# Design and Testing of Non-axisymmetric Propeller Ducts

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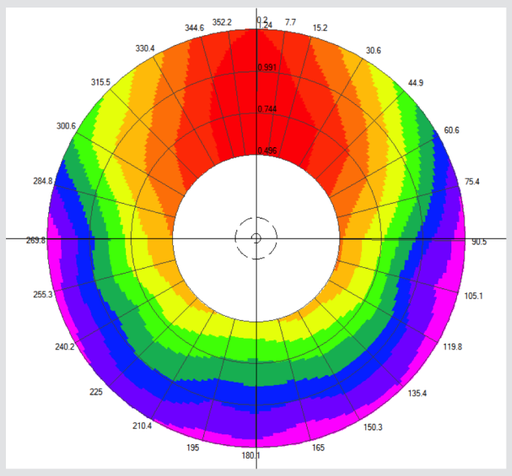
## Introduction

Ducted propellers are applied on a large range of specialized vessels, such as tugs, anchor handlers, fishing vessels etc. In the later years, we have seen the development of improved propeller duct designs. The potential of making duct geometries that are customized to fit the wake field should be explored - and then it is mainly the potential for making non-axisymmetric ducts that is most tempting.

## The wake field

The given axial wake field, measured from an arbitrary fishing vessel.




## Cavitation Tunnel Test

The following tests were done in the cavitation tunnel at MARINTEK to verify the customized ducts:

- Open water test
- Cavitation bucket (six values of $K_{t,total}$)
- Pictures
- Noise measurements

## Discussion of Results

Focus of the analyze has been to compare the customized ducts against the 19A duct, when it occurs and how it affect the propulsion properties.

As one can see from the open water diagram (at the bottom of the poster), the efficiency is higher for both Duct A and B compared to Duct 19A [1].

Cavitation buckets were made for all three ducts. It presents inception of different cavitation phenomena, as a function of the cavitation number (tunnel pressure). The buckets tells that inception of bubble cavitation, which is a source of cavitation [2], occurs at a higher tunnel pressure for the 19A duct than for the customized one. It seems like tip vortex cavitation, which generates noise, occur at about similar cavitation number.

Duct cavitation occurs only at the 19A duct, and only for low cavitation number.

## Recommendation

"Non-axisymmetric ducts can be the future"

Professor Sverre Steen

## References

[1] Steen, Sverre and Minsaas, Knut: *Propeller Theory*, NTNU, Department of Marine Technology (2013)

[2] Savio, Luca: *Propeller Cavitation*, NTNU, Department of Marine Technology (2011)

## Design Criteria

Different vessels generates different wake fields. As a general rule they are non-axisymmetric. I will therefore study the possibility to neutralize the effect of the wake field into the propeller. **By designing the ducts, I want to achieve a homogeneous flow into the propeller. The main goal is to decrease the risk of cavitation**, and to reduce the effect of cavitation. Also the ducted propeller efficiency will be studied.

To achieve a homogeneous inflow to the propeller I will design the ducts with respect to a given wake field. The given wake field contains only axial velocities.

I will design the ducts, as a function of duct induced axial velocity. **When designing a duct cross section, I varied four parameters; camber, thickness, angle of attack and length.** It has to be known that the duct has to be customized for each propeller and each wake, as they interfere with each other.

**Two customized ducts, named Duct A and B are 3D-printed and tested against the well-known 19A reference duct.**

## Design Procedure for the Design of Non-axisymmetric Ducts

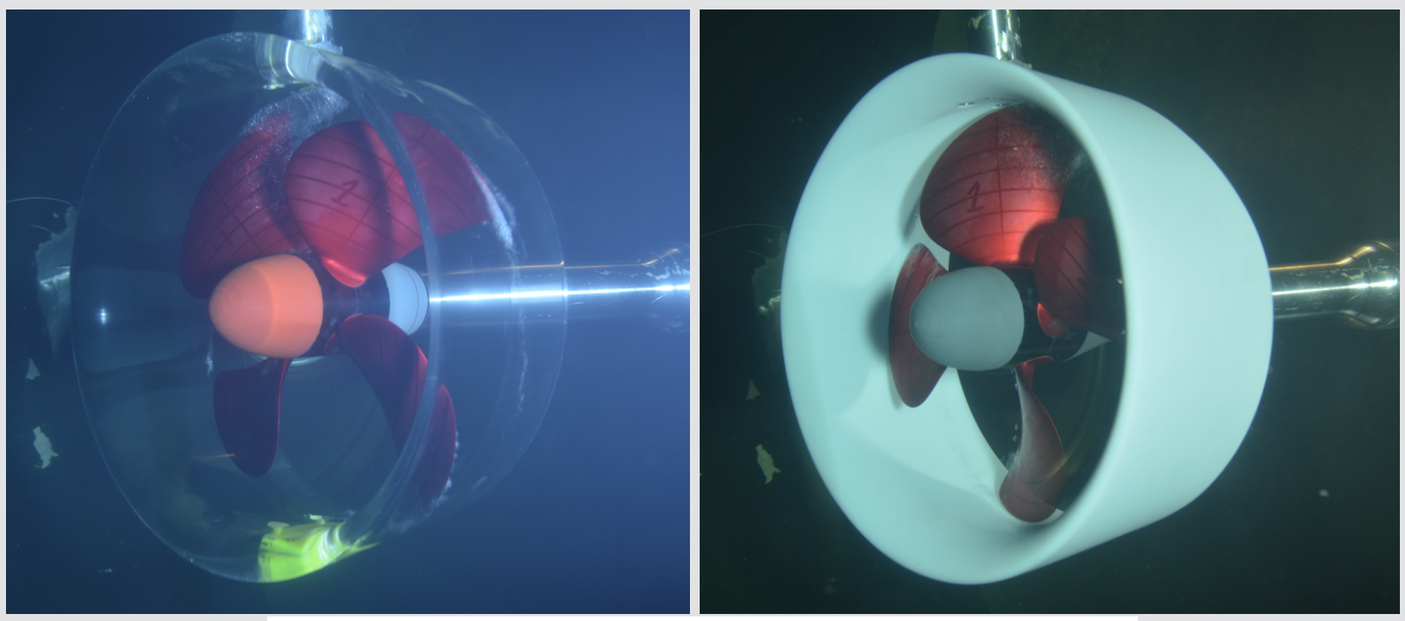
The used design procedure is:

- A MATLAB script, named **Haavik's model**, read a given arbitrary wake field. The script will divide the wake field into sections, and calculate the effect of the wake.
- Haavik's model generates a matrix that propose a non-axisymmetric duct. The proposed duct contains different duct cross sections, depending on the wake field.
- The duct cross sections are taken from a duct library. The cross sections are in the library presented as a function of duct induced axial velocity. The induced velocity is calculated in AKPA 6.0.
- A 3D-model of the proposed duct has to be made for production and testing of the duct

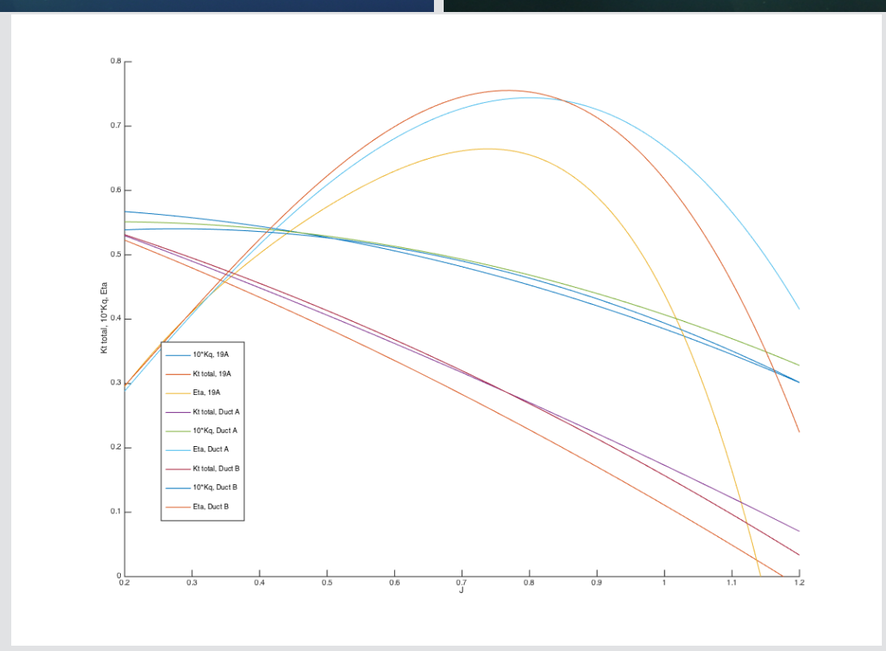
## Results

Lower left picture is the 19A duct and Duct B to the right, where both Duct 19A and B operate affected of bubble cavitation. The interesting point is that inception of bubble cavitation occurs at a lower cavitation number for Duct B than Duct 19A.

The open water diagram below shows that the efficiency is higher for the two customized ducts.





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