure position support beam		**10**	ZB1	100	3,6
Placing of lower left			PC1	30	1,08
Twist tabs for secure position lower left		2	ZB1	20	0,72
Pick up and place on table - top wall, cable support and tray	2,5m		AH2	45	1,62
Placing of top wall			PC1	30	1,08
Twist tabs for secure position of top wall		2	ZB1	20	0,72
Placing of cable support			PC1	30	1,08
Twist tabs for secure position of top wall		4	ZB2	40	1,44
Pick up and place on structure - front surface			AK2	75	2,7
Twist tabs for secure position of front surface		8	ZB1	80	2,88
Placement in jig for correct angles	1m		AK1	50	1,8
Visual control			VA	15	0,54
Spot-welding		41		12300	442,8
Grinding of welds and tabs		41		6150	221,4
Pick up and place on structure - left side plate			AK2	75	2,7
Pick up and place on table - vacuum formed tray			AH2	45	1,62
Fit rubber seal on back wall edge				400	14,4
Pick up and place on structure - vacuum formed tray			AK2	75	2,7
Place sealing		1		400	14,4
SUM					731,0
Technical stop (15%)					109,6
Operator slack (5%)					36,5
Operator rest (25%)					182,7
Total time [s]					1059,9
Total time [min]					**17,7**

Table 25: MTM-UAS analysis for the assembly of the base unit with the vacuum formed tray concept.

	Distance	Repeated	Code	Time [TMU]	Time [sec]
Pickup and placing of rear plate			AH1	25	0,9
Walk to storage pallet	2,5m		KA	62,5	2,25
Pick up and place on table - lower and higher left bracket and right sidewall			AH2	45	1,62
Walk back to table	2,5m		KA	62,5	2,25
Placing of right wall			PC1	30	1,08
Twist tabs for secure position right wall		2	ZB1	20	0,72
Placing of high left			PC1	30	1,08
Twist tabs for secure position high left		2	ZB1	20	0,72
Placing of lower left			PC1	30	1,08
Twist tabs for secure position lower left		2	ZB1	20	0,72
Pick up and place on table - top wall, cable support	2,5m		AH2	45	1,62
Placing of top wall			PC1	30	1,08
Twist tabs for secure position of top wall		2	ZB1	20	0,72
Placing of cable support			PC1	30	1,08
Twist tabs for secure position of top wall		4	ZB2	40	1,44
Pick up and place on structure - front surface			AK2	75	2,7
Twist tabs for secure position of front surface		8	ZB1	80	2,88
Placement in jig for correct angles	1m		AK1	50	1,8
Visual control			VA	15	0,54
Spot-welding		35		10500	378
Grinding of welds and tabs		35		5250	189
Pick up and place on structure - left side plate			AK2	75	2,7
Pick up and place on table - injection molded tray			AH2	45	1,62
Fit rubber seal on back wall edge				400	14,4
Pick up and place on structure - injection molded tray			AK2	75	2,7
Mount tray with use of screws		4		240	8,64
Place sealing		1		400	14,4
SUM					637,7
Technical stop (15%)					95,7
Operator slack (5%)					31,9
Operator rest (25%)					159,4
Total time [s]					924,7
Total time [min]					**15,4**

Table 26: MTM-UAS analysis for the assembly of the base unit with the injection molded tray concept.

	Distance	Repeated	Code	Time [TMU]	Time [sec]
Pickup and placing of rear plate			AH1	25	0,9
Walk to storage pallet	2,5m		KA	62,5	2,25
Pick up and place on table - lower and higher left bracket, right sidewall and base bracket			AH2	45	1,62
Walk back to table	2,5m		KA	62,5	2,25
Placing of right wall			PC1	30	1,08
Twist tabs for secure position right wall		2	ZB1	20	0,72
Placing of high left			PC1	30	1,08
Twist tabs for secure position high left		2	ZB1	20	0,72
Placing of base bracket			PC1	30	1,08
Mount base bracket bending manual-bend		**1**		60	2,16
Placing of lower left			PC1	30	1,08
Twist tabs for secure position lower left		2	ZB1	20	0,72
Pick up and place on table - top wall, cable support	2,5m		AH2	45	1,62
Placing of top wall			PC1	30	1,08
Twist tabs for secure position of top wall		2	ZB1	20	0,72
Placing of cable support			PC1	30	1,08
Twist tabs for secure position of top wall		4	ZB2	40	1,44
Placing of tray			PC1	30	1,08
Twist tabs for secure position of tray		6	ZB1	60	2,16
Pick up and place on structure - front surface			AK2	75	2,7
Twist tabs for secure position of front surface		8	ZB1	80	2,88
Placement in jig for correct angles	1m		AK1	50	1,8
Visual control			VA	15	0,54
Spot-welding		37		11100	399,6
Grinding of welds and tabs		37		5550	199,8
Pick up and place on structure - left side plate			AK2	75	2,7
SUM					634,9
Technical stop (15%)					95,2
Operator slack (5%)					31,7
Operator rest (25%)					158,7
Total time [s]					920,5
Total time [min]					**15,3**

Table 27: MTM-UAS analysis for the assembly of the base unit with the fixed steel tray concept.

	Distance	Repeated	Code	Time [TMU]	Time [sec]
Pickup and placing of rear plate			AH1	25	0,9
Walk to storage pallet	2,5m		KA	62,5	2,25
Pick up and place on table - lower and higher left bracket, right sidewall and base bracket			AH2	45	1,62
Walk back to table	2,5m		KA	62,5	2,25
Placing of right wall			PC1	30	1,08
Twist tabs for secure position right wall		2	ZB1	20	0,72
Placing of base bracket			PC1	30	1,08
Mount base bracket with use of screw		**1**		60	2,16
Placing of lower left			PC1	30	1,08
Twist tabs for secure position lower left		2	ZB1	20	0,72
Pick up and place on table - top wall, cable support and tray	2,5m		AH2	45	1,62
Placing of top wall			PC1	30	1,08
Twist tabs for secure position of top wall		2	ZB1	20	0,72
Placing of cable support			PC1	30	1,08
Twist tabs for secure position of top wall		4	ZB2	40	1,44
Pick up and place on structure - front surface			AK2	75	2,7
Twist tabs for secure position of front surface		8	ZB1	80	2,88
Placement in jig for correct angles	1m		AK1	50	1,8
Visual control			VA	15	0,54
Spot-welding		29		8700	313,2
Grinding of welds and tabs		29		4350	156,6
Pick up and place on table - steel tray			AH2	45	1,62
Fit rubber seal on back wall edge				400	14,4
Pick up and place on structure - steel tray			AK2	75	2,7
Mount tray with use of screws		4		240	8,64
Place sealing		1		400	14,4
SUM					539,3
Technical stop (15%)					80,9
Operator slack (5%)					27,0
Operator rest (25%)					134,8
Total time [s]					782,0
Total time [min]					**13,0**

Table 28: MTM-UAS analysis for the assembly of the base unit with the removable steel tray concept.

Assembly of the current upper door	Distance	Repeated	Code	Time [TMU]	Time [sec]
Walking to shelf	2,5		KA	62,5	2,25
Pickup and placing of upper and lower profile, right and left side wall.			AH2	45	1,62
Walking back to table	2,5				
Assemble lower profile and side walls using pop rivets		21		8400	302,4
Placing of upper profile on assembly	1		PC1	30	1,08
Assemble lower profile and side walls using pop rivets		14		5600	201,6
Walking to shelf	2,5		KA	62,5	2,25
Pickup and placing door skin	0,4		AH2	45	1,62
Walking back to table	2,5				
Mount skin using pop rivets		14		5600	201,6
Pick up and place brackets for gas-spring	0,5	2	AK2	90	3,24
Mount brackets with use of screws		8		480	17,28
Walking to shelf	2,5		KA	62,5	2,25
Place door on pallet			AH2	45	1,62
SUM					738,8
Technical stop (15%)					110,8
Operator slack (5%)					36,9
Operator rest (25%)					184,7
Total time [s]					1071,3
Total time [min]					**17,9**

Sm skruer vanskelige plassere

Assembly of Wood concept	Distance	Repeated	Code	Time [TMU]	Time [sec]
Walking to shelf	2,5		KA	62,5	2,25
Pickup and placing door laminate			AH1	25	0,9
Walking back to table	2,5		KA	62,5	2,25
Place brackets on laminate	0,5	2	PC2	80	2,88
Place screws in place	0,5	4	PC2	160	5,76
Assemble brackets onto skin with two screws each		4		800	28,8
Walking to shelf	2,5		KA	62,5	2,25
Place door on pallet			AH1	25	0,9
SUM					46,0
Technical stop (15%)					6,9
Operator slack (5%)					2,3
Operator rest (25%)					11,5
Total time [s]					66,7
Total time [min]					**1,1**

Assembly of Rolled profile concept	Distance	Repeated	Code	Time [TMU]	Time [sec]
Walking to shelf	2,5		KA	62,5	2,25
Pickup and placing door skin, and two sidewalls			AH1	25	0,9
Walking back to table	2,5		KA	62,5	2,25
Assemble brackets onto skin with use of pop rivets		24		9600	345,6
Walking to shelf	2,5		KA	62,5	2,25
Place door on pallet			AH1	25	0,9
SUM					354,2
Technical stop (15%)					53,1
Operator slack (5%)					17,7
Operator rest (25%)					88,5
Total time [s]					513,5
Total time [min]					**8,6**

Table 29: Assembly of the door concepts requiring assembly.

F Transportation distances

The transportation distances of the T-XX, and T-XXX machines, from production to the market have been estimated in tab. 30. The data were calculated for use in the ECO99-indicator analysis for the concepts.

	Distance	Group	Distance average of group	Installed machines			Percentage truck/tanker	Weighted average of transport distance
Japan	8800	Asia		500	1 %	Ship		
USA	8300	North America	7750	15000	23 %	Ship	25 %	8282
Canada	7200	North America				Ship		
South america	10000	South America		1000	2 %	Ship		
Iceland	2600	Scandinavia	1740	15000	23 %	"Truck"		
Sweden	1700	Scandinavia				Truck		
Danmark	1100	Scandinavia				Truck		
Norway	1700	Scandinavia				Truck		
Finland	1600	Scandinavia				Truck	75 %	1048
Netherlands	1100	Central Europe				Truck		
Austria	600	Central Europe	850	12000	18 %	Truck		
Germany	700	Germany		23000	35 %	Truck		
				66500				
All sea transport also requires transport to and from bay Distance between the south of Poland, to the center of the countries								

Table 30: Transport distances for the tomra front machines

G Slides from the development process

During the work of the thesis weekly meetings were conducted, in collaboratio with the supervisors at Tomra. In each meeting a presentation of the work conducted the last week would be given. The presentation was then followed by a discussion, and workshop of the challenges having occured during the week.

In the following the presentations from these meetings are collected, giving a detailed, chronological insight in the development. The presentations can be seen as an addition to the PU-journal which also gives an insight into the work conducted.

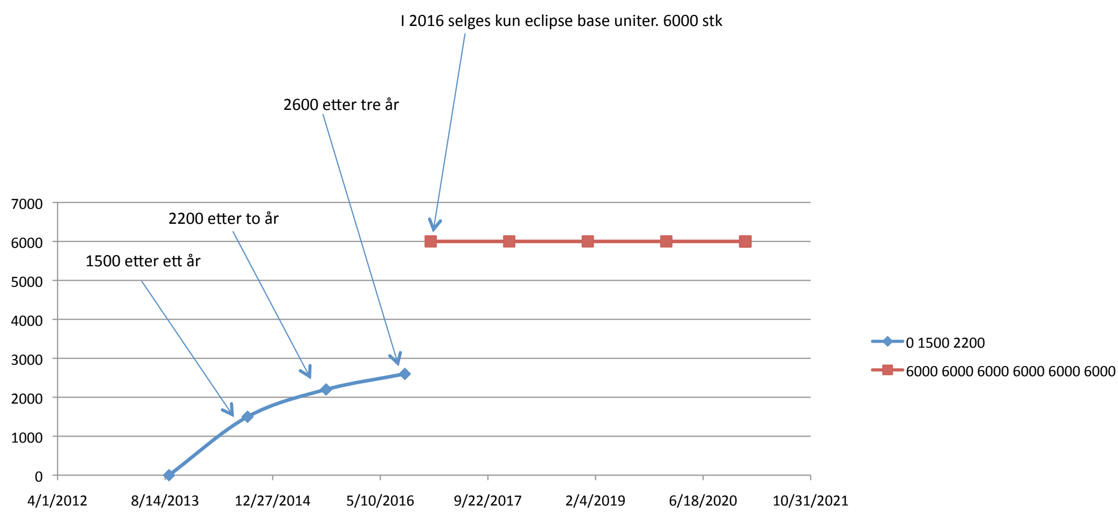
Some of the data given in the presentations, may at a later stage in the development have changed.

Be aware that some of the simulations done, were conducted with falsely applied forces. It is therefore advised to look at the results presented in section A for correct simulation results.

Most slides will be in Norwegian.

Siden sist:

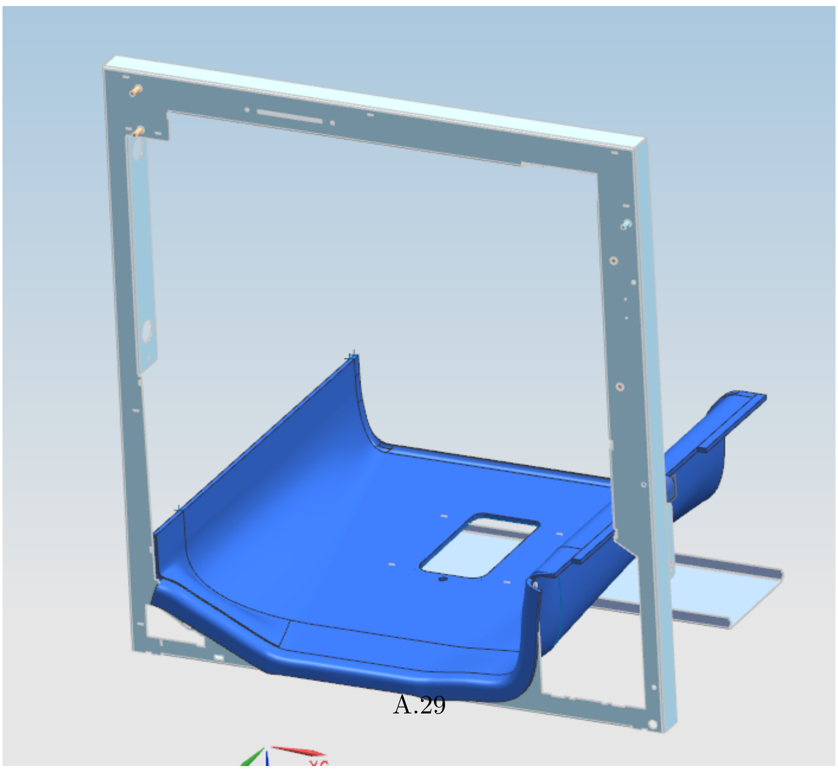
- Fått avtale med Ekornes – Knut Tore Fausa
  – 1. mars
- Avtale om besøk hos Cipax
  – Fredag? Onsdag neste uke?
- Møte med Knut Aasland
  – Knut mener jeg bør konsentrere meg om én del. Følg vanlig PU metodikk. Skal komme opp med telefonnummer til person i HÅG som jobbet med skum i PP.
- Euro Expo
  – Robust: Reklamerer for formverktøy for del i stål. Tipper verktøy til ca. 250 000 kr. Mener det er «billig».
  – ST bilbygg: composite honeycomb sandwich. Knekker blir ikke pent.
  – LVD: Knekker bruker 35kW, 3-500 000kr for maskin.
  – Din Maskin: Nye knekker bruker 4kW, 500 000kr for knekke, 2mill for revolverstanse.
- Må jobbe med kravspesifikasjon -> mer spesifikk produktkravspesifikasjon
- Toleransekrav til venstre flens på bunntrau er store pga bruk av refleks, ikke speil.



- Vis ECO99
  - Plast og miljøaspekt
- Kostnad på deler, mer eksakt
  - Vet kost baseunit
  - Vet kost multipac kabinett

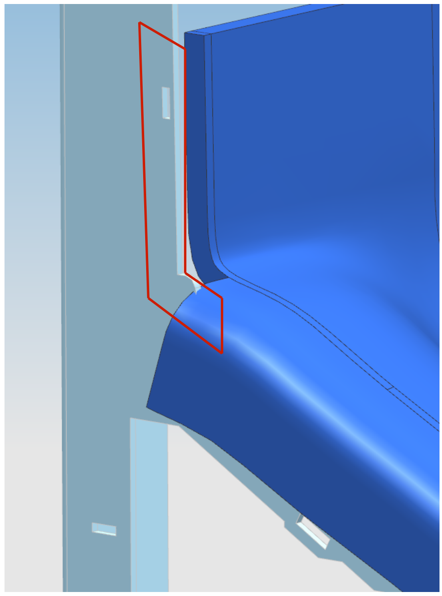
Siden sist:

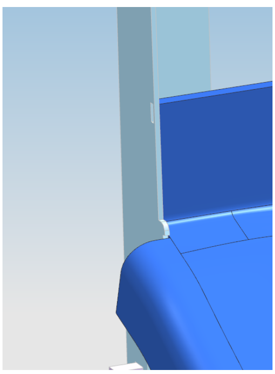
- Laget utkast til termoformet del/lært masse om flatemodellering.
- Fått ny avtale med Cipax, tirsdag neste uke.
- Snakket med Plascore, materialet er vacumformbart. Ikke fått svar på epost til guruen deres.
- Fått microdemonstrasjon av optikkgjengen. Refleksflate skal ikke stå 90grader på kamera. Det er dårlig. 1-5grader er bra, mer går mot ugunstig igjen. Et par millimeters ekstra vridning om en ekstra akse; ikke noe stort problem.
- Tom: Vibrasjoner i transportbånd må unngås pga ømfintlig vekt – forsterk stålbit under trau. Må undersøkes. Konstruerer nå i 5mm ABS = ganske stivt.
- Fått en ny kontakt innen trelaminering -> ledet til tysk firma med «bibel» om laminering. Dette firmaet oppgir 2000euro som normal pris på treverktøy med alupadding. 6000euro for rent aluverktøy. Kan lage flameretardant plywood = Incendur.
- En type i kantina foreslo å ekstruderer døra i fiberforsterket plast.



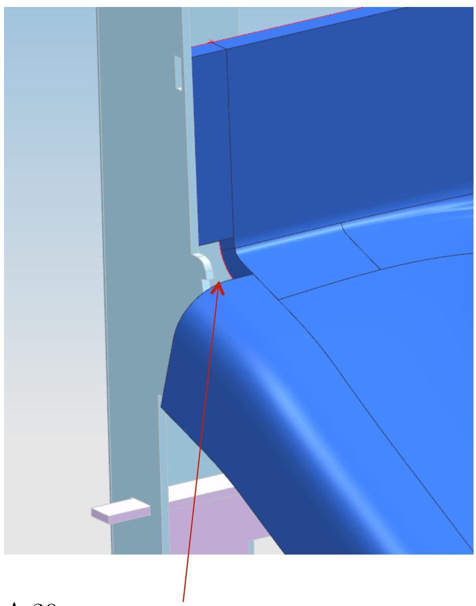
Bunntrau

- Mulighet for å klippe bort materiale på frontplate?





Evt må man feste på annen måte.



Eller få litt mellomrom

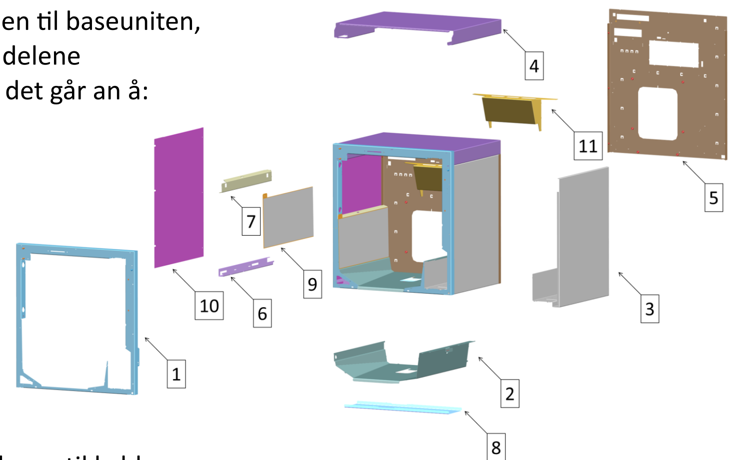
Siden sist:

- Tor Helge og Hans Georg: Bekreftet mulighet for å legge høyre flens fra bunntrau på neste tynnplatedel.
- Snakket med Håkon Haflan om testing av vibrasjoner og deres innvirkning på vektsensoren. Konklusjon: Han hjelper meg å teste når jeg har laget oppsett.
  - Tidlige vekttester på eclipse var dårlige, men etter aluklump ble det bedre. Tung ting på bunnen av fjæra gjør at vibrasjonene dempes?
- Mercedes trucks, programvare mener at en vektbesparelse fra 40 til 30 tonn vil gi ca 0,5l besparelse på 100 mil.
- Primo: Ekstrusjon i plast går kun opp til 30cm i tverrsnittdiameter.
- Horizon Aluminum i Kina: Ekstruderer digre ting i Alu 1000tonn trykk. Koster mye å lage verktøy, koster mer å bruke fordi du stjeler produksjonstid fra luftfartsindustrien. Brukt til seter til london OL? Brukt til design prosjekt .
- Besøk hos Cipax: 1000 enheter form/år, 6mm tykkelse, 60000 for stålverktøy 150000 for alu (bedre overflate).
  - Sendt step-filer og tegninger for prisoverslag for produktsjon i Polen

Sist møte snakket vi om at det var to nye scenarier for bunntrauet, tykk – bidrar til vektbæring, tynn – har kun dekkende hensikt.

Har jeg skrevet om funksjonen til baseuniten, gått gjennom funksjonen til delene systematisk, og funnet ut at det går an å:

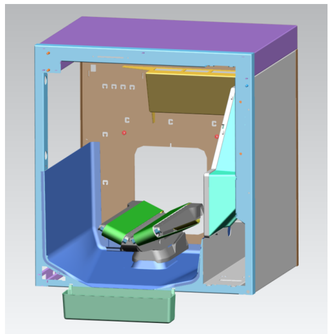
Slå sammen 2, 7 & 9
Biffe opp 8
Slå sammen 6 & 10

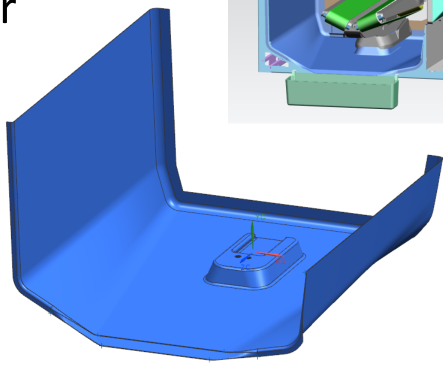


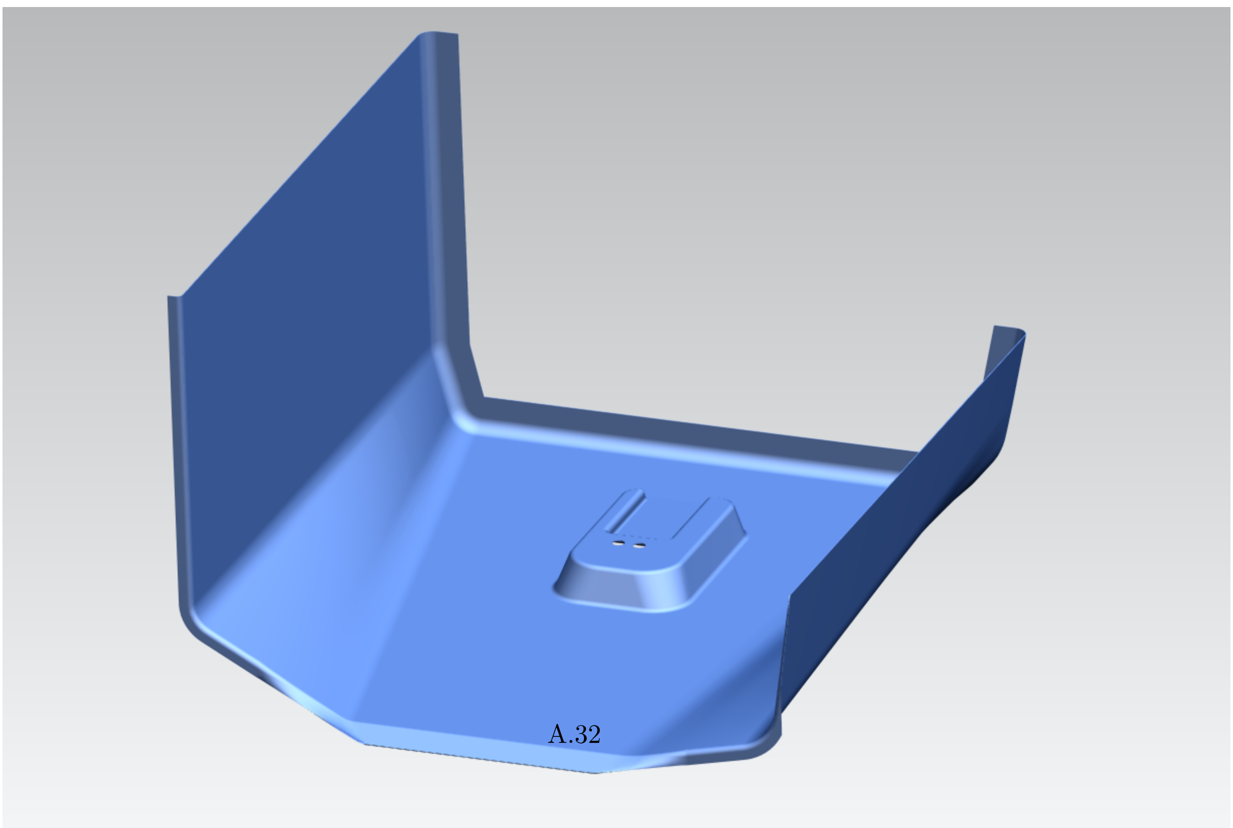
Hvordan muliggjøre?
Grunn for løs ytterflate: tilgang til kabler
Grunn for løs refleks: tilgang til kabler, utskiftbarhet
Hvis bunntrauet+refleksen kan tas ut, trenger ikke sideflaten å være åpen under montering.
Dag krever at 7 blir borte for at kabling skal gå lett fra innsiden.

Siden sist:

- Laget alt i ett løsning for bunntrau
- Tatt ut oppgaven.
- Sett på LCA muligheter
- Jaktet på NX med advanced simulations
  - Reinstallerer det selv, håper på det beste.





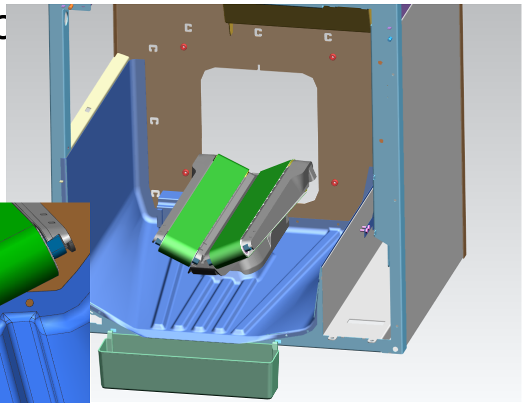


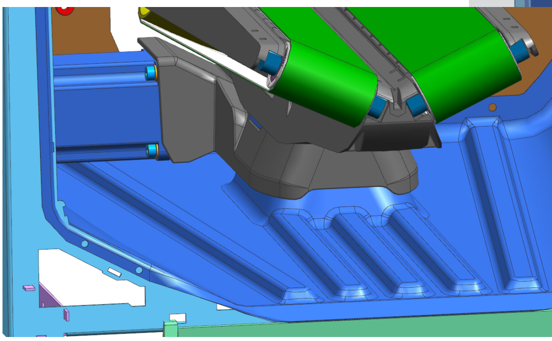
Siden sist:

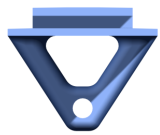
- Besøk hos Ekornes
  - Positive til å lage dør i tre
  - Kun spant: Material 40kr, lim 6kr, pressing 7kr, fresing 33kr, pussing 16kr, lakkering 102 kr = 204kr. MED LØNN PÅ 200kr timen… Ikke uaktuelt i polen?! Potensielt stor besparelse?!
  - Ikke mulighet for produksjon hos Ekornes, men Norlam:
    - Kjøpt av Kvist i danmark
    - Har polsk datterselskap
    - Skal få kontaktinfo
  - Ved 6-7mm tykkelse er vridning litt vrient, men kan løses ved god kontroll på fukt i materialer under produksjonen.
    - Må også varme opp under pressingen med plater - ikke høyfrekvent liming, for å holde bedre kontroll med temp.
  - Foreslår å legge inn skinne på bånn i aluminium eller liknende
    - Magnet over hele kanten (for kombinasjon med friksjonshengsler?)
    - Ekstrudert aluminium?
      - Kun U-profil
      - Med hele den nederste knekken, gjør del i tre veldig enkel å produsere.
  - Forslag til innfestninger av gassfjær:
    - Legg inn nedsenede U-klemmer i alu
    - Lag spant på siden som før, i 12mm kryssfiner (1/3 av prisen på maxbo minst!)
  - Anbefaler å legge plastlag på innsiden av døra ettersom det er denne som potensielt kommer i kontakt med guff. Billig.
- Epost fra hydro
  - Skulle ringe på mandag?!
- Kristian har fastslått at jeg kan bruke NX-lisensen til NTNU her.

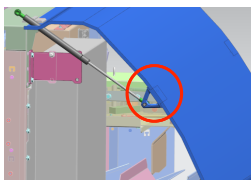
Siden sist:

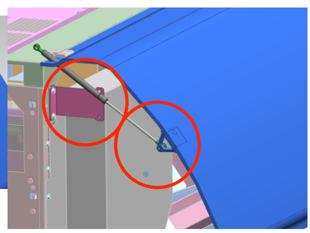
- Kolliderer med moto



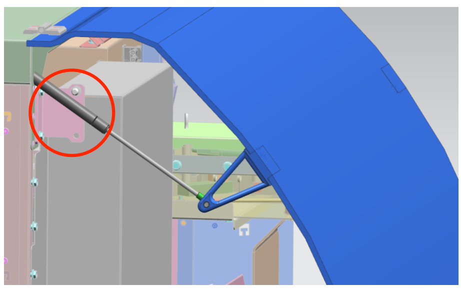








Forflytte utover:



Ekstrudere/valse alu-profil vs støpe sink/alu

Est/vals: + sikkert billig pr meter – får ikke krumning i ytterflate og må bore hull til skrue.

Støp: + krum flate – må ha ekstra «pinne» i verktøy for hull.

Dagens løsning

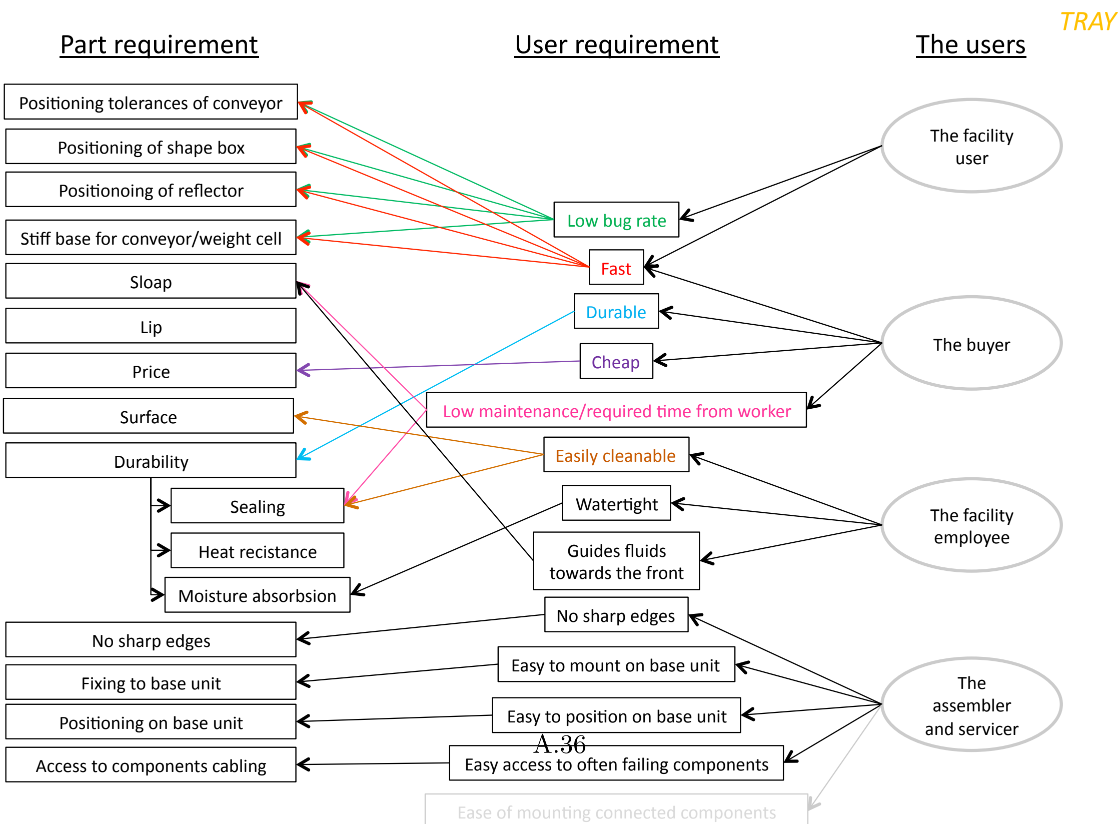
Siden sist:

- Laget laminat hjemme for testing av styrke
  - (Ikke 5x1,5mm enkeltlags finer, men 5x1,5mm trelags kryssfiner…)
- Vært i kontakt med Kvist/Månedalen laminat
  - Produksjon i Latvia, stor nok kapasitet til dørene hvis aktuelt
  - Har sendt fil for prisoverslag.
- Har fått noe, og purret på annen info fra Cipax (rotasjonsstøp).
- Arbeidet med utkast for rulleforming. Forsøk på verkstedet for å se på stivhet i 2mm Alu.
- Lagt plan for å få fram konkrete konsepter for utvelgelse neste fredag (forhåpentlig).
- Jobbet med brukerkrav
  - Snakket med Espen Lund om hva som går i stykker på dagens maskiner.
  - Snakket med Eirik Foss om utskifting av vektceller.
  - Kokt ned info fra Frank Lippert om hva kjøper og sluttbruker ønsker seg
- Jobbet med produktkrav
  - Snakket med/sendt epost med Hans Georg om toleranser på conveyor i forhold til gjenkjenningssystemene.
  - Startet gjennomgang av excel ark med kostnader for å få oversikt og lage enkel modell for tipping av pris på framtidige braketter/sjekke om 3x materialpris er godt nok estimat.
- SPØRSMÅL:
  - RIM

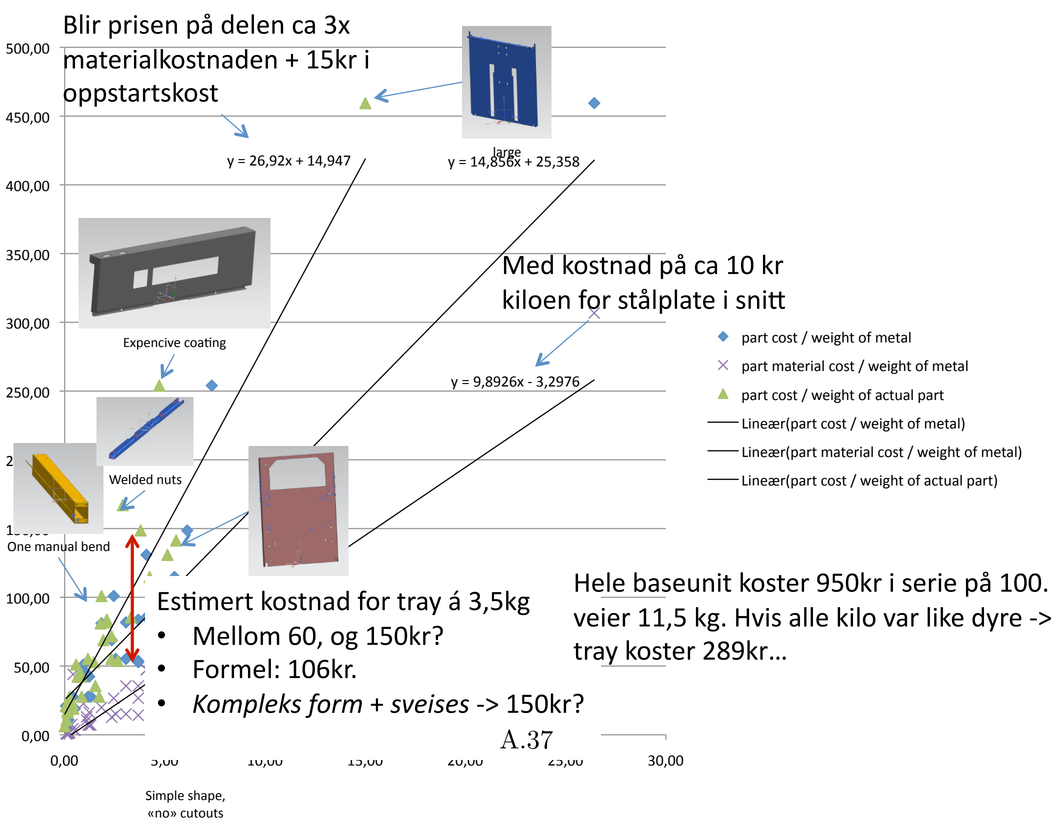
Mandag	Tirsdag	Onsdag	Torsdag	Fredag
			• Lage valset test • Trau – stål løs, m base, u refleks	Trau – stål, fast, u base, u refleks
Trau – Stål, all inclusive	Trau – sprøytestøp, u refleks, u base	Trau – sprøytestøp, u refleks, m base?	Dør – RIM	Møte

Siden sist:

- Jobbet med brukerkrav og produktkravspesifikasjon.
  - Skal snakke med Markus Näs i dag om tilbakemeldinger på maskin ute.
  - Lurer på tempkrav til trau (motor). Måle?
- Laget flere konsepter i nx, flere variasjoner av samme del.
  - Forsøkt å hente inn priser på ulike konsepter/prosesser
- Jobbet med å kartlegge kostnader ved platedeler.
- Fått montert den valsede døra.
- Bestillt gassfjærer tilpasset vekt av alu, og tredør

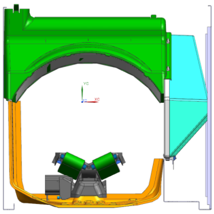


Product requirement spesification		
Positioning tolerances of conveyor (for recognition systems to function)	Depth: >0mm between field of view of onering and conveyor belt. Width: +/-~3mm at tip of conveyor, Height: Overlap of conveyor in shape recognition camera field of view of >5mm.	Depth: Between the field of view of the two lower cameras on the "one ring", and the belts of the conveyor there has to be a gap. Modeled there is no such gap, but as the pulley is mounted on springs, and the conveyor bands them selves are shorter than in the model, there is a gap. This varies somewhat, as the bands are not precicely equally long. Width:Not as strict.
Positioning of shape box	Two cut-outs on far right flange.	
Positioning of reflektor	Loose toleranse, 1° + <2° / - >0,3°	
Stiff enough to provide a steady base for conveyor weight cell	Tray deflection <1,4mm in front of base with 10kg load at conveyor tip.	Todays solution has 1,4mm deflection in front of base with 10kg load at the conveyor tip. Vibrations should be minimized.
Sloap	0,8° (or more) tilted towards front.	
Front-lip for controlled pouring	Lip is 10mm deep, and should have edges to avoid spillage. Has to provide space for mounting of collection tray.	
Sealing for fluids	0 ml.	Electrical components for the crate unit will be placed below the tray, and hence it is an absolute requirement to keep the bottom of the common base unit sealed.
Withstand heat from motor		Motor produces heat.
Moisture absorbsion	Corrosion protect/waterproof barrier	Humid environment
Durability	7 years of use.	The machines usually last much longer, but the design requirement is 7 years.
Surface	Smooth, enabling easy cleaning. No sharp bends.	
Edges	Avoid sharp edges and corners	To minimize personell damage upon assembly
Price		
Positioning on base unit	Guides, tabs, screw holes or similar for easy placement	The current setup has tabs for easy positioning of the tray.
Fixing to baseunit	Rigid connection to baseunit	The tray is welded to the base in the current setup.
Access to components	Cabling and worn out components must be accesable	Around 250 weight cells brake every year. The cell has to be accessable. This goes also for the cabling running up along the left, front side of the cabinet.

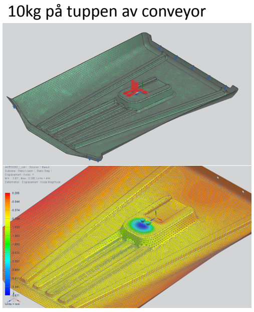


Konsept 3.1

- Uttakbar, innfesting i front og bakkant med skruer.
- Trau må ut for bytte av vektcelle.

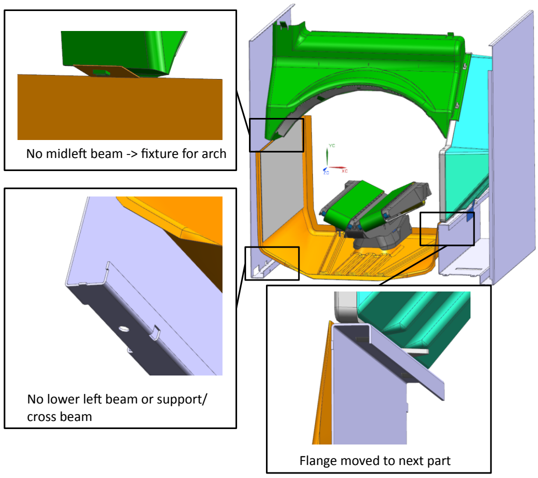


10kg på tuppen av conveyor



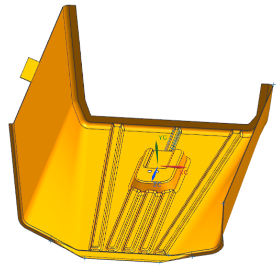
- Omtrent samme deformasjon som originalt oppsett med 0,7mm plate.
- Store deformasjoner omkring hull for innfesting av vektcelle -> mulig at mye av kreftene forsvinner dit, og deformasjonen skulle vært noe større.
- Mulighet for å legge ringer omkring hull/brakett på undersiden?

Steel all inclusive



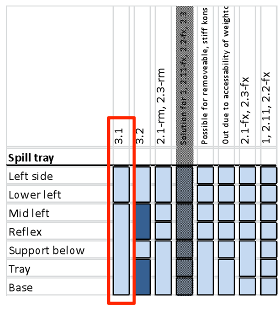
Fordeler:

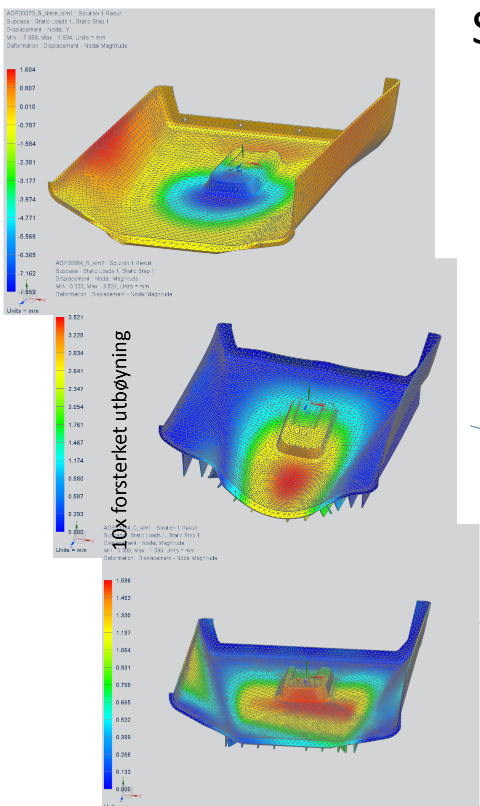
- Muliggjør kutt av 4 deler.
- Estimert/tippet kostnad konsept:



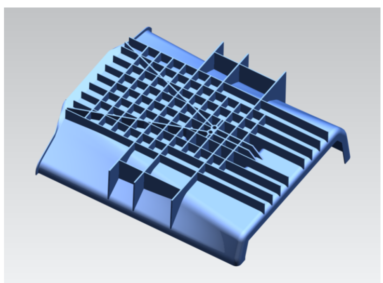
- Innfesting med f.eks. skruer i front og bakkant.
- Ingen utvei for væske utenom fram og ut.

Delintegrasjon

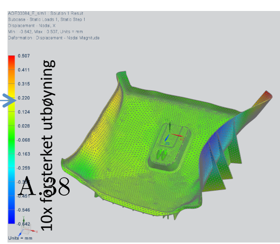




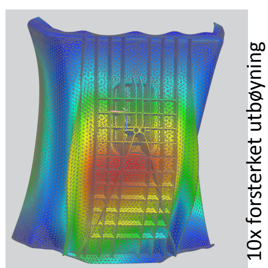
Sprøytestøp



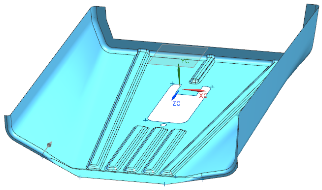
Svinger inn på sidene, på grunn av utbøyning. Ikke så mye som det ser ut som, men litt uheldig. Må fikses i evt. neste itterasjon.



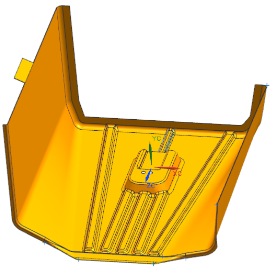
Ca 1 mm innsving på hver begge sider



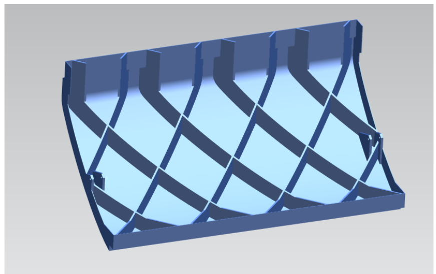
Stål, uten refleks og uten base
-> kan sveisesfast som dagens løsning.



Vil ikke la seg «tykknes», men illustrerer hva jeg ønsker.

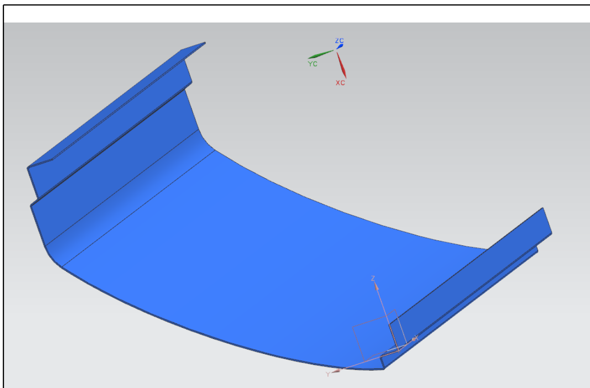


RIM dør

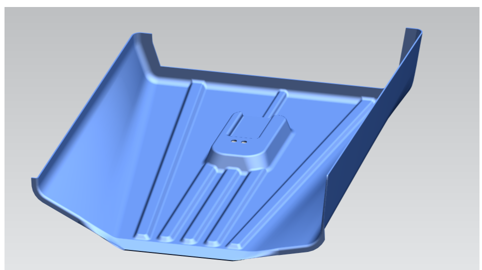


Ikke direkte gjennomførbar –> umulige underkutt.

SENDT TIL KINA

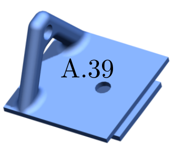


Forespørsel om pris og samarbeid om design av *valset profil* sendt til IB Andresen, intet svar. **Skal ringe i dag.**



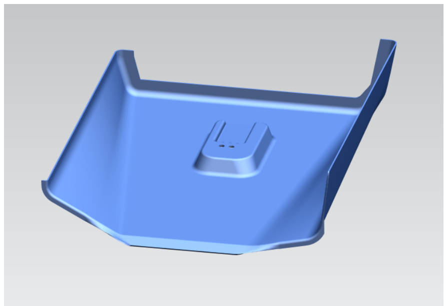
Stål, base på, uten refleks. Ferdig

Fått pris på laminat i bøk/bjørk fra Kvist/Måndalen 435kr for all prosessering inkl lakk. Ca. 40 kr mindre enn stålet i dagens løsning. Må ha fester for gassfjær i tillegg...



Vakuumformet del, MED bjelke

- Sendt til Nyplast, fått tilbud, 42kr stk med enkelkavitet.
- Base bør ikke innebygges fordi
    - Selv om dagens base taes bort, må en ny brakett for innfesting av vektcelle konstrueres. Dagens base koster 6kr, og er svært konkurransedyktig.
- Stiv, vakuumformet del blir henlagt etter samtale med Svein i Nyplast.



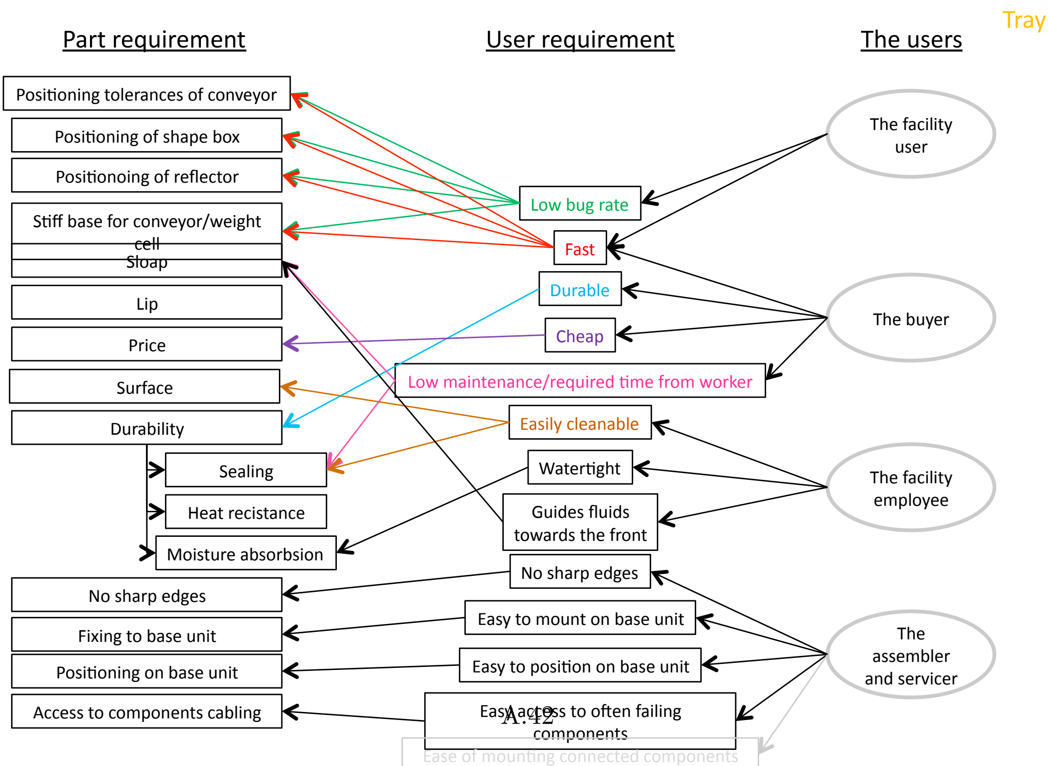
Design review 15.04.13

The spill tray of the T-9

Frist: Requirements

Mål med review:

- Er det krav dere savner?
- Gjennomførbarhet etter kravene
  - Vil dette fungere i praksis?
- Tips og triks for å få å nå målene.



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Positioning of shape box	Two cut-outs on far right flange.	
Positioning of reflektor	Loose toleranse, 1° + <2° / - >0,3°	
Stiff enough to provide a steady base for conveyor weight cell	Tray deflection <1,4mm in front of base with 10kg load at conveyor tip.	Todays solution has 1,4mm deflection in front of base with 10kg load at the conveyor tip. Vibrations should be minimized.
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Surface	Smooth, enabling easy cleaning. No sharp bends.	
Edges	Avoid sharp edges and corners	To minimize personell damage upon assembly
Price		
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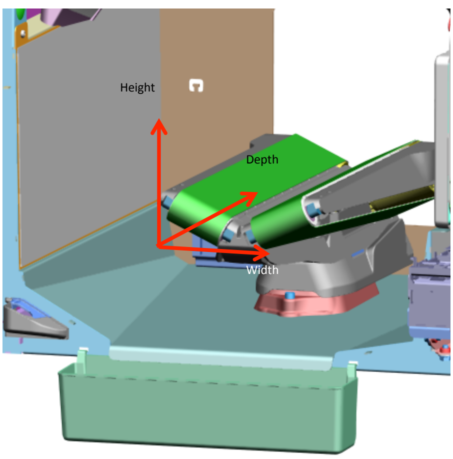
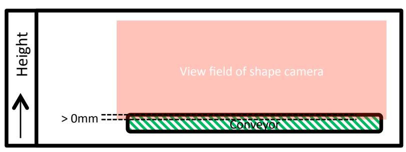
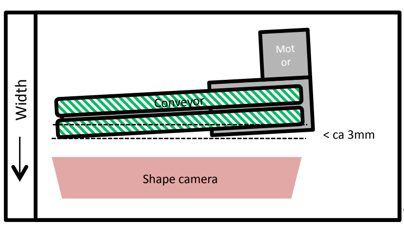
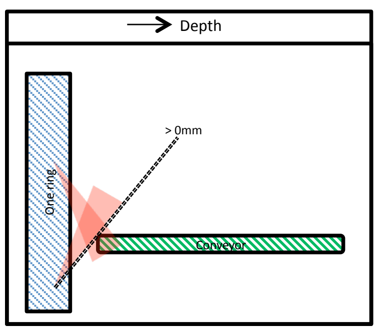


Posisjonstoleransene



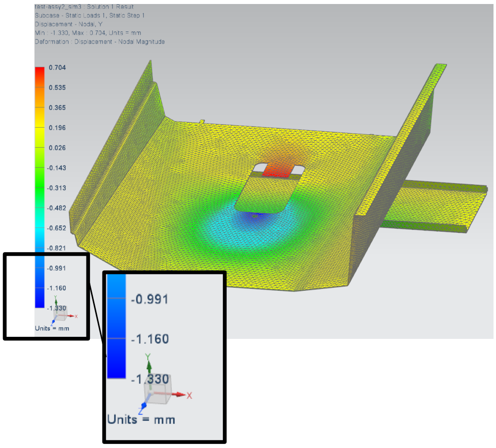


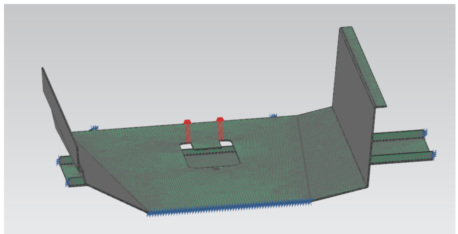


Stivhet i innspenning

Dagens løsning ble simulert for å få inntrykk av stivheten i systemet.

Last ekvivalent til 10kg på tuppen av transportbånd.



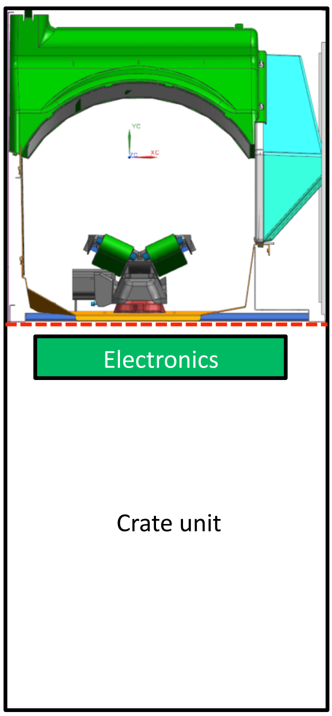


Innfesting og krefter opp i bakkant, ned i hull forran.

*Kan gi for «snille» krav, fordi kraft ned foran vil fordeles over et større areal langst kanten.
*Motorens vekt er ikke med.

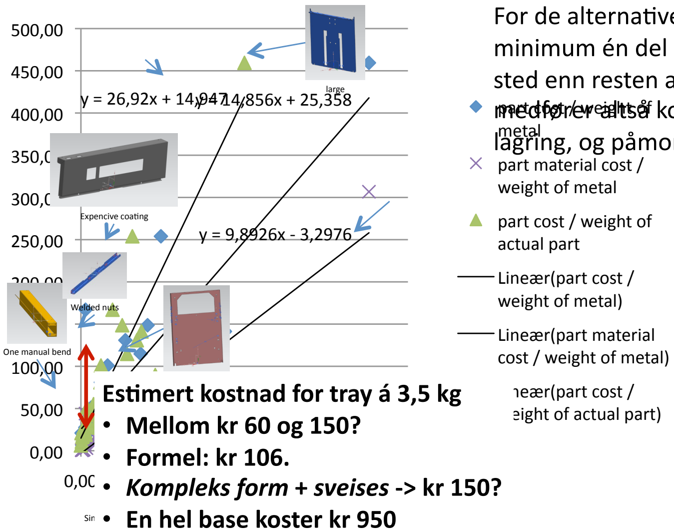
Tetting og «vanntetthet»

Hvis den nye Crate uniten ikke får «tak» vil det være påkrevd av trauet å være 100% vanntett.



Kostnad

Med bakgrunn i kostnadene av deler i multipac, ser det ut til at 3x materialpris ikke er et dumt estimat. Litt over for komplekse deler, litt under for simple. Sveising og fancy lakk driver kostnadene



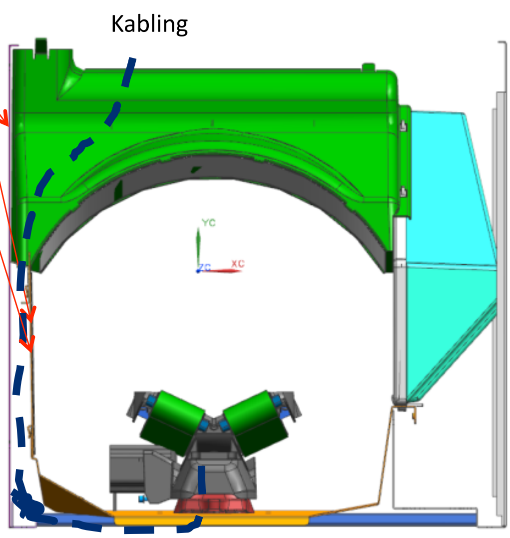
For de alternative konseptene vil minimum én del produseres ett annet sted enn resten av base uniten. Det medfører altså kostnader til transport, lagring, og påmontering på baseenheten.

Estimert kostnad for tray á 3,5 kg

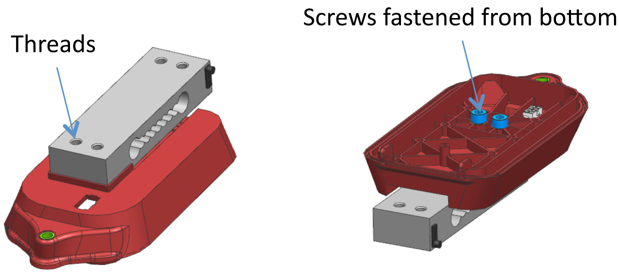
- **Mellom kr 60 og 150?**
- **Formel: kr 106.**
- ***Kompleks form + sveises* -> kr 150?**
- **En hel base koster kr 950**

Tilgang

- For å få tilgang til kabling under montasje tas venstre sideplate og refleksplate av.
- For å få tilgang til kabling etter montasje i butikk blir refleksflate og reflektor buen fjernet.
- Ved å gjøre trauet uttakbart, bør venstre sideflate kunne integreres i base uniten som en sveiset del. Tilgang til kabling vil alltid skje fra innsiden.



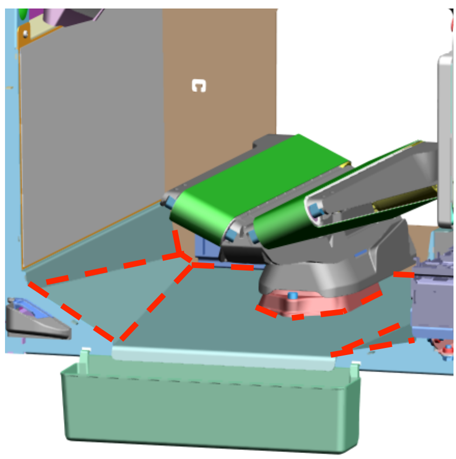
Tilgang 2



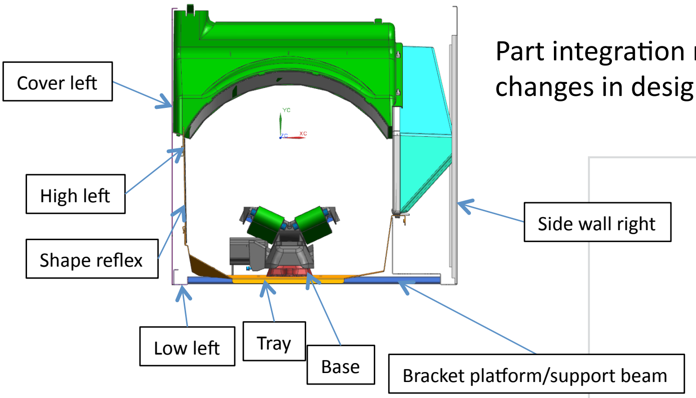
A fixed tray results in a separate base. The weight cell screws are mounted from the bottom, and hence unaccessable when the tray is mounted.
Brackets for access thorugh bolt in front of the built in base was constructed, but found unfeaseable as the current base costs approximately 6 NOK.

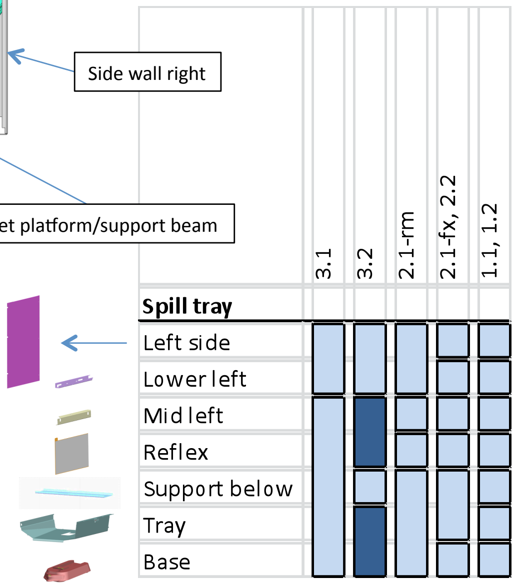
Vaskbarhet

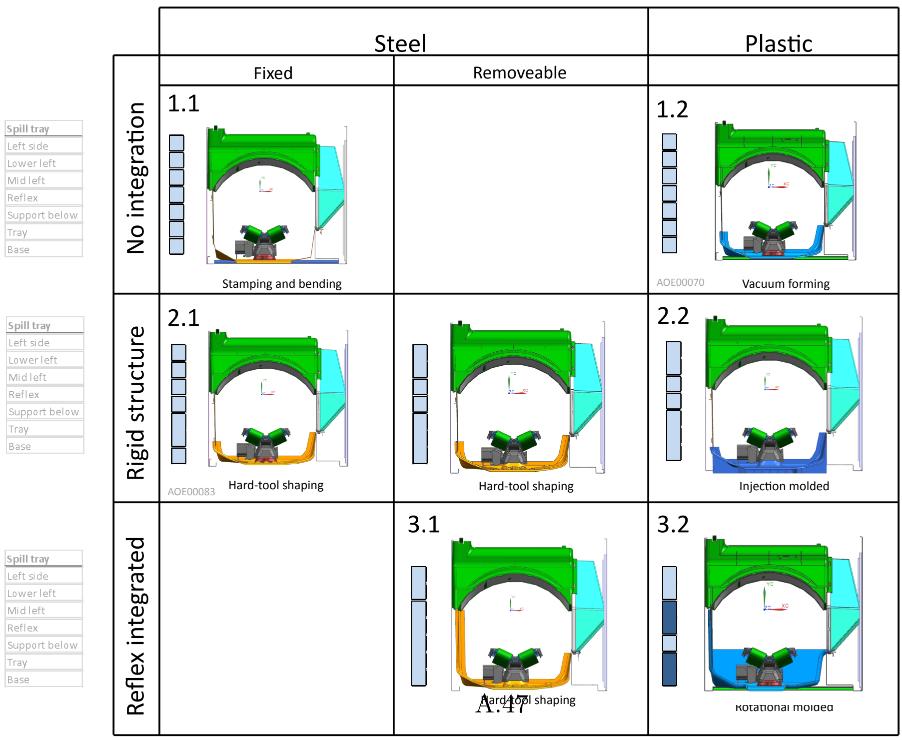
Dagens trau har mange kanter og kroker som er potensielt kjipe å rengjøre.



Part integration made possible by changes in design



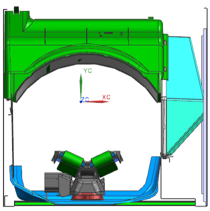




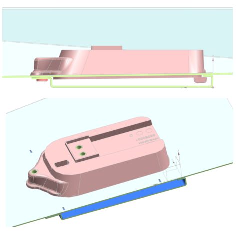
Consepts

Konsept 1.2

- Uttakbar, innfesting i front og bakkant med klips/ skruer.
- Vektcelle tilgjengelig

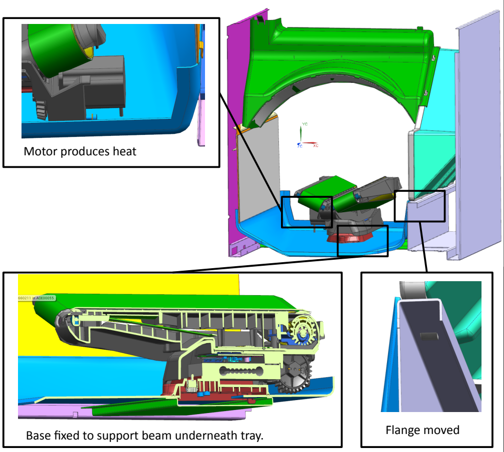


10kg på tuppen av conveyor



- Original base, forlengede «kroker» for innfesting.
- Ny tverrbjelke gir all stivhet
- INGEN TESTING UTFØRT.

Vacuum formed



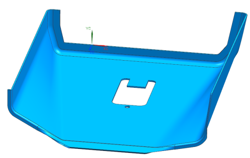
Fordeler:

- Enkelt å rengjøre.
- Lav kostnad for delen

Ulemper:

- Ikke en integrert/innsveiset del av base uniten, kanskje mer arbeid i montasje?
- Tett i bakkant av trau?
- Er bjelken/kan en bjelke være stiv nok?
- Posisjonering?

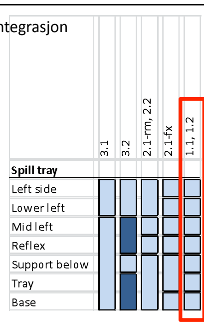
Posisjonering	Stivhet	«Tetthet»	Kostnad	Tilgang	Vask



- Like mange åpninger i bunnen som dagens løsning.

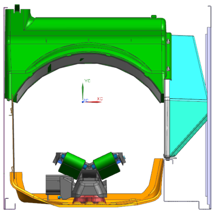
Del: kr 42 pr. stk. i Norge
Aluverktøy: kr 17.000

Delintegrasjon

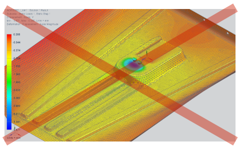


Konsept 2.1-fixed

- Tenkt fastmontert, uten mulighet til å fjernes.
- Sveises inn med de andre komponentene i basen

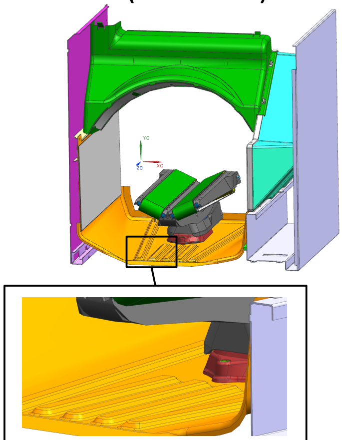


10kg på tuppen av conveyor



- INGEN SIMULERING UTFØRT
- «Storebror» klarte seg bra
- Mulig man må bruke bjelke, og kutte ut ribbene.

Steel fixed (ext. Base)



Flange moved. Pattern of bulges for stiffening.

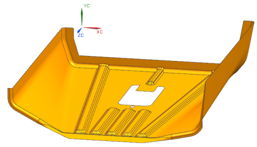
Fordeler:

- Moderat enkel å rengjøre (veldig enkel om bjelke må benyttes).
- Lav kostnad for delen (antakelig)
- Eliminerer én del.

Ulemper:

- Besparelse?
- Produksjon foregår *manuelt* i Kina

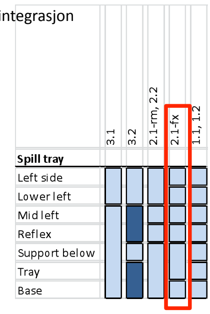
Posisjonering | Stivhet | «Tetthet» | Kostnad | Tilgang | Vask



- Like mange åpninger i bunnen som dagens løsning.

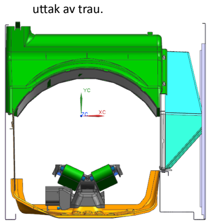
Del: ? pr. stk,
Verktøy: kr 350-500.000

Delintegrasjon

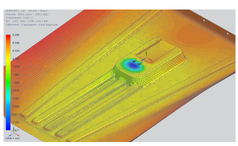


Konsept 2.1-removeable

- Uttakbar, innfesting i front og bakkant med skruer.
- Vektcelle tilgjengelig ved uttak av trau.

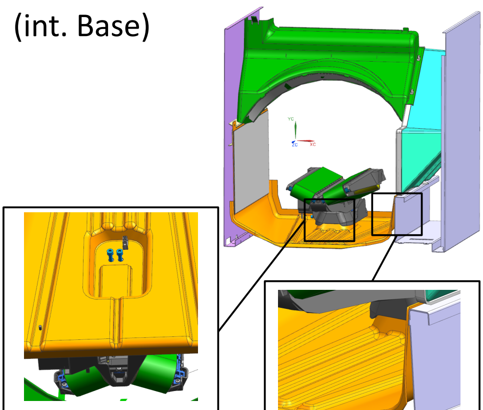


10kg på tuppen av conveyor



- Simulering på 0,7 stål gir samme utbøyning som dagens løsning med bjelke.
- Mye av deformasjonen tok sted omkring hullene -> gjør simulering mindre riktig.
- Med økt tykkelse, og bedre løsning for festing av skruer kan mye løses?

Steel removeable
(int. Base)



Base included in tray. Screws for weight cell.

Flange moved. Bulges for stiffening.

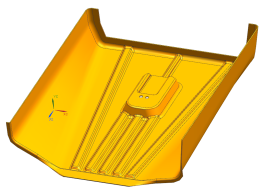
Fordeler:

- Moderat enkel å rengjøre.
- Mulighet for å eliminere 3 deler.
- Lav kostnad for delen (antakelig)

Ulemper:

- Ikke en integrert/innsveiset del av base uniten, kanskje mer arbeid i montasje?
- Tett i bakkant av trau?
- Produksjon foregår *manuelt* i Kina

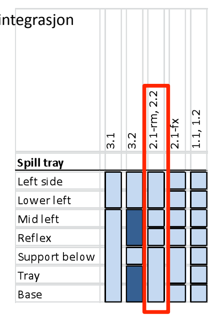
Posisjonering | Stivhet | «Tetthet» | Kostnad | Tilgang | Vask



- Færre åpninger i bunnen enn dagens løsning.

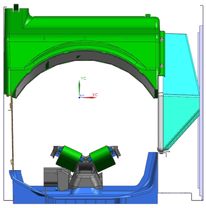
Del: ? pr. stk,
Verktøy: kr 350-500.000

Delintegrasjon

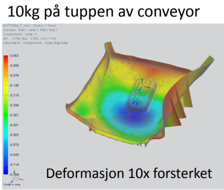


Konsept 2.1-removeable

- Uttakbar, innfesting i front og bakkant med skruer.
- Vektcelle tilgjengelig ved uttak av trau.

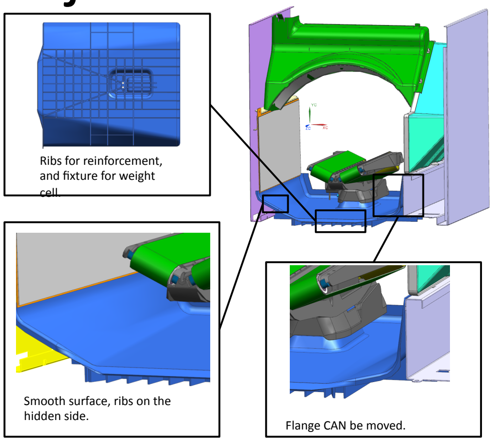


10kg på tuppen av conveyor



- Med litt for lange 2 og 3mm brede ribber, og 2mm form i ABS blir stivheten en del bedre enn dagens.
- Man får også spenninger som forsøker å bule sidene innover.
    - Trau kan festes i sidene.

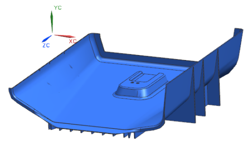
Injection molded



Fordeler:
- Svært enkel å rengjøre.
- Mulighet for å eliminere 3 deler.
- Lav kostnad for delen.

Ulemper:
- Ikke en integrert/innsveiset del av base uniten, kanskje mer arbeid i montasje?
- Tett i bakkant av trau?

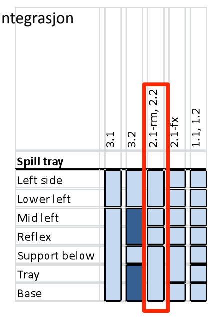
Posisjonering	Stivhet	«Tetthet»	Kostnad	Tilgang	Vask



- Færre åpninger i bunnen enn dagens løsning.

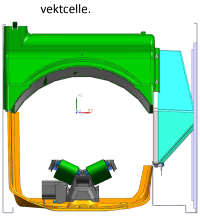
Del: ? pr. stk,
Verktøy: kr 350-500.000
Forespørsel ligger inne

Delintegrasjon

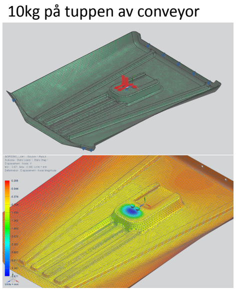


Konsept 3.1

- Uttakbar, innfesting i front og bakkant med skruer.
- Trau må ut for bytte av vektcelle.

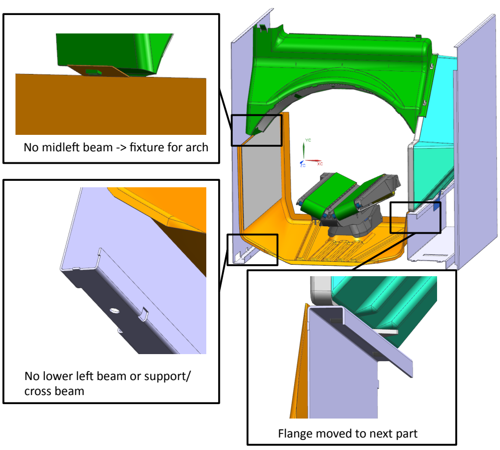


10kg på tuppen av conveyor



- Omtrent samme deformasjon som originalt oppsett med 0,7mm plate.
- Store deformasjoner omkring hull for innfesting av vektcelle -> mulig at mye av kreftene forsvinner dit, og deformasjonen skulle vært noe større.
- Mulighet for å legge ringer omkring hull/brakett på undersiden?

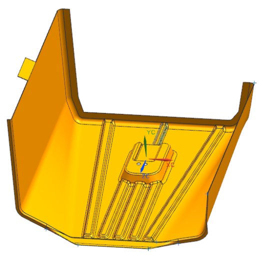
Steel all inclusive



Fordeler:
- Muliggjør eliminasjon av 4 deler.
- Estimert/tippet kostnad konsept: ?
- Relativt enkel å rengjøre?
- Bedret tilgang til kabler ol. Når maskinen står i butikk.

Ulemper:
- Mulig for væske å komme ned i bakkant av trau?
- Produksjon foregår *manuelt* i Kina.

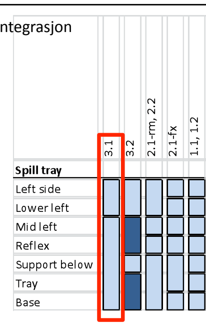
Posisjonering	Stivhet	«Tetthet»	Kostnad	Tilgang	Vask



- Innfesting med f.eks. skruer i front og bakkant.
- Ingen utvei for væske utenom fram og ut.

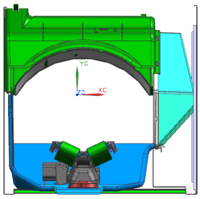
Del: ? pr. stk,
Verktøy: kr 350-500.000
Forespørsel ligger inne

Delintegrasjon

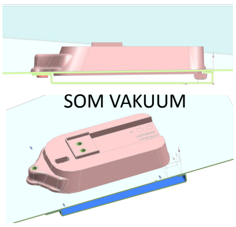


Konsept 3.1

- Uttakbar, innfesting i front og bakkant med klips/ skruer.
- Ekstern base

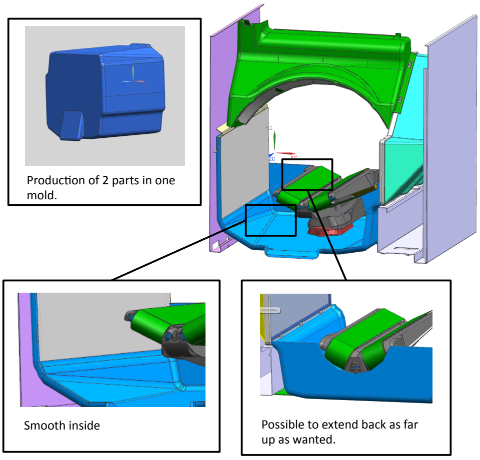


10kg på tuppen av conveyor



- Original base, forlengede «kroker» for innfesting.
- Ny tverrbjelke gir all stivhet
- INGEN TESTING UTFØRT.

Rotational molded



Production of 2 parts in one mold.

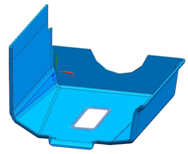
Smooth inside

Possible to extend back as far up as wanted.

Fordeler:
- Muliggjør eliminasjon av 3 deler.
- Enkel rengjøring
- Bedret tilgang til kabler ol. når maskinen står i butikk.

Ulemper:
- Potensielt kostbar prosess.
- Varierende kvalitet og tykkelse.

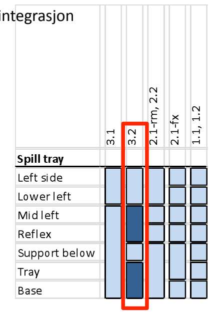
Posisjonering	Stivhet	«Tetthet»	Kostnad	Tilgang	Vask



- Like hullete i bunnen som dagens løsning

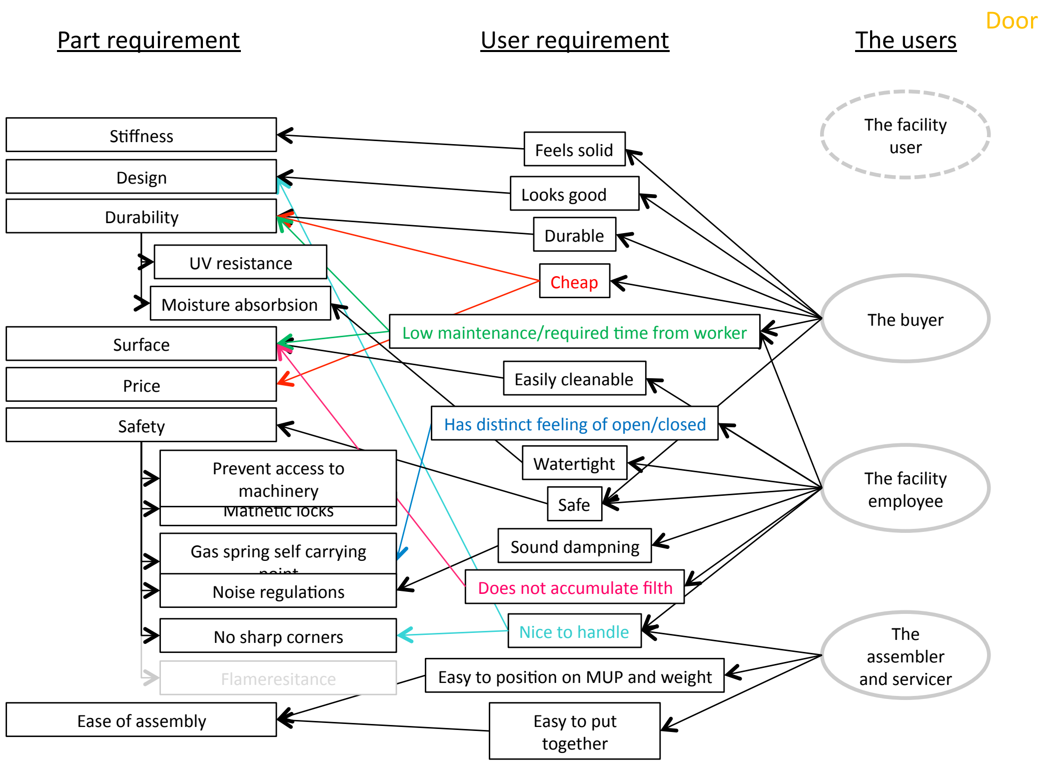
Del: kr 198 pr. stk,
Verktøy: kr 120.000
Cipax

Delintegrasjon



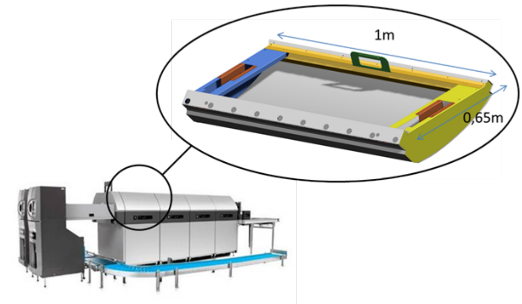
The upper door of the Multipac cabinet

Reqirements



Product requirement spesification		
Stiffness	Subjective optinion	
Design	Keep todays exterior lines. Easy to open and close.	Todays exterior is award winning, and hence should not be tampered with. Changes are run through Silje (the designer). The profile acts as handle, and should provide sufficient grip to open.
Durability	7 years.	The part should withstand wear and tear of 7 years operation. Keywords: UV-resistance, mostiure absorbtion, corrosion etc.
Surface	Smooth, no open up-facing U-profiles	
Price	<570 NOK	
Safety	Prevent access to machinery	
	Contain 2 magnetic locks	
	2 gas springs carrying the door at horisontal opening	
	Noise level <80dB-A over rep. working day, <120dB-C peak	Current setup is approved. Measures to reduce noise has been tried, without luck. The noise escapes the cabinet at many points making the importance of the doors soundproofness questionable.
	No sharp corners	
	Flame resistance	Due to UL? Standards in the US
Ease of assembly	Lowest possible weight, minimum amount of parts and fastners.	

Stivhet



Må føles solid nok.

Dagens løsning tåler atomkrig.

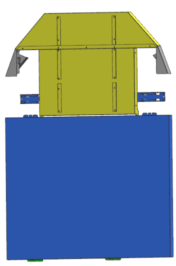
Er det nødvendig?

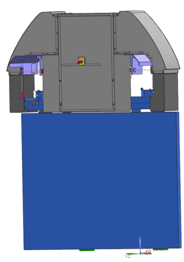
Design

Dagens løsning har et karakteristisk ytre som skal bevares.

Innvendig er det rom for endringer.

Om sideløse dører skal benyttes må den ene enden av maskinen (gul og grå del under) endres.

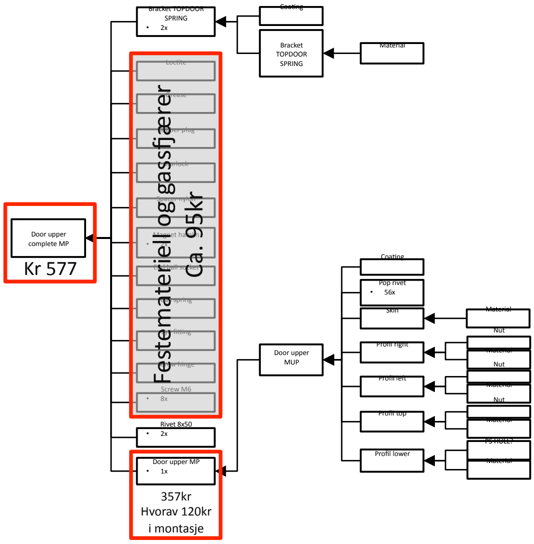




Kostnad

Må være billigere enn:

- Kr 577 for ferdig montert på multipac
- 577-95 = **482 kroner uten gassdemper og hengsler.**



Montasje

2x2 skruer fester magnetbryter

2x4 skruer fester brakett for gassfjær
2 braketter for gassfjær - 2 knekker hver

2 bolter for å feste gassfjær
4 spacere i plast til gassfjær
2 låseringer el. fester boltene til gasssfjærene

2 gummipropper ligger mellom lokk og boks
2 magnetbrytere

1 profile low – 8 knekker, 1 håndknekk
1 profile top – 8 knekker, 1 håndknekk
1 profile left – 2 knekker
1 profile right – 2 knekker

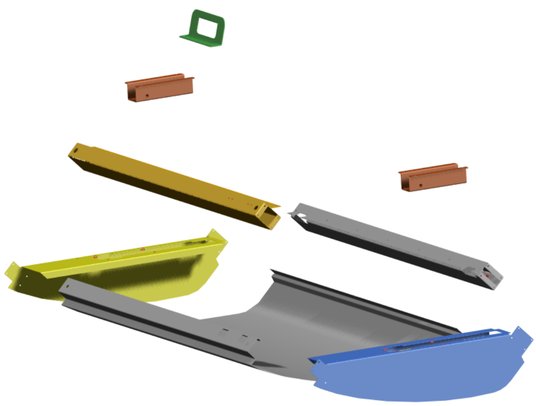
1 «skin» – 7 knekker

1 handle innside – 1 knekk, 1 fold

58 pop-nagler
20 pressmuttere

++

Dagens løsning inneholder svært mange komponenter som må settes sammen.
I tillegg er den tung 10,4 kg



To deler er ikke med i illustrasjonen

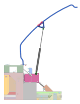
Slitestyrke

I følge Espen Lund dimensjoneres de fleste delene (teknisk sett) for 7 år i bruk.
Døra skal tåle en del væske, sollys, varme og kulde.

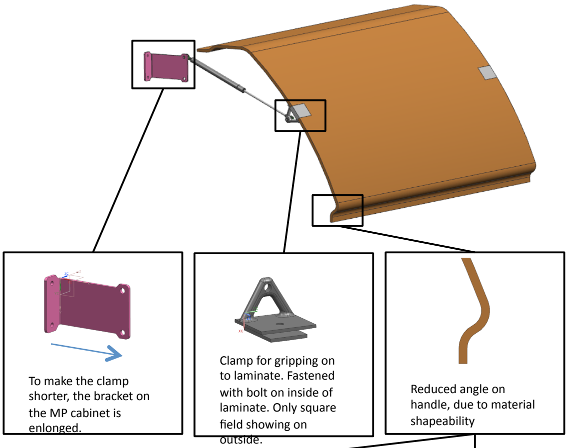
Laminat i bøk eller bjørk

- Pris: kr 435 for laminat uten «clamp».
- Verktøy/programmering: kr 100.000 / 7.000.
- Produksjon i Latvia
- Teoretisk pris etter Ekornes estimat: ca. kr 250.

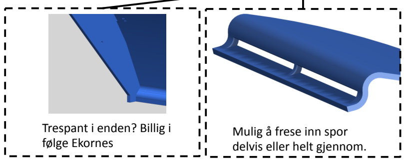
Fordeler:
Miljømessig gunstigst
Ser kult ut
Lett



Ulemper:
Krever dyktig produsent (vridning)
Holdbarhet?
Mindre stivt?



Deler:
1x Skin
2x Brackets
4-8x Screws



Forlenget brakett og endestykke

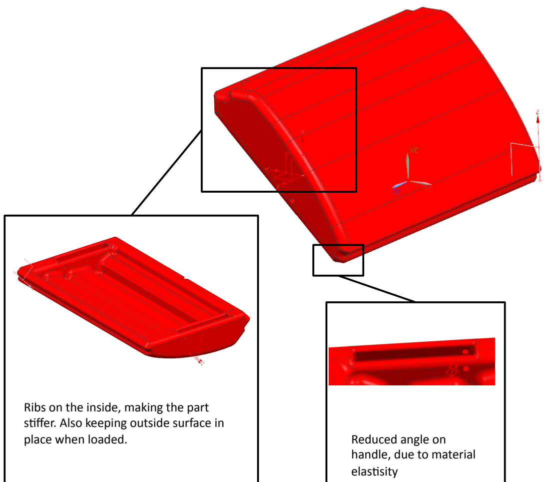
Stivhet	Design	Kostnad	Montasje	Slitestyrke

Rotasjonsstøp

- Pris: kr 357 hos Cipax på Bjørkelangen
- Forespeiler produksjon i Polen, med en del lavere kostnad.

Fordeler:
Miljømessig gunstig (PE)
Lett
Dobbel barriere mot lyd?

Ulemper:
Produksjonstoleranser og svinn
Utseende/material?



Deler:
1x Body m innstøpte muttere

Possible to mold part with nuts inside. Enables no additional work on part.

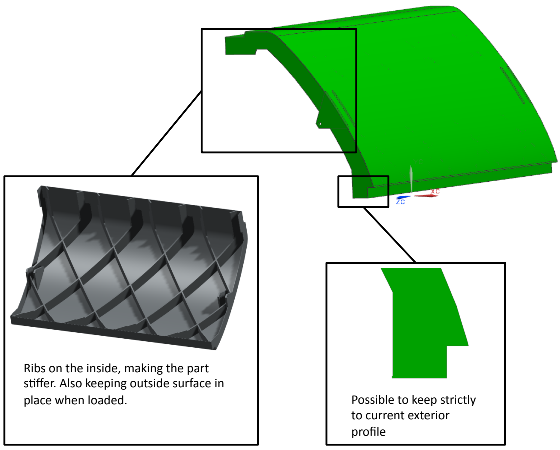
Stivhet	Design	Kostnad	Montasje	Slitestyrke

Reaction Injection Molding

- Pris: ?
- Produksjon i Kina

Fordeler:
Trolig billig
Lett
Mulighet for fine overflater

Ulemper:
Lite miljøvennlig
Material?



Deler:
1x «Skin» med innstøpte muttere

Forlenget brakett og endestykke

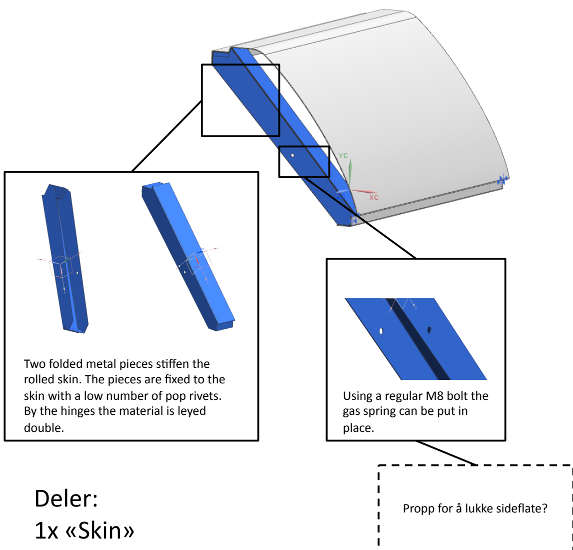
Stivhet	Design	Kostnad	Montasje	Slitestyrke

Valset profil

- Pris: kr 70/m profil (600x1000mm del, enkel, kr 50/m) + 2x braketter á ca. kr 55/stk = kr 170(+++)
- Verktøy: kr 150-500.000 (?)
- Produksjon i Danmark + Polen

Fordeler:
Trolig veldig billig
Lett
Samme lakk som i dag

Ulemper:
Stivhet ved dagens prototype?



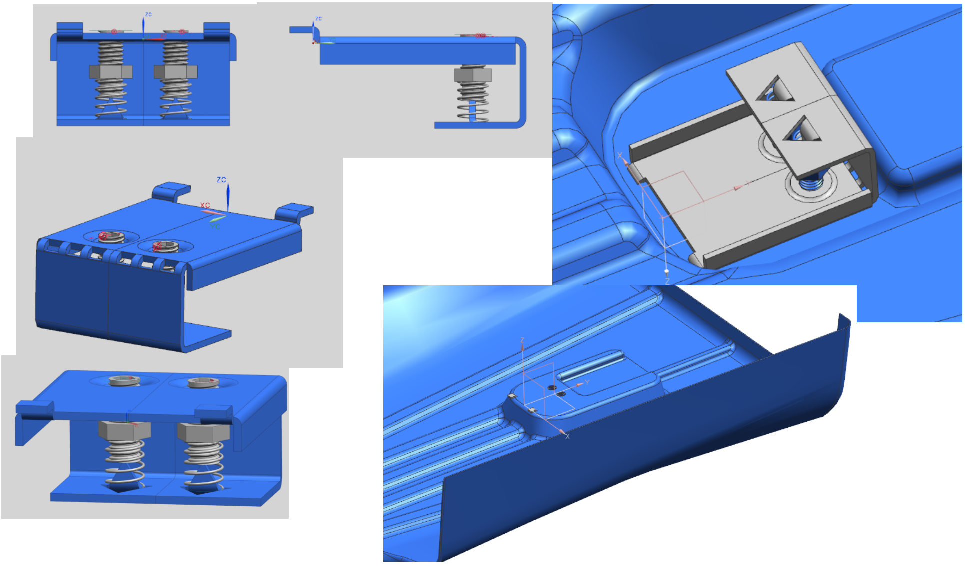
Deler:
1x «Skin»
2x profiler
8-10x popnagler

Nytt endestykke

Stivhet	Design	Kostnad	Montasje	Slitestyrke

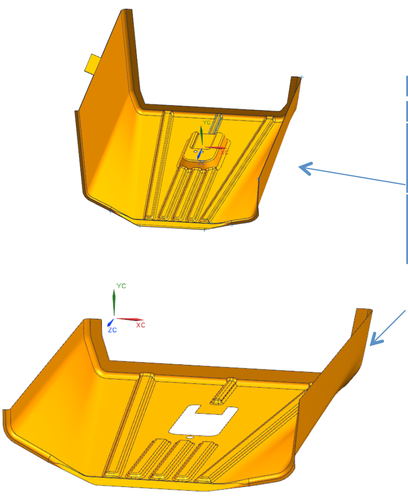
Siden sist:

- Tenkt på hvordan man kan løse ståltrau med innebygget base, SOM er sveiset fast.



Siden sist:

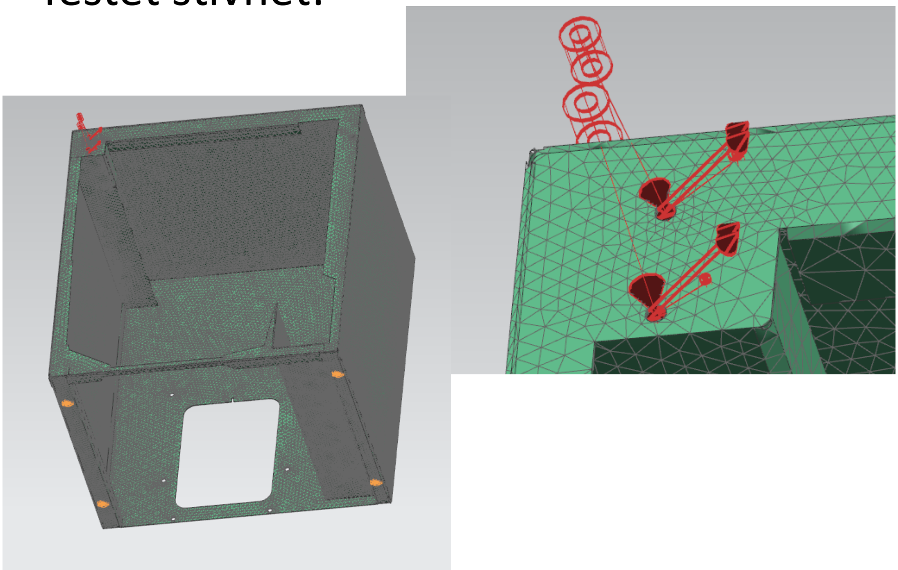
- Fått priser fra kina på dyptrekkdeler



		Part Price(W/O VAT)		Tool Price(W/O VAT)
		Aluzinc	SECC	
AOE00062	5000pcs/yr	¥54.49	¥52.72	¥213,600.00
	2000pcs/yr	¥59.94	¥57.99	
	1000pcs/yr	¥65.39	¥63.26	
AOE00083	5000pcs/yr	¥41.79	¥40.58	¥176,400.00
	2000pcs/yr	¥45.97	¥44.64	
	1000pcs/yr	¥50.15	¥48.70	

Siden sist:

- Testet stivhet:



Egenvekt av dør uten trau
Rett ut

0,33mm total utbøy

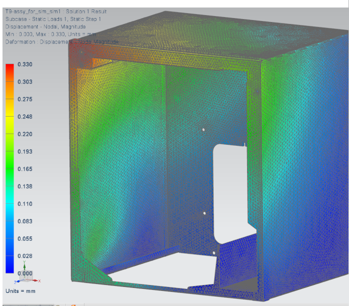
3x egenvekt 0,99

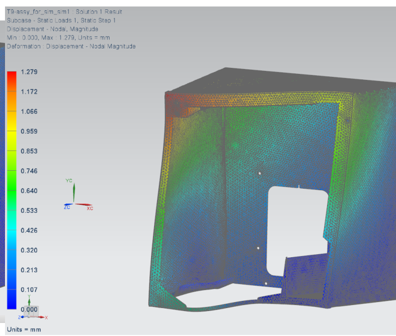
3x egenvekt
45 grader åpning

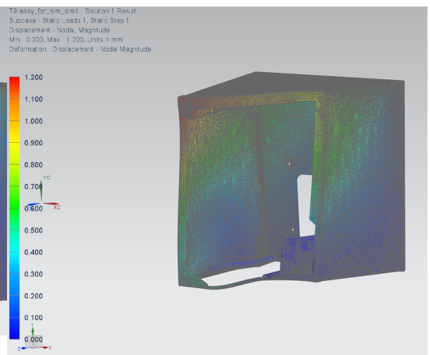
1,28mm total utbøy

3x egenvekt
Lukket uten støtte

1,2mm total utbøy

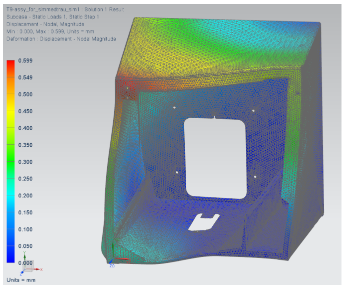






3x egenvekt
45 grader åpen

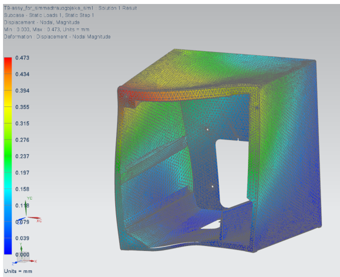
MED TRAU
0,6mm

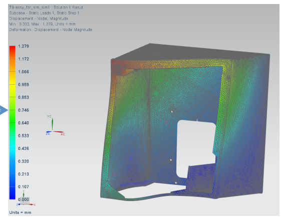


0,47mm -> 1,28mm
Når trau er ute av maskin

3x egenvekt
45 grader åpen

MED TRAU OG BJELKE
0,47mm





Siden sist:

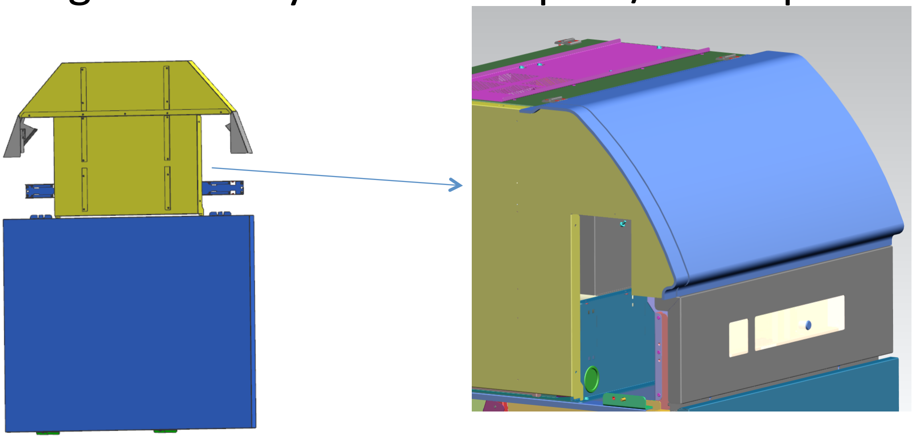
- Kontakt med Ekornes
  - Mener pris er litt stiv, vil ikke regne på det – uetisk.
  - Mener tilbudet bør inneholde retningslinjer for retur ved vridning.
  - Usikker på holdbarhet, mener UV-lakk bør vurderes.
  - Tror brakettene er store nok (?).

Siden sist:

- Kontakt med Becker
  - Ønsker tilbud nr. 2.
  - De har masse kunnskap, fisker etter lakk/ holdbarhets-info.

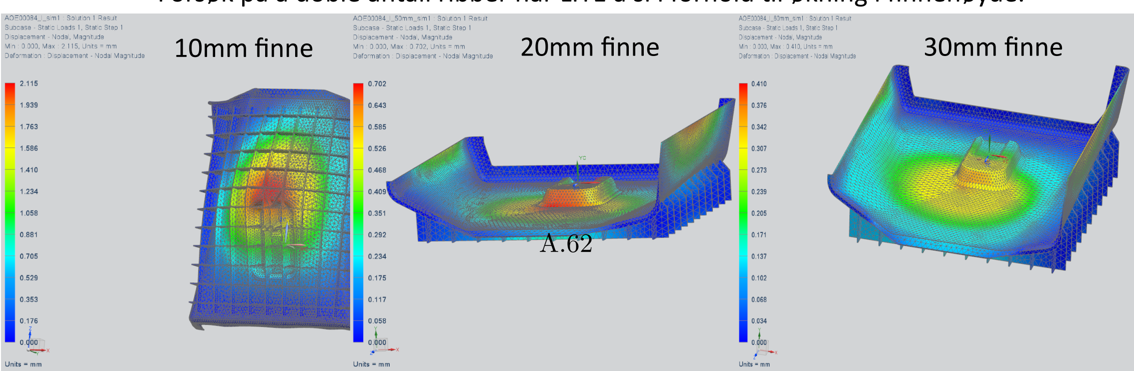
Siden sist:

- Laget endestykke for trespant/valset profil:

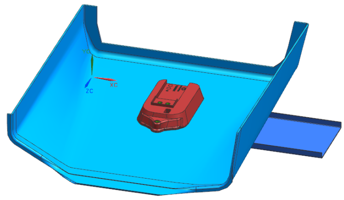


Siden sist:

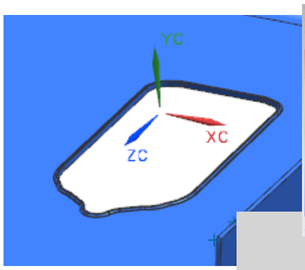
- Simulert stivhet i sprøytestøpt del:
  - Hvis finnehøyde er større enn tilgjengelig plass -> finner stikker ned i crate unit, er stivhet mer enn god nok.
  - Hvis finnehøyde er innenfor det tilgjengelige i baseuniten, er *ikke* stivheten god nok.
  - Kristian mener det er dumt å la den stikke inn i crate pga mulige fremtidige endringer i dens design/bruk i andre maskiner.
  - Forsøk på å doble antall ribber har LITE å si i forhold til økning i finnehøyde.

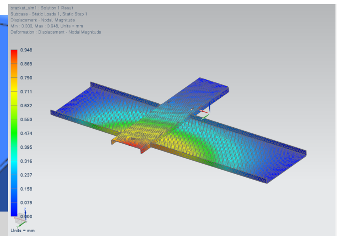


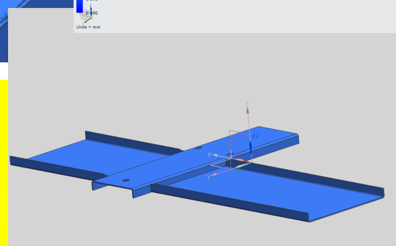
Siden sist:

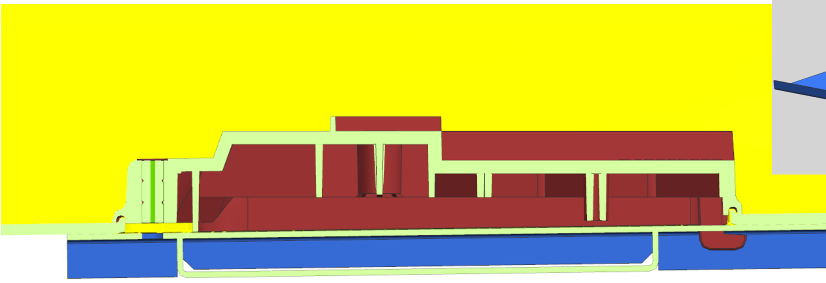


- Vekuumformet del -> kant opp
- Laget og simulert stivere bjelke for bruk med vakuumtrukket trau.



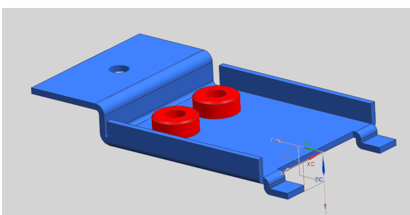


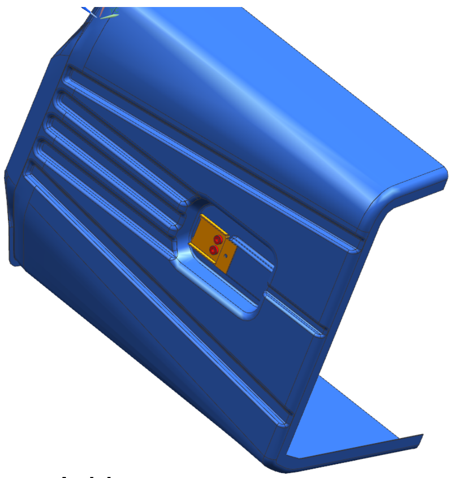




Siden sist

- Stål not fixed -> brakett for stivh
  - Simulere?

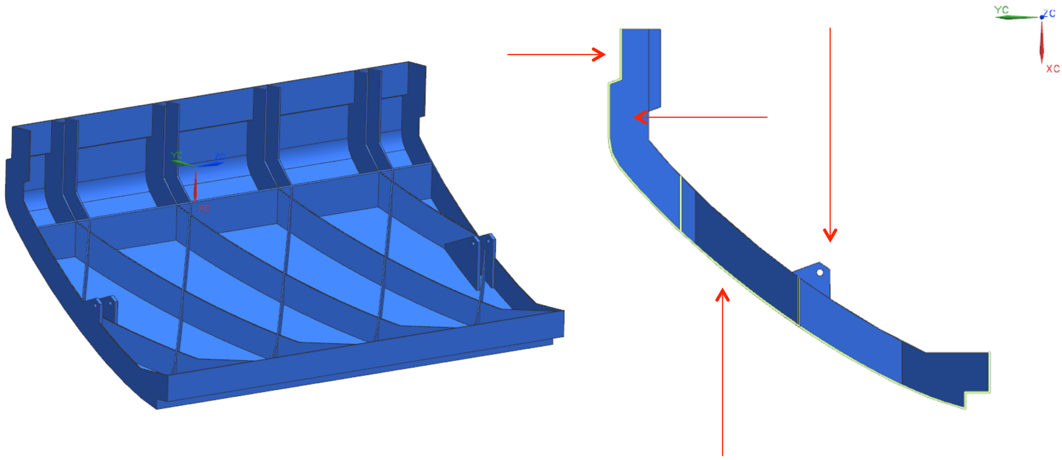




- Dimensjoner på rotasjonsstøpt del -> sjekket

Siden sist:

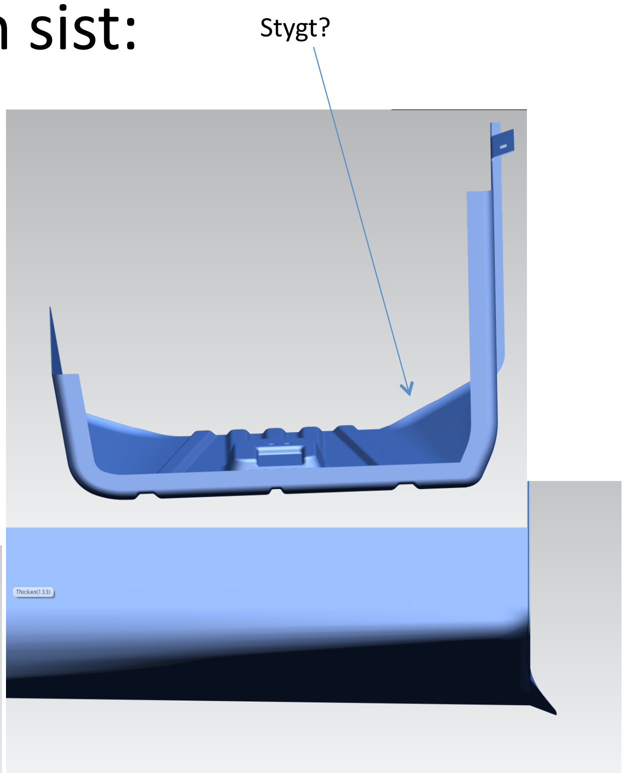
- RIM -> gjennomførbart design. Ikke gunstig form



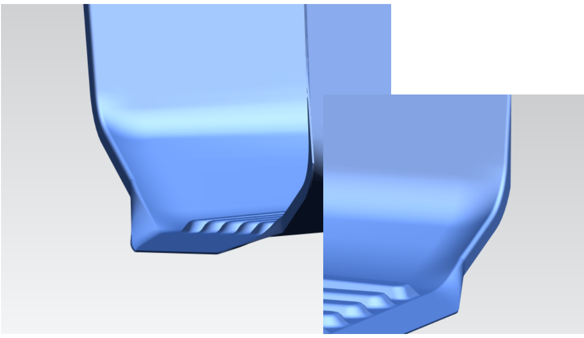
Siden sist:

- Kontakt med IB Andresen -> Ikke mulig å valse profil.
- Kontakt med Bendiro -> Kan selv ikke valse profilen, men mener Welser i Østerrike kan.
- Kontakt med Welser -> Skal undersøke muligheter. Er positive.

Siden sist:



- Fikset form på trau for å sikre at vann ikke renner ut på sidene av oppsamlingstrauet.



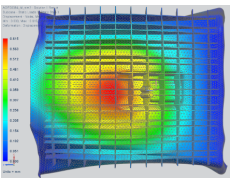
Neste steg:

- Innfesting
- Tetting
- Tilbakemelding fra Welser – Rulleformet stål
- Tilbakemelding Becker – Laminat (ny pris)

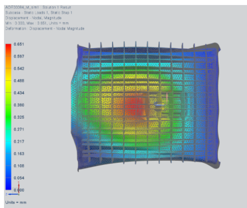
Siden sist:

- Forhørt meg med Tom Veble om endringer på ståltrau vil gi prisendring. Han mener endringene ikke har noe å si.
- Simulert ståltrau med slakere front. Gir større spredning i utbøyning, men ikke noe mindre.

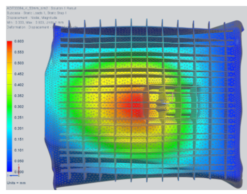
AOE00084-m-sim2
Stor vinkel-> ribbe

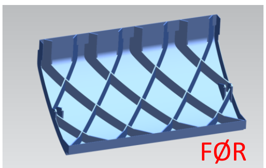


AOE00084-m-sim1
ca45grader ->ikke ribbe

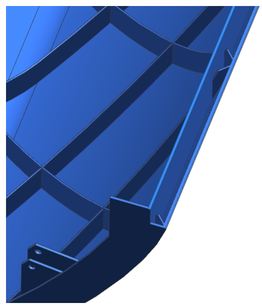


AOE00084-k-sim2
liten vinkel -> ribbe

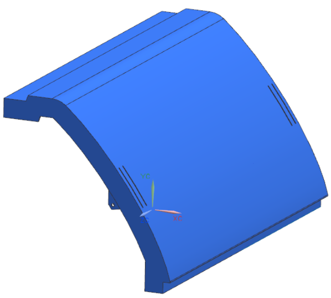


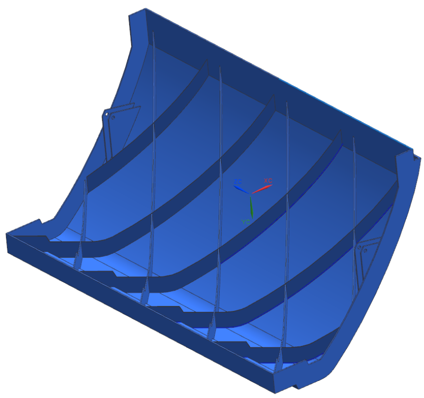


Siden sist:

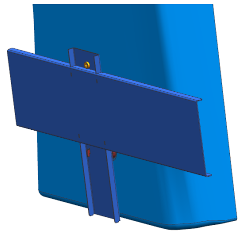


- Byttet vaffelretning på RIM dør
  - Kan produseres i todelt verktøy.
  - Ikke fullstendig tetting mot håndtak.

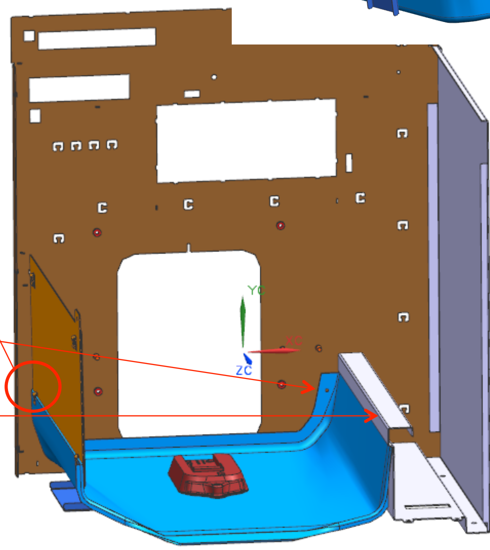




Siden sist:



- Tetting



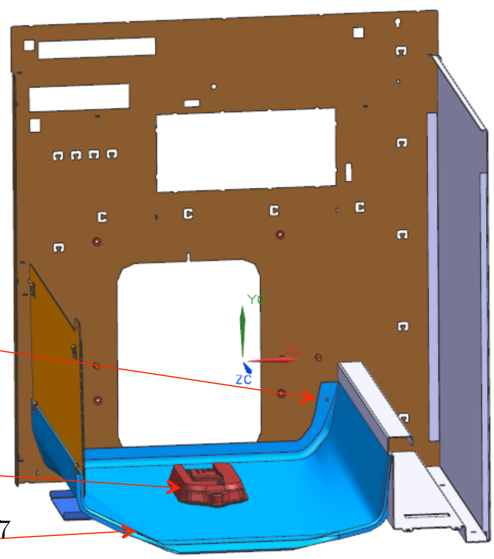
Problem?

Ser for meg en pakning i bakkant?
Hva slags? Hvordan?

Knekt hylle dekker kant trau
Godkjent av Pontus

Siden sist:

- Innfesting
  - Vakuum



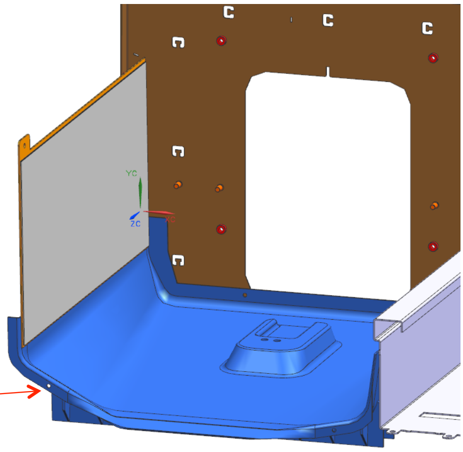
2x Skruer for at trauet ikke skal vike når det vaskes

Base holder på plass

Trau hviler på front

Siden sist:

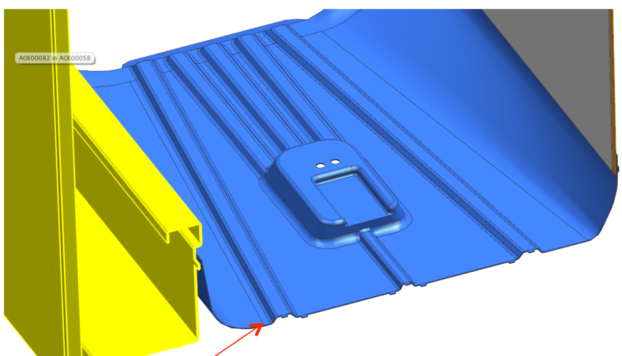
- Innfesting
  - Sprøytestøp



2 Skruer foran
2 Skruer bak

Siden sist:

- Innfesting
  - Stål innsveiset

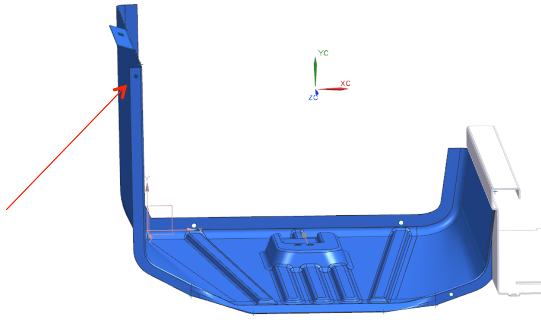


7 Tabs bak pga ingen vertikal kant til å stive av
2 foran + Hviler på front

Siden sist:

- Innfesting
  - Stål hel skrudd

2 skruer i front
2 skruer bak

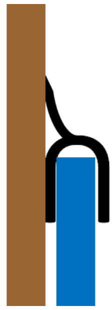


Siden sist:

- Får ikke kontakt med Becker for pris nr 2 på laminat
- Welser (rulleforming) kommer snart med tilbakemelding på rullet profil til dør.
- Tatt opp skrivingen igjen
- SPØRSMÅL: Hvor nøye skal jeg følge opp delene rundt trauet?

Siden sist:

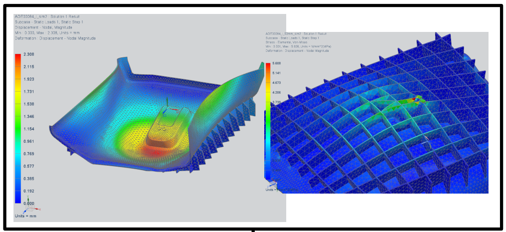
- Tetting i bakkant
  - Stikke gjennom
    - Stikke bakkant igjennom -> No stikker ut på baksiden -> Der skal moduler monteres ☹
    - Hull på bakplate er så stort som det er for at ikke korker el. skal kunne kile seg fast mellom kant og transportbånd -> Gjennomføring av trau vil svekke bakplate betydelig.
  - Brette over
    - Bakkant får flens som i dag, men den rette delen av flensen brettes over et bredere hull i bakplata.
    - Stikker også utover bakplata.
  - Neopren tape
    - Norsk Gummi foreslår å bare bruke en neoprentape.
  - Gummiprofil
    - Forespørsel er sendt til RJ Rygg om bruk av gummiprofil på kant av trau.
  - Brette fram
    - Mulig å brette kant fra bakplate fram fra bunnkant av hull?
  - Kombinasjon?



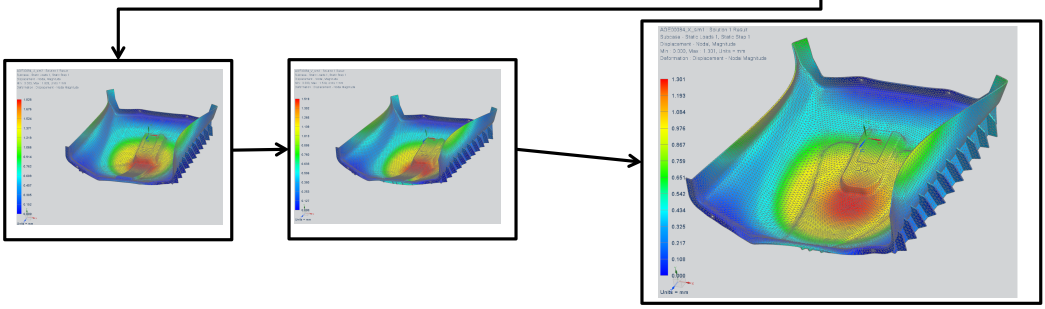
Siden sist:

- Tilbud på laminat fra Becker
  - 46 euro = kr 340.
  - Med CPL = *Mehrschichtig aufgebautes Laminat, dessen hochwertige Harze eine ausgezeichnete Oberflächendichte und Abriebfestigkeit aufweisen.*
  - Ønsker man CPL overflate? Hva er det?
  - Forespørsel sendt, bortreist til 27.05...

Siden sist:

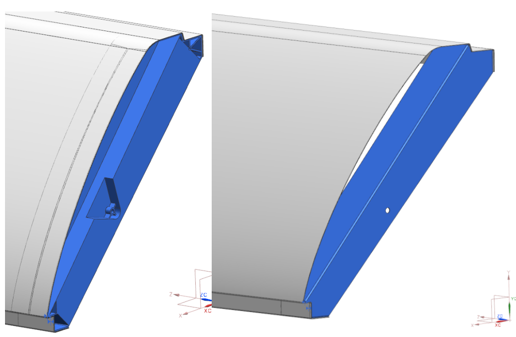


- Simulering av sprøytestøpt trau.
- Rettet og gjort på nytt gamle simuleringer (feil last) – uten at det ga noe særlig annerledes resultat.
- Forhøyet gulv gradvis og på stedene med høyest spenninger.
- Forespørsel sendt til kina om kost og produksjon.

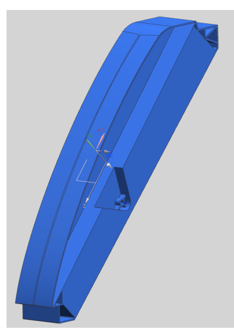


Siden sist:

- Rullet profil
  - Braketter
  - Åpen eller lukket sideprofil?



  - Knekket stål ca. kr 65/stk
  - Sprøytestøp ca. kr 20/stk
    - Forespørsel om pris sendt til Kina.



Framover:

- Gjøre ferdig modellering…

- Skrive om utviklingsprosessen.
  - Skal ikke være kronologisk men følge en produktutviklingsmetodikk
    - Analyse
    - Syntese
    - (Simulering)
    - Evaluering

    Hmmmmm….

Siden sist:

- Eco99-indicator gjort nesten ferdig analyse for dør
  - Spørsmål om sink
  - Spørsmål om støping
  - Trau gjenstår
- Kostnads estimering
  - Logistikkostnader: Snakket med mange på huset. Kommet fram til taktikk.
  - Montasje: Spurt Pontus, gjort MTM-UAS analyse med usannsynlig resultat.
- Tettning, får tilsendt tetningslist fra Otto Olsen.
- Skrevet mye

Assembly of the current common base unit					
	Distance	Repeated	Code	Time [TMU]	Time [sec]
Pickup and placing of rear plate			AH1	25	0,9
Pick up and place on table - lower and higher left bracket, and right sidewall	2,5m		AH2	45	1,62
Placing of right wall			PC1	30	1,08
Twist tabs for secure position right wall		2	ZB1	20	0,72
Placing of high left			PC1	30	1,08
Twist tabs for secure position high left		2	ZB1	20	0,72
Placing of lower left			PC1	30	1,08
Twist tabs for secure position lower left		2	ZB1	20	0,72
Pick up and place on table - top wall, cable support and tray	2,5m		AH2	45	1,62
Placing of top wall			PC1	30	1,08
Twist tabs for secure position of top wall		2	ZB1	20	0,72
Placing of cable support			PC1	30	1,08
Twist tabs for secure position of top wall		4	ZB2	40	1,44
Placing of tray			PC1	30	1,08
Twist tabs for secure position of tray		6	ZB1	60	2,16
Pick up and place on structure - front surface			AK2	75	2,7
Twist tabs for secure position of front surface		8	ZB1	80	2,88
Placement in jig for correct angles	1m		AK1	50	1,8
Visual control			VA	15	0,54
Welding of front surface points		19		1900	68,4
Turning			ZA1	5	0,18
Welding of rear surface points		20		2000	72
Grinding of welds and tabs		39	HC1	1950	70,2
					165,6
Driftsteknisk tilleggstid (15%)					24,84
Operatør-tilleggstid (5%)					8,28
Tillegg for hvile (25%)					41,4
					240,12

En punktsveis tar 3,6 sek?

A.73

Logistikkostnadsestimering

- Transportøkonomisk institutt sier:
  - Logistikkost: 40% transport, 40% lager, 20% annet.
  - Transport koster ca 8000 for trailer fra sentral-europa til polen, 12000 til norge.
- Konteiner fra Kina koster ca 20000kr (40')
  - Skal ta kontakt med lagerhus for å forhøre om pris.

Production									
Materials, processing, transport and extra energy									
material or process	amount		indicator		result	assumption			
Wood board	7,0	kg	39	mPt/kg	273				
Pressure forming	7,0	kg	6,4	mPt/kg	44,8	Same value as for plastic			
~~Zink cast brackets~~	~~0,4~~	~~kg~~	~~3200~~	~~mPt/kg~~	~~1280~~				
Aluminum cast brackets	0,4	kg	780	mPt/kg	312	Only new material			
Energy needed for casting	0,5596	kWh	46	mPt/kWh	25,7416	Double of European High Voltage			
Total					655,5416		79%		
Use									
Transport, energy and any auxiliary materials									
process	amount		indicator		result	assumption			
Transport Tanker	*42*	*tkm*	*0,8*	*mPt/tkm*	*33,6*	*25% av all transport*			
Transport Trailer 40t	*14*	*tkm*	*15*	*mPt/tkm*	*210*	*25% av all transport*			
				Sum	*243,6*				
				Sum x 25%	60,9				
Transport Trailer 28t	*7,35*	*tkm*	*22*	*mPt/tkm*	*161,7*	*75% av all transport, 1000km*			
				Sum x 75%	121,275				
Total					182,175				
Disposal									
Disposal processes per type of material									
material and type of processing	amount		indicator		result	assumption			
Average of paper/cardboard	7	kg	-4,75	mPt/kg	-33,25				
Total					-33,25		-4%		
Total (all phases)					832,2916				

H Communication

During the work communication found useful or interesting was written down in a document. This document is presented in the following. The document is in Norwegian.

Samtale med Tom 09.01.13

Base-enheten er laget med stivhet som overordnet mål, men med fokus på å minske materialbruken. Også trauet tilfører konstruksjonen stivhet.

Plastdesign har også blitt tegnet, men ikke utprøvd pga. usikkerhet og tid. Krever store radier. Trolig dyre verktøy. 500(?) 000 for front til T600. Anne-Carine er ansvarlig for prisinnhenting. Får ofte detaljerte kostnadsvurderinger.

Samtale med Hans Georg 10.01.13

Har sett på å dyp-trekke trau (i stål) Gamle prosjektleder var gira. Ikke gjennomført pga risiko, og tid.

Bak fronten kommer mange deler som fortsatt ikke er på plass. Store krav til stivhet på denne.

Kaldformet stål med høyt trykk til front har blitt prøvd. Store radier i hjørnene. 7 maskiner utfører slikt i verden. En i Danmark.

Plastkonstruksjon tar lengre tid å bli god på.

Sveising krever fagutdannet personell. Pop-nagler gjør det ikke. Bruker likevel sveis fordi det sparer flenser som må knekkes som er nødvendige når delene skal popes. Ved sveising brukes tabs som posisjonerer delene. Noen er gjennomgående og vris, og holder sådan delene på plass «som lego».

«Collin(?)» i kina henter inn anbud på sprøytestøping.

Samtale med Terje 10.01.13

Tror de øvre kabinettdørene på multipac kan endres (for mange popnagler, deler ++), muligens to lag plast med skum i mellom. Tror største utfordring er hengsler og montasjepunkt for gassfjæra er problematisk (punktbelastninger) da begge må kunne byttes (må skrus på el.). Hvis man kunne støpt inn hengslene i luka hadde dette antakelig vært løst. Tror ikke den nedre døra vil være like hensiktsmessig å gjøre i plast.

Samtale med Pål Arne 11.01.13

Mange av de mindre tynnplatedelene lages med progressive verktøy som gradvis former delene. De er små og mye av flyttingen av delene stegvis foregår manuelt, i kina. Besparelsene ved å flytte produksjonen til kina er stor, men det å innføre slike verktøy for forming bidrar med ytterligere ca. 30% besparelse (mye manuelt arbeid, ville sannsynligvis ikke gitt samme besparelse i vesten). Pris på verktøy tett knyttet til størrelse. Kompleksitet påvirker lite.

Mulighet for å lage bunntrau i plast. Så på mulighet for å gjøre flens som holder refleksjonsboks til del av annen plate.

Tror bunnflaten kanskje er for kraftig. Har uansett fire bein som skrus fast i kasse/komprimatorenheten.

Sammenføyning av plater ved trykk! Unngå sveis og nagler.

Samtale med Terje 14.01.13

«Dritt renner nedover» - Ikke lag åpne u-bjelker på bunnen av konstruksjonen.

Bruk én type nagler hvis mulig – hull ser like store ut, selv om de er noen millimeter i forskjell.

Samtale med Terje 15.01.13

20euro for stansing, 1,5euro for knekking, 40euro for «blåkrom»-behandling -> Overflatebehandling som følge av sveising er DYRT.

Samtale med Hans Georg 16.01.13

THERMOFORMINGSTIPS – Alltid avforming i tankene. Husk på at det blir forskjellig fra modell. Lag delen du vil ha produsert (ikke forma), produsenten f.eks. plexx leverer forma. Maskinering skjer med fres, og avtales med produsent – de ordner det.

Besøk hos Moss jern og stanseindustri 16.01.13

Pulverlakk koster 70kr/kg, 0,7kg/m^2.
600kr/time på stansemaskin
1200kr/timen på pulverlakk -> 2 mann på linja
FinnPower maskin stanser opp til 8mm stål. Derfra bruker man laser.
Det går mye gass til sveising av syrefast stål. Veldig kostbart.
Store deler som må blåkrommes må ut av bedriften. De kan ikke lages på linje, man trenger transport osv. Det blir dyrt.

UKEMØTE Katrin og Kristian 23.01.13

Fornøyde med at jeg skal på rotasjonsstøping hos cipax, synes finer er spennende. STØY er en faktor på maskinene. Bruk porøst materiale for å stanse lyd. Bruk glassvatt -> tar ikke til seg væske. Utprøvd hos firma i Arendal som lager interiør til skip (samme formål). Vanskelig å masseprodusere.

Hvem er brukeren i Brukerkravspesifikasjonen? Kjøper, bruker, montør?

Samtale med Pontus 23.01.13

Trau er festet i reflekspanel med spor som legger seg på hver side av trauet -> at kuttet er rett er altså viktig. Tykkelse har lite å si.

Kaj 24.01.13

Geir Einbo, Espen Lund Har peiling på avhending.

Samtale med Geir Einbo 24.01.13

I USA leases maskinene, og brukte maskiner kommer tilbake – settes i stand og går ut igjen. Noen kommer tilbake og man henter reservedeler.

Maskinene kommer oftest tilbake til Tomra også i Norge. Kjedene setter de største og beste maskinene i de største butikkene, og flytter dem til mindre, ny-oppstartede/pussede butikker ettersom de blir eldre. Ved endt liv leveres de tilbake, brytes ned i sine verdifulle komponenter (stål, kabling, motorer etc.), og selges.

Overhørt i kantina 24.01.13

«Store problemer» med rengjøring av bånd på multipac, ikke resurser til å rette i original. Vask tar 9timer vs. 2timer på masterpac.

Omvising Värmland 25.01.13

Sammenføyning av stålplater ved trykk er unøyaktig og vanskelig å montere. Manuelt arbeid. Trenger jigg for å bli bra. Kinamat? Bruker ca 80% av platene de legger inn, minus alle utstansinger; mye mindre enn 80%.

Samtale Ole Vedvik hos Hjelle 28.01.13

Hjelle bruker frompressing om en form. Formen er laget av ekornes, formingen skjer hos møbeltre as – tidligere grodås møbler.

Samtale med Møbeltre AS 28.01.13

Snakk med Ekornes på tynes.

Samtale med Ekornes Tynes – skiftleder 08:40 28.01.13

Snakk med Knut Tore Fausa – tlf. 920 29 256 – Konstruktør treforming - Ekornes tynes.

Samtale med Knut Tore Fausa 28.01.13

Positiv til samarbeid. Har lab for prototyplaging. Enkle former og vakuumforming. Bruker lim fra akzo nobel. Snakker om «Møbellaboratoriet» som driver med miljøtesting. Forstrøm? Formaldehyd er et «problem»? 3B-sverige gir miljøsertifisering.

Skal starte skiproduksjon gjennom Hardhaus butikken.

Tror det er mulig å lage dørene i tre. Ønsker velkommen til besøk om 2-3 uker. Kan plukke meg opp på fergekaia hvis ønskelig. Ekornes bruker 1,5mm finer av bøk.

Samtale med Oddvar 29.01.13

Friksjonshengsler og dempehengsler. Kostbart, men ikke for kostbart. Ikke umulig å bruke friksjonshengsler på overdører. Dempehengsler trenger noe for å holde det i posisjon, har for mye slark og er generelt ganske ubrukelige. Ankepunkt at de ikke dumper til skikkelig lukket posisjon. Ønskelig med klart skille mellom åpen og lukket.

Møte med Knut Aasland 31.01.13

Mener jeg bør konsentrere meg om ett produkt. Utarbeide mange konsepter for dette. Huske å holde på også de dårlige ideene/det som ikke går. Ikke så viktig at ting skjer kronologisk. Viktig at ting skrives systematisk etter PU metodikk. Snakket om HÅG – deres stolrygger har vært utsatt for mye miljøtenkning. Hadde ett annet menneske som også kunne kontaktes. Ønsket møte igjen ved oppgaveuttak. Likte Ekornesforslag.

Samtaler Euro Expo 31.01.13

Robust

To svensker, forteller om formingsverktøy for stålplate. Forteller at det vil lønne seg i nesten alle tilfeller. Jeg tegner del jeg vil forme, og setter på overordnede mål. De mener verktøy vil koste ca. 250 000 kr, designet i Skandinavia, produsert i Kina. Foreslår å legge inn flere steg i prosessen. Først knekke flens for posisjonering av optikk-boks. Så resten i ett steg. Så til slutt et ubrukt plass på verktøy for modifikasjoner – flytting av hull, tilførsel osv.

ST bilbygg

Produserer skapløsninger for lastebiler. Bruker composite honeycomb sandwich – her tenker jeg plascore… 90graders knekk var ikke pent.

LVD

Knekker og stanser. Snakker om strømforbruk på 34kW – stor kostnad. Ellers få kostnader ved bruk av knekk. Maskiner fra 300 – 500 000.

Din Maskin

Stor forskjell på gamle og nye knekker. De gamle brukte 35kW, mens de nye bruker omkring 4kW. Overgang fra hydraulikk til elektrisk. Stor forskjell. Interesserte i å videreformidle det til omverdenen. Kost knekke ca. 500 000, Revolverstanse fra 2 mill. Bruk i 15 år. 4 timer service, + vedlikehold, i året på de beste.

Leif Estensen Sintef

Gyliplast i Kristiansand. Dyktige på vakuumforming.

Prototal

«Champagnekjøler»/vask 800x500x250mm til 3000kr. Virker kostbart.

Samtale Steinar Gamst 31.0.1.13

Krav spesifikasjonene må fikses. Legg mer presise, tallfestede krav.

Samtale tvillingfar i softwareavdelingen 04.02.13

Toleranser på bunntrauets venstre side er ganske store. Refleksjonspanelet som monteres på, er refleks, ikke speil. Refleks reflekterer tilbake i samme retning som lyset kom fra, mens speil vinkler. Ergo, geometritoleranser er ergo ikke så viktige som tidligere antatt.

Møte med Nyplast - Svein Fagereng 05.02.13

Tykkelse trau ca. 5mm. Deres vakumformingsmaskiner tar plater i størrelser 1950x1200 -> 1100x800, eller 950x700 -> 300x450mm.

En-kavitetsverktøy i Alu 14 000 kr. 4-kavitetsverktøy 30-35 000 kr.

ABS 17kr/kg, PC –sterkere- 30kr/kg.

Trau, 50x50cmx5mmx0,1kg/m^3(??) -> 1,25kg, 20kr -> 25 pga påslag i materialpris -> 40 for ferdig formet del.

Hvis store kvanta (5-6000stk/år) bruk flerkavitetsverktøy.

Spor for posisjonering av kabelkanal kan freses med 2mm sagblad, men da må delen snus i maskinen. Eller freses med 2,5 og riktig lengde.

Ikke dypere groper enn bredden på gropa. Ved flerkavitetsverktøy brukes enkle trebiter festet på pnaumatiskkstylindere til å presse ned folien mellom formene, før forblåsing slik at materialet strekkes i begge kavitetene. Lurt.

Plastplata man bruker er gjerne 5-10cm større i begge retninger enn forma.

Telene/skumbaksprøytede vakumformede deler er dyrt i forhold til å lage tykkere del.

UKEMØTE 2 med Kristian og Katrin 05.02.13

Ring plascore for å høre om norske forhandlere, be om vareprøve, se eksempler.

Primo gjør ekstrudering av ABS med skum på en side, fast på andre. Bjørn Hågan.

Nina Mathiesen kan priser på folk i polen.

Pontus kan kalkulere pris på platebiter. For oss andre bruk material x3, evt. 60-90kr/kg, pga forbehold om avansert geometri. Pris pr kg. = 10-12kr. Kristian har kanskje kalkyle for overdør.

Stig Evensen sitter en etasje opp, lager demonteringsmanualer. Vet sådan sikkert noe om hvem som bruker dem, og hva de gjør.
Ole Martin Løstergård er selger i Tomra butikksystemer. Kan kanskje svare på hva som skjer med produktene ved avhending.

WEEE i malvik driver med spesialavfall. Mulig de vet noe om hvor mye plast som faktisk gjenvinnes i Norge.

Bruk bjelke under trau for festing av transportbånd.

Kan refleks festet på trauet bøyes, og fortsatt virke? Sitter det på stålbit?

Demonstrasjon software-gjengen 05.02.13

Refleks trenger ikke stå – bør ikke stå – rett på kamera. Noen grader vinkel er bra. Ikke så nøye. Litt vridning går også bra (ca. +-5 grader). Ikke noe problem.

Samtale Tom 05.02.13

Vekt i transportbåndet er ømfintlig i forhold til vibrasjoner. Trau/Bjelke under må være stivt.

Samtale Kristian 05.02.13

Ikke noe poeng å ha pris på enkeltdel, har pris på baseunit. Lag utkast til ny baseunit, send forespørsler til leverandører, finn ny totalpris.

Samtale med salgsdame hos Plascore Tyskland 05.02.13

PP honeycomb skal kunne vakuumformes.

Ta kontakt med Christoph Denker – christoph.denker@plascore.com for mer info.

Kjøretur mot Oslo med Kristian 06.02.13

Siste tall sier at overdør koster ca. 800kr. Underdør med alt 3600kr.

Funnet på nettsiden til Becker i FAQ – Link fra Varier som lager Gravity stoler 08.02.13

Treverktøy for pressforming av tre koster ca 2000 euro med alu varmeelementer i de viktigste sonene. Rent aluverktøy koster 6000 euro.

Kan lage flame retardant plywood – Incendur.

Samtale i Kantina 08.02.13

Ekstrudere profil til dør i fiberforsterket plast?!

UKEMØTE 3 12.02.13

Tre senarier for bunntrau i plast – dagens – tykk/kraftig abs bit, stiv nok i seg selv m dagens bjelke – tynn plast, med kraftig stålbjelke under for stivhet. Stivhetskrav for vekt.

Hvis tynn plast -> innfesting kun for posisjon.

Evt. bøye til i tre? Stivt nok i seg selv?

Ekstrudere dør i fiberforsterket plast, evt. aluminium? Ekstrudert plast primo

Kristian foreslår å legge knekk for innfesting av kameraboks til annen del. Mulig utfordring med ekstraflens. Katrin: Spør Pontus.

Hvis mulig; tre vekumtrekk inn i spor på den siden.

Legg flens kun over mindre del av front.

Samtale med Tor Helge og Hans Georg 13.02.13

Store muligheter for å legge flens for innfestning av refleksjonsboks på tynnplatebit som ligger også utgjør sideflate. Stor sjanse for at denne delen vil bli delt i to, fordi montasje vil bli vanskelig med sideflate fastmontert.

Samtale med Hans Georg og to herrer i software-avdelingen. 13.02.13

Snakk med Håkon Haflan om testing og testresultater av vektas funksjon. Har testet både uten og med tverrgående støttebjelke.

BRAINWAVE 13.02.13

Slå sammen refleksflate og bunntrau (svakt). Biffe opp brakett under. Må finne ut hvor mye av torsjonsstivheten denne tilfører i dag, for så å øke dens stivhet tilsvarende tap ved tynn vakuumformet bunn.

Anonym kilde hos Mercedes Trucks 14.02.13

En besparelse i lastebilvekt fra 40 til 30 tonn gir ca 0,5l besparelse pr 100 mil. I følge deres interne programvare.

Samtale med Tom 14.02.13

Bunntrau og refleks er todelt for tilgang til kabling. Hvorfor man har både løs refleksplate, òg løs venstreside er uviss. Spør kabelmennesker. NX-modellen er ikke oppdatert på kabling på lenge.

Samtale med Dag Windelstad 15.02.13

Kablene ligger kuttet til lengde og organisert i proppen. Legges bak frontkant venstre, helt opp og så bakover mot el-boks. Også langs front til høyre side og ned bak frontkant til printer. Kabel til transportbånd går nede på venstre og inn ved støttebjelken. Ikke noe ønske om at trau+refleks skal være delt ved montasje – det er nok med tilgang fra utsiden. Ved vedlikehold derimot, vil yttersiden av maskinen være klemt mot vegg. Ikke tilgang til kabling – panel på innsiden må kunne fjernes.

Braiwave 15.02.13

Lage refleksjonspanel og trau i ett, slarkete og billig panel som settes inn til sist. Dermed muliggjøres tilgang til kabling selv etter påmontering av sidepanel.

Samtale Håkon Haflan 15.02.13

Det er ikke så farlig om vekta måler feil, så lenge den måler konsistent feil. Dette kan rettes inn. Vekta måles på flere tidspunkter mens flaska fraktes innover på båndet. I bestefall svinger vekta opp og ned, før den stabiliserer seg. Dette var veldig bra på forrige unit, bra nok på den nye. Tester utført på siste utgave (m bjelke). Tidligere var ikke fot til transportbånd i aluminium. Denne endringen har gjort målingene mye bedre. Jeg tenker det kan ha noe med at du legger til en stor masse i andre ende av den «fjær», neste fjærs stivhet får således mindre å si. Tenker bakke (rigid), dekk (fjær), fjær, bil (rigid).

Brainkill 15.02.13

Svar på epost fra Primo (ekstrusjon av plast). Ikke mulig å ekstrudere dør. For stor profil.

Fant nettside for kinesisk produsent for ekstrusjon i aluminium. 100MW ekstrusjons skrue = akkurat passe. Har ekstrudert store, pene ting før (seter til OL stadion i London 80 000 plasser, sikkert á 50 cm hver) men i STORE kvanta . Tar det som hint om at dette ikke lønner seg med 2500m i året.

Pontus 18.02.13

Trau er ikke ideelt for knekking. Det kan kun knekkes med robot (ikke knekkesenter), umulig å legge inn alle parametere riktig. Må bruke en mal, og sammenlikne.

Transportbåndets plassering er viktig, viktigst i dybderetningen da avstanden til oneringen er kritisk. Sideveis mindre kritisk, men fortsatt viktig.

Frontplate er allerede for kompleks for stansing, kuttes med laser.

Besøk hos Cipax 19.02.13

Største kostnader: Materiale, Oppvarming av plast, Etterarbeid, Transport

Mulig å produsere ca 1000 enheter i året pr form, i Norge. Mer andre steder.

Bruker 6mm tykkelse på alt på karusell. Tynnere tilgjengelig i polen.

Hjørner ned i 5mm er ok, 10 er fint.

Pris på verktøy ligger omkring 60 000 med stålverktøy, 150 000 i aluminium.

Kan få polert overflate, det koster. Anbefaler ru overflate. Ser bra ut på båtseter.

Ønsker step-fil med ønsket del og enkel tegning med mål. Skal gi prisoverslag for produksjon i polen.

Samtale Kristian 20.02.13

Multipac = anlegget – består av 4 maskiner for kaufland, 5 maskiner lidl (?). 2x dører pr. De nevnte 500 -> 1200 er ANLEGG. 4000+ dører.

Mitt overslag på pris på rotasjonsstøp gir ikke fornuftige tall, men kanskje man kan si at delen gjerne koster omkring x ganger material?

UKEMØTE 4 21.02.13

Sjekk vink.no og astrup for med info om større ekstrudere av plast

Undersøk muligheter for å inkludere fot for vektsensor i bunntrau.

Ta kontakt med Tom Veble om hardtool

Collin er sprøytestøpmannen, snakk med Tor Helge om info.

Sjekk organoblech mer, og opp mot omsprøyting av pps for fot.

Artikkel på techcenter lanxess som eier/samarbeider med Bond-Laminates 21.02.13

Prosessen med organoblekk vil bli virkelig lønnsom når man klarer å dyptrekke og sprøytestøpe i samme operasjon uten separat oppvarming.

Toleranser ved rotasjonsstøp av trau – innsiden er viktig for posisjonering av base?

Tynnplate kostnadsestimat 60kr kiloen del.

Underkabinett skal ikke ha «tak», bunn i eclipse må være 100% tett.

Brainwave 21.02.13

Kan legge pakning i bakkant av trau om problematisk med tetthet, spenne det fast.

Ukemøte 28.02.13

Kristian – stablbarhet av AOE062, trau med alt i stål er kanskje ikke god nok. Lag alternativer.

Samtale med Hans Georg 28.02.13

Positiv til trau med refleks og base i ett stål stykke. Mener man må finne ut av toleranser og muligheter for å justere seg inn hvis feil.

Mener toleranse i dybderetning for transportbånd ligger på noen millimetere.

Besøk hos Ekornes og Knut Tore Fausa 01.03.13

Produksjonen 0,4% svinn:

Finer kommer inn på pall, en semitrailer om dagen. 8-10% fukt fra produsent. Tørkes ved vakuum og 80 grader. Varmeplater med vann -> kjøleplater med vann -> Kondensering på disse. = 4-6% fukt.

Alltid lavere fuktprosent i ytterlag -> væske dras utover fra midten i tørkingen.

Presse

Bearbeiding

Pussing

Lakkering

Kostnader:

7000kr/m^3 – 10,5 kr pr ark á 1,5mm pr m^2.

B-C kvalitets laminat er ok for mitt bruk, ikke sprekker, men noe kvist.

100 x tykkelse = g lim/m^2

+-70% tørrstoffinnhold i lim er ønskelig

10-15kr/kg lim

Pressemaskin og mann

Fres

Pussing

Lakkering -> lakk = material + alt annet hittil

Deres arbeidere tjener omkring 180-200kr/timen + overtid ++ på akkord.

Anbefalinger:

Bruk u-profil med gummitrekk på innsiden, små skruer som klemmer profilet fast på laminatet. Kan felles inn i treverket. Evt sette inn stykke i siden for å kunne ha innfesting av gassfjær.

Bruk metallflate/magnet over hele bredden for å stive av for vridning.

Ikke legg inn springback i tegningene, snakk med NorLam og hør hva de tenker. Ikke gi for mye info. Regn gjerne på springback før samtale.

Ny maskin kan levere ca 120m finer med lim på pr min.

En press syklus tar ca 1 min (1:05, 55sek) med høyfrekvensliming. 8-10min med varme. Varme brukes på tynne tverrsnitt fordi de trenger jevnere varme for ikke å vri seg. (Fra trykk på start til trykk på start maksimum 2x tid syklustid + noe for opplegging av laminat med lim).

Helrobotisert celle går også helt fint an. Fot til stressless f.eks.

UF lim er ikke farligere enn en type som røyker i nærheten. Framtiden uten F.

Legg inn plastlag på innsiden for økt slitestyrke.

Samtale Oddvar 04.03.13

Tipser om plex med flerlags pressing av plast

Samtale med Kristian 04.03.13

Kristian presenterer excel ark med kostnader pr vekt av tynnplate. Tenker jeg kan gå gjennom delene, se på kompleksitet opp mot pris.

Oppdagelse 04.03.13

~~Gassfjærene på overdør koster ikke 200kr for 2x, men 200kr pr stk. mest sannsynlig. Produksjon av dør = 400 ikke 600 slik tidligere antatt…~~

Gassfjærer koster omtrent 200 kr for 2x, ALDRI stol på priser i Teamcenter!

Oppdagelse internett 07.03.13

Profilrulling, alternativ til ekstrusjon. Forming.ch, sveitsisk spesialist. BRG indisk.

Muliggjør produksjon av profiler billig i 1500m lengde+ med verktøy til ca hard-tool pris i følge manufacturing processes for design professionals

Samtale med Kristian 07.03.13

Rulleforming av stål har han sett på i 2008, har navn og bedrifter og priser. Sender epost «fejl i kalkulajonen» der han får priser fra IB Andresen. Priser ligger på ca 50kr meteren for stor, men enkel del. Verktøy på om lag 150 000 med 4x 90 graders bøyer.

Er positivt til å utforske.

Samtale Tom Veble som har vært i kina i 2 år 07.03.13

En 40-fots konteiner koster 20 000 kr fra kina til polen. Definitivt mulig å lage delen. Lag utkast, flere av gangen – med step og tegning.

Verktøy koster lite 70 000 – 150 000 for tidligere jobber. VELDIG billig i kina. 600 000 i sverige.

Snakker og om die-kasting. Også billig, men kanskje ikke for denne delen.

For denne delen (trau m flenser og innbakt base stål «dyptrekk») -> pris = ca delens vekt x3 (8kr/kg).

Produksjon skjer step-step vis, dvs kinesere med forskjellige maskiner utfører forskjellige steps manuelt med form verktøy.

Produsentene hjelper til med utvikling/forbedring av verktøydesign. Ta kontakt så fort som mulig. De er dyktige. Ta turen, de ønsker å snakke ansikt til ansikt og drikke te. Jiaxin er bra fordi de har dyre verktøy og lav enhetspris.

Størrelse ikke et problem.

Samtale med Frank Lippert 08.03.13

Front maskin

Kunden – kjøperen – bryr seg om lukt, bråk og bryderi + hvor mange konsumenter kan behandles

Kundens kunder – hastighet og kapasitet

Nyere maskin = flere pantere

Storpanterne kjøper for ca 50% mer (sverige for noen år siden)

Bakrom 600-serie maskin har kapasitet til 300 glass/gjenbruks, 80 PET og 350 boks i opplagring. Må tømmes ca 5 + 2 + 1 gang om dagen + 3 x falsk alarm = 11 interaksjoner = 11+ sinte kunder.

Nyere maskin, og nyere bakrom gir ikke problemer på samme måte.

Fordi PET vokser masse, vil også de gamle maskinene ha enda dårligere prestasjonsevne nå fordi de har blitt utviklet for et annet marked.

Hvis man kjøper stort/dyrt anlegg sparer man f.eks. 140 000 i arbeidsmengde i året, og differansen til en mindre maskin tjenes fort inn.

Service skjedde før på timebasis, nå er det fastpris -> økt fokus på service-tid. Tilgjengelighet av vitale komponenter.

80% av service skjer på bakrommet, 20% på frontmaskin.

Samtale med Katrin 08.03.13

Se på innspenning av vekt i base for riktig simulering. Ide om å legge brakett på undersiden av trau.

Samtale med Tor Helge 08.03.13

RBE1 og 2 i nx for simulering av tyngde av deler. Husk motor og aluminiumdel!

Samtale med Tom 08.03.13

Del med base og refleksplate er fin, men ikke helt gjennomførbar. Innfesting av vekt i base skjer fra undersiden. Han ønsker å fjerne refleksbiten fordi han mener den kommer til å bli for vanskelig å dyptrekke -> sveise resten. Da får man ikke tilgang til skruene som fester vekta fra nedsiden… Ergo dårlig deal. Ønske om å kunne fjerne den: Kanskje, men tenk på optikk/software-gjengen, og ikke tro at service menneskene ønsker å skru ut mer enn 1 skrue.

Kan ha skrueløsning fra front av innebygd base.

Samtale med Kristian 08.03.13

Fokuser på å oppnå ønsket stivhet i del, innfesting av vektcelle finner man ut av. Hvis vektcelle byttes svææert ofte, kanskje ikke egnet løsning hverken med 4x skruer eller innsveiset. Spørsmål om tid det tar å bytte vektcelle + hvor ofte -> hvor stor merkostnad vs hvor mye besparelse i design ellers + prod + material + transport + montasje… God helg ☺

Samtale med Hans-Georg og Pontus 12.03.13

Sinkstøpt hengsel til eclipse koster 21 kr, i rustfritt stål koster det ca 60. Alu antatt nært sink i pris. Alu base til transportbånd koster ca 40 kr og kjøleribbe 2-3x større enn base koster ca 100kr.

Tysk firma som produserer i kina. Går gjennom kinaavdelingen.

Samtale med Tom 12.03.13

Synes tredør er kult, mener det bør prøves. Lag et forsøk for å teste innfesting. Gjerne to forankringspunkter Få hjelp til maskinering, snakk med Kristian.

Ukemøte 14.03.13

Kristian er enig i at spant-dør, uten side er ok i forhold til sikkerhet -> når ikke inn til skumle komponenter i kabinett ved siden.

Mener jeg bør se på mulighet for både knekt og ekstrudert profil på bunnen av døra.

Kobling mellom spant og gassfjær. Viser limte forbindelser i Der Becker s.151, ikke superpositiv. Mener liming er underlegent skrueforbindelse pga. krav om lufting, nøyaktighet, variasjoner i limingskvalitet/repeterbarhet + arbeidskostnad.

Mener løsning med u-klemme ikke er dumt. Først positiv til en tilkobling, men etter knekking på brett mer klar for to forankringspunkter slik Tom Lunde er.

Viser frem excel-ark med priser, faktisk kostnad på dør er 570kr. Mye mindre enn tidligere antatt. Gassfjærer er billig. Koster 29kr. UPPDER DOOR ID: 624

Jeg forteller om ønske om å utarbeide konsepter for løsning av problemene fram mot en uke etter påske, han foreslår møte med beslutning av hvilke løsninger som skal jobbes videre med omkring da. Lurt.

Har mest tro på Rotasjonsstøp, men vil ikke helt avskrive tre heller.

Ønsker at jeg skal analysere excel-ark for å dekomponere kostnadene i arbeid, lakk, material osv. for sammenlikning med andre prosesser.

Samtale med Pontus 14.03.13

For å få vakuumtrekk svak, innspent, og kanskje også uttakbar til å sitte godt, og tett hvorfor ikke bare endre på basen, gjøre hakene litt lenger og gjøre det som nå? Pris verktøy er kun 32000kr så tjenes fort inn. Godt poeng

Samtale med Rekdal hos NorLam 21.03.13

Ta kontakt etter påske, kan tilby tips og hjelp.

Epost fra Hans Georg 22.03.13

Hei Arne Olav

Det som har størst betydning er conveyor-«nesen» vs OneRing. Problemene oppstår dersom bevegelige deler av transportøren (=beltene) blir synlige i det croppede synsfeltet til OneRing.

Størst utslag vil nok variasjon i transportørens lengderetning få, men det er kanskje den som er letters å ha kontroll på.

Den det er vanskeligst å kontrollere er vel vinkelen med horisontalplanet? Jeg vil si at nesen til transportøren bør ha en max toleranse på +0/-4 (gjetning). I denne inngår naturligvis en lang rekke toleranser, som alt i alt munner ut i at innfestingen av DockingUnit nok blir avspist med relativt snevre toleranser. Vi har ikke satt noe på tegning til Baseunit ennå, usikker på hva som er reelt oppnåelig slik vi skal produsere den. Skal diskutere dette med Pontus over påsken.

Samtale Rekdal hos NorLam 02.04.13

Radius = 10 x finertykkelse -> 5 av 15 blir bra, litt mer -> 98 av 100. vil ha tynnt lag fenolpapir i midten og aluform 60-100000 kr. Send fil for prisestimat.

Mail sendt.

Samtale Espen Lund 02.04.13

Maskiner utvikles for å holde i 7 år.

I henhold til undersøkelser av hvilke deler som byttes, utført mellom januar og august 2012 er TRANROT, utgående transportbåndsystem for frontmaskin nr. 4 på lista over hyppighet av utskiftning. Dette utgjorde 2386 komplette enheter. 10155 besøk ble utført på grunn av feil på tranrot, men kun 1,2 del ble skiftet pr besøk.

Vet ikke om noen spesielle problemer med vektcelle. Har vært problem med ødeleggelse ved dårlig stabling av tranroter under transport (nederste er ødelagt).

Snakk med service personell på Lier.

Samtale Kristian 02.04.13

Snakk heller med Eirik Foss om hvor mange reserve vektceller som benyttes.

Samtale med Eirik Foss 02.04.13

Part nr 60092003 LOAD CELL NOMINAL LOAD 35KG -> 50092113 i hans system.

Se epost, tolket: 180 bestilt mellom 04.11-03.12, 255 bestillt mellom 04.11-03.13.

Altså ikke hyppigst forekommende, men det skjer.

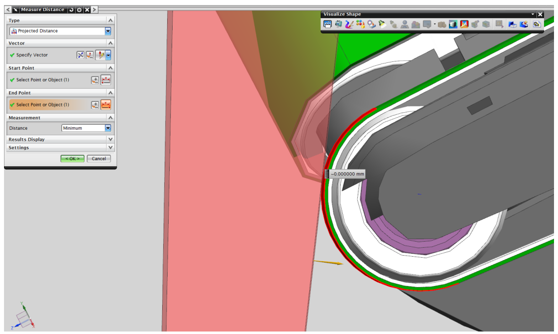
Samtale Kristian 02.04.13

Kommenterer som Espen Lund at transportskader ofte forekommer, og at dette vil bli et mindre problem med eclipse.

Samtale Katrin 02.04.13

Støymålinger av multipac kabinett. Har blitt utført. Hun sender standarder og oppsett på epost.

Samtale Hans Georg 02.04.13



Tiltross for at det i modellen er 5mm overlapp mellom shape recognition boksens synsfelt og transportbåndet, er det 0mm i virkeligheten. Skal rettes opp til å bli 5mm i virkeligheten.

Samtale med Tore 03.04.13

Mulighet for å lage valset profil i alu 2mm i morgen. Ikke valset industrielt, men i manuell valse her. For å kunne sjekke stivhet.

Samtale med Cipax 03.04.13

Verktøy for tray koster 120 000 kr, Verktøy dør kr 180 000 kr. Delpris kommer i løpet av morgendagen +.

Ukemøte 04.04.13

Snakk med Pontus om lakking av alu for mulig valsing av dør i alu. Kristian skeptisk til materialkost ved 2mm alu skin.

Hvis man trenger mer brukerinfo kan man snakke med Einar Hirsch (markedsavdelingen) -> har brukerundersøkelser. Sikkert et virvar.

Markus Nes (svensk) har peiling på Eclipse maskinen i butikk.

Kall inn til møte så fort som mulig.

Samtale Katrin 04.04.13

Snakk med Nyplast om mulighet for stiv vakumtrukket del, formbarhet i 5mm ABS.

FARGER FOR Å ILLUSTRERE FORSKJELLER PÅ DESIGN REVIEW.

Samtale Tom Weble 04.04.13

Kina RIM, pris på ca en uke. Hardt materiale tvers igjennom hos de to aktuelle leverandørene.

Samtale Tor Helge, Brynjar og Pontus 11.04.13

Snakk med Haflan om varmeutvikling på motor. Han skal gjøre test neste tirsdag.

Pontus: Sjekker pris på trau.

Design review 1 15.04.13

Dør:

Vurder hull og sikkerhet.

Endre på profil for å få nok «håndtak».

Valse ferdig lakket? Få leverandører?

Magneter innstøpt i tre?

Plassere magneten i laminatet med magnetisme.

Se mer på telene fra buddybilene, Kai kjenner kanskje noen der.

Mulighet for å lage en (H-?)profil, i plast (kanskje glassfiberforsterket) til valset profil.

Tray:

Vakkum tetthet midt på side av base, bule ned og lekke? Lag tut oppover! Tykkelses issue!?

Se illustrajon i boka.

Steel fixed posisjon for tray i base unit

Steel removeable: posisjonering av tray – flathet.

Lakket alusink/syrefast som i utslagsvasken.

Ukult at rillene blir tettere og tettere?

Sjekk mulighet for å gjøre om fester på vektcella -> Muliggjøre fixed med inkludert base. Uten base er ikke aktuelt.

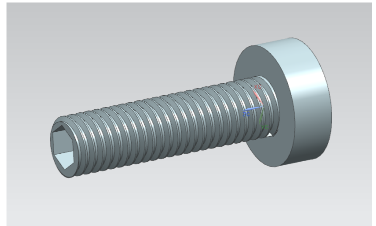
Steel All inkl. rem: Stivhet i kabinett uten trau? Toleranser?

STIVHET I KABINETT VED FJERNET TRAU ER ISSUE MED ALLE UTTAKBARE:

Måling på gående test Eclipse 17.04.13

Motor blir 49,6grader varm under kontinuerlig drift.

Samtale Hans Georg, Tom L og Tore 17.04.13



Ønsker noe liknende for å skru vektcelle fast fra oversiden. Her kan vektcelle skrus på de oppstikkende skruende med umbraconøkkel gjennom de gjengede hullene i vektcella.

Det nærmeste du kommer til dette er en settskrue med låsemutter. Tom ønsker heller at det ikke er gjenger i vektcella.

Samtale i lunsjen 17.04.13

Problem med at flaske detter av transportbånd i eclipse. Noe jeg kan fikse?

- Tenker det er enklere å løse med transportbåndet? Sette på «gjerde»?

Samtale Bente 17.04.13

Ikke mulig/imot policy å bruke andre vektceller enn i de andre maskinene. Derfor er det vanskelig å få gjennomslag for vektceller uten gjenger. Prosjektgruppa ønsket også det, men de ga seg.

Samtale Hans Georg 17.04.13

Løsning med settskruer er upopulær fordi begge skruene må skrus ca simulatnt.

M5 og drit i gjengene i M6en?

Samtale Tom Veble 22.04.13

Subjektivt krav til stivhet er ok.

Samtale Tom Veble 23.04.13

For hard-tool kanskje lavere enn 3x material kost. For plast sier man 2x, men fordi tomra skal ha få deler må de betale mer.

Samtale Knut Tore Fausa 24.04.13

Mener det er viktig å få inn i tilbud hva som gjøres med vridning; reklamasjon osv. Anbefaler UV-lakk = samme som i bruk på kjøkken.

Ukemøte 25.04.13

Kristian mener AOE00096 brakett med fjærer viser hvorfor det er lurt å bytte til vektcelle uten gjenger.

Samtale Tom Veble 26.04.13

Stålpris i kina ca 8kr/kg -> ca. 2+ i faktor for deler i dyptrekk.

Samtale Kristian 29.04.13

Sprøytestøpt del kan gå ned i kabinett til kasse. MEN det er noe man har gjort tidligere og brent seg på fordi fremtidige endringer på kassemaskinen da må ta hensyn til dette.

Ukemøte med Katrin 10.05.13

GF+ABS – kan gjøre kritisk finnehøyde lavere?

RIM vaffel andre veien

Sprøytestøp –45 grader i front av base for å spre last?

Samtale Katrin 13.05.13

Synes ny RIM er bra, enig i resultat fra simulering av sprøytestøpt trau med slak kant.

Samtale Tom Weble 13.05.13

Tror ikke ny front kant på ståltrau er noe problem å produsere.

Samtale Tor Helge 13.05.13

Tetting – Kant på shapebox (trekker inn ekstra del for endring)

Tetting – Utknekk på flens på høyre side (BRA).

Samtale Pontus 14.05.13

Selv med ekstrakenekkene foreslått av Tor Helge er sideplata på høyre side produserbar. Den må knekkes i robotknekke fordi «høyden» fra den store sideflaten til enden av flensen er mer enn 160mm. I tillegg har de for mange knekker til å passe i knekkesenter.

Epost 16.05.13

Welser – kan lage rullet profil 14 euro/m.

Samtale Hans Georg 21.05.13

Hull på bakvegg er så stort som det er pga fare for at korker eller liknende kommer i klem og påvirker vektcella.

Samtale Ingrid 21.05.13

Tetting bak: Stikke gjennom hele veien med brett opp, pakning og klemm, bredde hull brette over kant på midten.

Samtale Eirik Foss 29.05.13

Kostnader til logistikk:

Tom Brodahl -> Konteinertransport

Ingunn Lundemo -> Transport på vei

Arne Ness -> Økonomi sjef tomra production

Nina Mathisen -> Lagerkost ved forsinket uttak i Polen

Samtale Ingunn Lundemo 29.05.13

1 bil tar 33 europaller

6 pr lag, 2 lag på hver pall

Lastebil fra Østerrike/Tyskland -> Polen = 8 000kr

-> Sverige = 12 000kr

Samtale Leif Magne Kvarme 29.05.13

Kostnader til lager

Lagerhold = f(verdi)

Transportøkonomisk institutt

Logistikkkostnad = ca 13% av omsetning i snitt for liknende bedrifter i norge

Tomra har høyere margin en snittet -> Lavere prosent (10?)

Viktigste parametere:

Lagerkost + håndtering (inn på lageret, ut av lageret)

Transportkost

Kapitalkost

Forsikring

Administrasjon/system

Risiko for endringer i produkt

Annlaug + Tonje Regland? Kan ha peiling på rentabilitets prosentkrav

Samtale Nils Olav Holand i Otto Olsen 29.05.13

Foreslår bruk av 46610083 – OO art. nr 3481014 = lagervare. Sender 1m vareprøve for test.

Foreslår evt. at man lager ny profil med mykere gummi i U-delen. Dette vil gi dobbel tetting. Man kan også legge inn riller i denne profilen, for enda større elastisitet.

Samtale SSBs bibliotek 03.06.13

Finnes ikke separat resirkuleringsstatistikk for termoplast og herdeplast, europas statistikk ligger i Eurostat-databasen. Sender epost med bruksanvisning.

Kari Mellem kan hjelpe med avfallshåndtering i europa. Snakket med, og skal få svar på epost.

Samtale Pontus 04.06.13

Den gamle base uniten tar 20min å sette sammen. Den nye tar antakelig litt mindre, 17min er ikke usannsynlig. Hvis man reduserer antallet deler til all inc, kanskje 12min.

Tenker at døra tar omkring 14min, rullet omkring 5-6min. Laminat kanskje omkring 3min.

Samtale Nils Holand hos Otto Olsen 04.06.13

Anbefaler neopren foran EPDM. Begge er gode, men neopren er bedre allrounder (olje, støv, varme). 30-40% komprimering av neoprenen gir best resultat. Anbefaler 5mm stanset pakning.

Samtale Nils Holand hos Otto Olsen 05.06.13

Kostnad til støpeverktøy for støp i gummi/silikon/plast ca 15-20 000 NOK. Skeptisk til om man får plastmaterialene myke nok. Skal regne på stabling av neoprenpakning og forhøre seg om støp.

Samtale og forsøk Brynjar og Tor Helge 05.06.13

Kommer på at det ikke eksisterer plan for magnetkobling på trelaminat. Magnetskinne har blitt glemt. Får tips om å finne forklaring av funksjon i Art. spec. Finner ingen forklaring, men tegn på at magnet fungerer også på høykant i Art. spec. Brynjar er enig. Finner magnetlist. Tester med Tor Helge. Magnetlist fungerer ikke, tiltross for sterkere magnetisk (prøver på annen del). Prøver med løs magnetbryter fra Hamlin. Fungerer på høykant like bra som på flatsiden.

Samtale Tom Veble 05.06.13

Hamlin og Tomra jobber tett i Kina. Antakelig gode muligheter for å få magnetsylinder uten støp rundt.

I Revisions to the old base unit

A study was conducted establishing whether changes to the current base unit were frequent or a rare event. The study showed that most parts saw changes in the period. Most changes were of a simple character, like adding or moving a hole or adding a bend.

Item nr.	Description			
14	Support upper right commbase			
		No revision		
13	Support low left commbase			
		A	Dim 33 was 34	
		B	Added item 2	
			1	Sheet metal No revision
			2	Nut
12	Plate separation commbase			
		A	Plate thickness reduced from 1.5 to 1. Rect. Hole replaced with circular	
		B	Dim 18 was 16.	
			1	Sheet metal No revision
11	Plate printer comp. Commbase			
		A		
		B		
		C	Moved tracks from strips 130 was 150mm	
		D	Added item 2	
		E	One dimension added	
			1	Sheet metal No revision
			2	Nut
10	Plate camera Commbase			
		A	More dimensions added to ease control in production	
		B	Increased square hole from 22x22 to square 24x24.	
			1	Sheet metal No revision
9	Plate rear commbase			
		A		
		B	Dim 58.5 was 38.5. Dim 79.5 was 59.5. 2x ARB-M6 added.	
		C	Hole pattern changed and moved. New hole pattern dadded. Tap holes reduced in number and repositioned. One T-type panduit added.	
		D	Item 4 ArbTank spec corrected with correct shank code (-012).	
			1	Sheet metal No revision
			2	Nut
			3	Nut
			4	ArbTank nut
8	Plate pc compartment commbase			
		A	Major changes. Check all. Material changed to ST1203.	
		B	Added specification for flush MINARB (nut).	
			1	MINARB nut
			2	Sheet metal No revision
			3	MINARB nut
7	Plate front commbase			
		A	Multiple changes. Check all. Material changed to ST-1203.	
		B	One hole 3 added.	
		C	Added hole 24x38mm for counter	
		D	Added one item 4	
		E	Added 2x item 1. Added hole 5,5. Modified dimension 156.8. Hole array added. Tap holes reduced in number and repositioned	
		F	Dimension changed to 48mm (was 45).	
			1	Nut
			2	Sheet metal No revision
			3-8	Nut

Table 31: Changes done to the current base unit since 2005 - part 1

6	Plate el. Support commbase			
		A	Multiple changes. Check all.	
		B	Dim 17.2 was 14.7. Dim 112.3 was 132.7. Cable strap added.	
		C	Hole 5 added (for suspension during painting).	
		D	Two panels removed major changes check all.	
			1	Sheet metal
				N/A 1
				N/A 2
				N/A 3
			2-4	Nut / stud
5	Frame lens w/assy commbase			
		A	added part 3 - stiffener	
		B		
		C	Item 2	
		D	Item 2	
		E	weld instruction	
		F	Item 2	
			1	plate lens holder
			2	plate lens commbase
				A
				B
				C
				D
				E
			3	plate stiffener common base-unit
4	Plate mirror angular t710 mk2			
		A	More dimensions added to ease control in production	
			1	Sheet metal
				No revision but MK2
3	Support distance nx3			
		No revision		
2	Plate tranrot support nx3			
	A	Added spot welding of clinch nut		
	B	Added remarks concering item 2		
	C	Material changed to ST1203		
		1	Steel 3mm	
			No revision	
		2	Nut clinch	
1	Plate tranrot hanger nx3			
	A	Two holes 10 added.		
		1	Sheet metal	
			No revision	

Table 32: Changes done to the current base unit since 2005 - part 2