Operator 4.0 – Emerging job categories in manufacturing

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Abstract. With the trends of industry 4.0 and increased degree of digitalization in production plants, it is expected that production plants in future is much more adaptive where they can both self-optimize production parameters as well as self-maintain of standard activities. All though this would reduce manual operations, new work activities are expected in a cyber-physical production plant. For instance, the establishment of digital twins in cloud solutions enabled with Internet of Things (IoT) can result in crafts in maintenance analytics as well as more guided maintenance for the maintenance operator with augmented reality. In addition, more service from external personnel such as the machine builder is expected to be offered in Industry 4.0. In overall, it will be of interest to identify and recommend qualification criteria relevant for a cyber physical production plant that would be implemented in the organisation. The aim of this article is to evaluate the role of operator as well as other relevant job categories in a cyber physical production plant. The result in this paper is a recommended framework with qualification criteria of these job categories. Further research will require more case studies of this framework.

Keywords: Operator 4.0, shop floor operator, maintenance personnel

1 Introduction

It is an important need in European manufacturing to sustain competitive supported by information and communication technology [10]. Several architectures have been developed for cyber-physical systems (CPS) that requires human interaction from an operator. An examples of such architectures is the 5C architecture integrating the

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sensor monitoring systems with the decision making systems in the organisation [11]. This architecture has a well-defined demonstrated the human interaction with a cognition level where e.g. an online prognostics health management platform will support with a visual interface in evaluating degradation of machines. Still, more detailed description is needed to clarify what role the operator will have in such architecture. From a cultural perspective it is at least required both a willingness to change and a more open communication to succeed with the ground-breaking technologies offered by Industry 4.0 [19].

In Norwegian manufacturing, the research project CPS Plant aims to develop a framework for the Norwegian approach for the digital manufacturing industry based on the breakthrough technologies from Industry 4.0.

Due to the increased automation in the operation of a CPS, it should be expected that degree of manual operations for the operator will be reduced and can be explained where manual operations are changed with assisted operations and increasing the automation level [16]. Although several technological solutions are offered for operators [18], it is also important to consider the future needs for the operator [7] as well as establishing a development path for Operator 4.0 based on Industry 4.0 principles [19].

The aim of this article is to investigate the role operator will have in an Industry 4.0 environment and to propose a recommended framework for qualification criteria for this operator.

The future structure in this article is as follows: Section 2 presents the opportunities with assistant systems for the future operator, whereas Section 3 proposes a framework for evaluating relevant criteria for this operator. Section 4 provides concluding remarks in the article.

2 New opportunities with a Assistant Systems

The benefit of CPS is the improved decision support for operators. For example, the 5C architecture provides decision support in terms of visualization of degradation and “digital advices” in maintenance scheduling [12]. From an operator perspective this interface is also denoted as a decision support system (DDS) or assistance system and can have different modules such as production status evaluation, adaptive decision logic, dynamic resource position detection as well as an operator device [9]. Figure 1 illustrates the cooperation between the operator and the assistance system [15]. Instead of manually collect and analyze the information with the help of the existing systems, the operator can now use the assistance system and carry out the production control partly automatically with support from DDS.

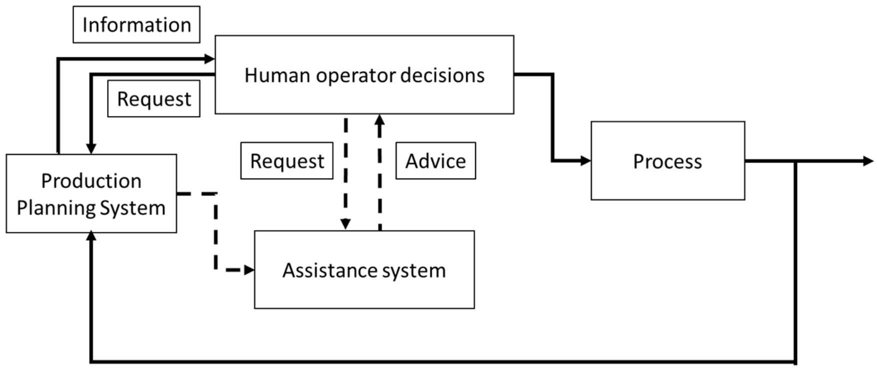

Fig. 1. Human-machine interface for decision making [15].

3 Framework for evaluating Operator 4.0

Figure 2 illustrates the recommended framework for qualification criteria of operator 4.0. The aim of this framework is to ensure that both the needs in future industry are met with the breakthrough technology offered by Industry 4.0 and that the organization ensures a ramp up for this job category.

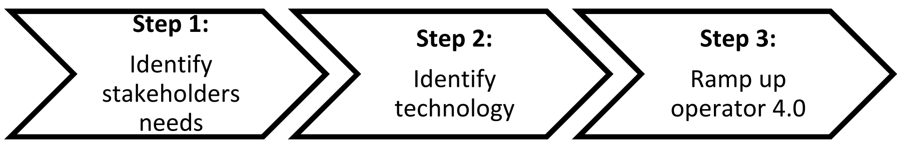

Fig. 2. Framework for qualification criteria for operator 4.0

3.1 Step 1: Identify stakeholders needs

This step aims to understand the needs from relevant stakeholders. A classical definition of a stakeholder is "*...any group or individual who can affect or is affected by the achievement of the organisation's objectives*" [4]. For manufacturing companies who maps out a strategy for Operator 4.0 formalized in their own organisation's objectives, this broad definition will include a wide-ranging network of among others enterprises such as technology providers for Industry 4.0 as well as the users of the technology in the manufacturing environment. This article includes both existing and future employees in manufacturing when understanding their needs.

In Swedish manufacturing several surveys have been conducted to investigate the future demands from operators in manufacturing [7,8]. These surveys describe the future shop-floor operator as involved in self-controlled team with high level of knowledge and which is dealing with increased extensive tasks. Even more, the results from these surveys clearly addresses that the future demands for operators are the ability to be innovative, creative and getting things done [7]. In additional, the need for updated IT-knowledge is critical where answers from a high-school student pin points the current gap in industry [8]: *"IT-knowledge is as important during your work as in everyday life, though industry is possibly a little bit behind."*

Also in Norway, there are concrete initiatives to investigate the future role of the operator. From an ongoing Norwegian project named "Skills" [20], it gives some indications of how operator and core skills may develop. That in future work life beside the possibility to learn and develop, you had to master ICT, cultural and language understanding. To contribute in improvement work and innovation, it is necessary for future operator skills to have communication and responsible competencies, and it is crucial for skilled workers to understand the whole picture of value creation and the chain, so they can see the context in production processes and participate in optimizing production lines.

To broaden the view of Operator 4.0, the competence needed for a maintenance technician specialist should be included as well due to their involvement of the equipment being operated. The existing required competence of this category has been identified in the standard EN 15628 for qualification of maintenance personnel [2]. In overall, the existing competence of the maintenance technician specialist includes independent performance of maintenance assignments. Further, this standard addresses the use of ICT systems as one key competence. When considering "maintenance employees" shop floor operators should be included in this category. For instance, the key innovation of the classical maintenance concept total productive maintenance (TPM) is that operators executes basic maintenance tasks on their own equipment [14]. This also seems to be the situation in Swedish industry where the scope was not limited to assembly and machining task, but preventive maintenance [8]. Based on contribution from maintenance experts in Swedish manufacturing industry a scenario for the maintenance function in 2030 were developed. In this scenario, it is specified that maintenance employees will have a new digital competence as well as social competence.

Table 1 summaries the stakeholders needs identified in this article.

Table 1. Stakeholders needs representing future roles for Operator 4.0

Norwegian operators	Swedish shop-floor operators	Swedish Maintenance employees
Master ICT skills Skills in communication and responsibility Understand the whole picture for the value chain	Self-controlled team Ability to be innovative Updated IT-knowledge	Digital competence, e.g. data analytics Social competence, e.g. interdisciplinary collaboration Continuous education and training Individuals have responsibility, authority, and autonomy

3.2 Step 2: Identify Industry 4.0 technology for cognition level

This step aims to identify the specific technologies based on the Industry 4.0 principles. Several studies have identified relevant technologies for Industry 4.0. An Operator 4.0 typology presented several technologies that would serve different roles for the operator [18]. The purpose of the technology is that the production performance improves (e.g. reduced throughput-time, reduced downtime and scrappage) where the operator interacts with the cyber-physical system. As an example, this interaction can be supported by the use of sensors, as they have been acknowledged for increasing built-in intelligence by providing information on the parameters being measured, and identifying control states [22]. Thus, live sensor-information with adjustable alert limits with direct connection to the operators' smartphone/tablet is one possible technology. In overall several categories of available technologies should be identified:

- Real time feedbacks system [13].
- Augmented reality with smartphones, tablets, and smartglasses [5].
- Personal digital assistant with speech- recognition [1,5,13]
- Warning message system of improper operation [13]
- Cobots: Robots cooperating with shop-floor operators without fences between them [7].

3.3 Step 3: Ramp up of Operator 4.0

This last step aims to ramp up the role of operator 4.0 so it can be implemented in the organization. It is well known that new frameworks in technologies can be described as double S-curves (innovation steps). Figure 3 illustrates an example of such a learning curve formed as a double S-curve in strategic development in manufacturing [21].

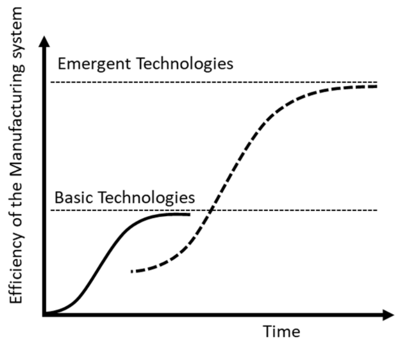

Fig. 3. Visualization of a learning S-curve in strategic development in manufacturing [21].

To bring open innovation and self learning of the employees a step further the S-curve should be applied in the organisation. In the quality area this can now lead to new ways of using statistical and quantitative models for developing, acquisition, decision making. Which by use of algorithms and safe measurement systems can be operated, correct and assisted for further improvement and implement rather fast in a production facility [3]. However this is much based on culture for organizational change and management skills which is rather different from one country to another country [6], so a implementation plan for industry 4.0 operator will depend much of the leadership in the organisation, the maturity development and the use of operator skills.

A recommended approach for the leadership facing this challenge is to follow the feedback learning curve [17]. Figure 4 illustrates this learning curve where the leader must facilitate both a learning stage towards acceptance in the organisation as well as an enlightenment stage in order to commit resources for actions in ramping up the Operator 4.0 in the organisation.

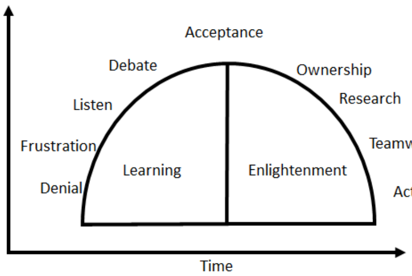

Fig. 4. Feedback learning curve, adapted from [17].

4 Concluding remarks and future outlook

This article has proposed a framework for qualification criteria relevant for operator 4.0. The framework consists of three steps where the stakeholders needs are identified (1), relevant technology is identified (2), and ramp up of operator 4.0 in the organization (3).

For step 1 in the framework, it is concluded that more studies are necessary for identifying relevant stakeholders. In this article, both existing and future employees was identified as relevant stakeholders. In future research, specification of the stakeholders must be further elaborated. For the maintenance employees this specification has already started in EN 15628 for qualification of maintenance personnel.

Also for step 1, it is concluded that it is not rather straightforward to generalize the stakeholders needs for all countries and industry branches. Nevertheless, some learning should be expected between the countries. For example, the experiences for future maintenance employees in Sweden has been shared in Norway where it is expected that the Norwegian maintenance society can learn from these experiences.

For step 2 it is concluded that the technologies should be elaborated more in detail. For example the technology readiness level (TRL) for the company should be specified more in detail.

For step 3 it is concluded that different types of learning curves should be applied when performing Ramp up for Operator 4.0 to be able to meet future needs regarding evolvement ofhigh knowledge level and extensive tasks.

In overall, it is concluded to further develop the framework proposed in this article. Further research for this framework will require more testing in the Norwegian project CPS-Plant as well as relevant case studies in Norway.

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