MARIN

Challenging wind and waves

Linking hydrodynamic research to the maritime industry

Mechanism (机理 jīlǐ) Study of Energy Saving Devices (ESDs)

ESD-JILI JIP

ESD机理

With the oil price skyrocketing and the implementation of the EEDI approaching, the issue on green ships comes almost daily into the discussions among the ship owners, the ship builders, the classifications, the shipping regulators and the governments. As one of the major driving forces on reducing bunker cost and pollution, energy saving issues become extremely important nowadays.

Both for new buildings and also for retro-fits, Energy Saving Devices (ESDs) are widely accepted as one of the important measures to tackle these problems. An energy saving device for a ship is often installed to the stern of the vessel close to the propeller and working together with the propeller forming a total propulsion system. An ESD can be a pre-duct, a pre-swirl stator and fins in the upstream of the propeller, or a post stator, a rudder bulb, rudder fins, a PBCF® or a twisted rudder in the downstream. Many new ideas and patents have been proposed in the last decades, and some of the ideas were tested in the towing tanks around the world. Several of the ideas were installed to real ships and tried in full scale. However very limited trial data are available to the public. According to publications, the best achievement on improving efficiency by adding an ESD to an existing vessel with existing propeller was more than 10%, according to the model tests. The feedback of full-scale sea trials show typically more than 5% improvement on total propulsive efficiency. These achievements are very promising, which attract a lot of attentions of the ship owners, the ship builders and the regulators.

But until now, there is very limited information on why and how an ESD can improve the total propulsive efficiency of a vessel. There are very limited studies carried out trying to understand the working principles of an ESD. Therefore, many ESDs were designed by try-and-error method and the designers had to hope that their designs would be proven by model tests. On the other hand, as widely known already, an ESD suffers a lot on scale effects so that the achievement on full scale is almost always different than that in model scale. This makes the implementation of an ESD to full scale sometimes questionable for ship owners and builders.

In order to resolve the doubts on the implementation of an ESD and help the designers and engineers in selecting and designing ESDs, we initiate this Joint Industry Project (JIP), called ESD-JILI JIP, trying to understand the working principles (机理 jīlǐ) of the ESDs. In order to have a focus of this JIP and also due to the limitations of the funds, we decide to limit our study to only three ESDs which are thought to be the most promising ones for merchant vessels. They are the pre-duct with inner stator (PDS) and the pre-swirl stator (PSS) in the upstream of a propeller and the Hub Fins (HFs) in the downstream.

In the progress of this present JIP, some more extended studies may be carried out if more participants and funds are available.

OBJECTIVE

The objective of this JIP is to understand the working principles of the ESDs in general by investigating the flows around the hull and the ESDs by using advanced PIV system to the aftbody of a ship, fitted with or without the ESDs, by measuring the forces and moments on all the components of the propulsor including the ESDs, by investigating the flow details with Particle Image Velocimetry (PIV), and by studying the scale effects using smart dummy model tests (see below) and CFD calculations. Based on the results of the tests and calculations, a novel extrapolation method will be developed to predict the performance of the vessel fitted with ESDs.

MARIN
P.O. Box 28
6700 AA Wageningen
The Netherlands
T +31 317 49 39 11
F +31 317 49 32 45
E info@marin.nl
I www.marin.nl

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SCOPE OF WORK

The scope of work of the ESD-JILI JIP consists of the following 4 work packages which are closely linked to each other:

WP1 Force and Moment Measurements

For all of the model tests and calculations within this JIP, we will make use of only one ship model, representing a typical full block low speed merchant ship such as a bulk carrier or a tanker. We will make comparative propulsion model tests with the original propulsion system without ESDs and also with the PDS, the PSS and the HFs fitted to the ship separately. The comparison shall show the improvement on the propulsive efficiency due to fitting the ESDs.

A single-screw vessel installed with an ESD, tested at MARIN (painted black for PIV measurements)

In order to understand the forces and moments generated by all the components of the propulsion system including also the ESDs, we will install force sensors to all of the ESDs during the propulsion tests. The measured forces, combined together with the results of the studies in the other work packages, will be used as the basis for the extrapolation of the test results to full scale and to assess the structural loads.

The tested PDS, PSS and HFs will be designed by the joint force of the participants of this JIP and aimed only on the working principles studies. No patented product will be used.

WP2 Flow Investigation with PIV

To understand the details of the flow around the hull, the propeller and the installed ESDs, it is proposed to measure the 3-D flow field at the stern of the ship model, by using MARIN advanced PIV system, for both the situations with and without the ESDs. In this way, we will know the changes of the flow situation due to the presence of the ESDs. This will provide us insights to the physics behind the efficiency improvement due to ESDs.

The measured flow field will be linked to the forces and moments measurement results, leading to a better understanding of the working mechanism of all the ESDs in question.

In addition, the flow field will serve as validation material for the CFD calculations. A well validated CFD software provides a cost-effective tool for the ultimate design of the ESDs in the best and the most correct way so that the highest efficiency improvement can be achieved.

MARIN advanced PIV system

WP3 Scale effect studies by CFD and smart dummy

At the time when we carry out propulsion tests to measure the forces and moments and carry out flow measurements by using the advanced PIV system, we will also make CFD calculations. The CFD calculations will help us to understand the mechanism more in detail and provide the tool for future ESD designs. In addition, the CFD will help us in understanding the scale effects on the ESDs.

At the same time, we propose also to use the CFD to design a smart dummy, which can be manufactured from the present ship model, so that the flow situation at the stern of the model in model scale will be identical to that of the ship in full scale. With this dummy model, we will also carry out all the tests defined in WP1 – measuring the forces and moments, while simulating the full scale propulsion tests. The comparison of theses series of propulsion tests, with and without ESDs, will lead us to understand the full scale performance gains due to fitting the ESDs.

WP4 Extrapolation of model test results

After the study carried out in WP1 through WP3, we shall understand the mechanism of the ESDs much better than before. With the help of the CFD calculations, the PIV results, and the propulsion tests both with the original model and with the smart dummy model to simulate full scale flows, a new novel extrapolation method will be proposed and developed for the performance prediction of ships with ESDs.

DELIVERABLES

- Understand the working principles of ESDs
- Technical report with guidelines on ESD designs
- Extrapolation method for ESDs

PARTICIPANTS

The following organization have confirmed their participation:

- Shanghai Ship and Shipping Research Institute (SSSRI)
- Guangzhou Shipyard International Co. Ltd. (GSI)
- Maritime Research Institute Netherlands (MARIN)

More participants are welcome (for the next phase).

BUDGET

The estimated budget for each work package will be roughly:

WP1 Force and moment measurements	70,000Euro
WP2 Flow investigation with PIV	40,000Euro
WP3 Scale effect studies by smart dummy and CFD	70,000Euro
WP4 Extrapolation of model test results	20,000Euro
Total estimated budget for ESD-JILI JIP	200,000Euro

The scope of work can be extended when more participants are joining this JIP. Fully scale trials are under consideration.

CONTRIBUTIONS AND SCHEDULE

The total budget of the ESD-JILI JIP is expected to be around 200,000 Euro. The contribution from each participant is (excluding VAT) 50,000Euro.

The time schedule for the ESD-JILI JIP is to have the kick-off meeting in the end of May 2011 in Shanghai/Guangzhou and to start the project before the end of June in 2011. It is a project for one year.

MORE INFORMATION

For more information on ESD-JILI JIP, please contact

Dr. Ir. Jie Dang
Senior Project Manager Ships
j.dang@marin.nl
+31-317-493525

Ir. Johan de Jong
Manager Ships Department
j.h.jong@marin.nl
+31-317-493222