The Effect of Mewis Duct Energy Saving Device to Propeller Performance

To cite this article: A Trimulyono *et al* 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1098** 012076

The Effect of Mewis Duct Energy Saving Device to Propeller Performance

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Abstract. Installation of ESD (Energy Saving Device) can improve ship propulsion performance. Mewis Duct is one type of ESD (Energy Saving Device) multi-component device that combines nozzle and fin into the nozzle. The structure can minimize losses due to small losses at the ship's stern and rotational losses or loss of thrust in the slipstreams area. Mewis Duct can reduce power by about 3-8% and increase thrust on the propeller by about 2-5%. This study aims to improve the performance of the INSEAN e779a propeller type using Mewis Duct. The modified Mewis ducts are the number of fins four, five, six asymmetrical and four symmetrical fins using the computational fluid dynamics (CFD) approach. The CFD code is based on the RANS (Reynolds - Averaged Navier Stokes) equation with the turbulent model is k-ε. This study found that installing Mewis duct as ESD in a ship increased the propeller thrust by 3-5% and the torque by 3-4%.

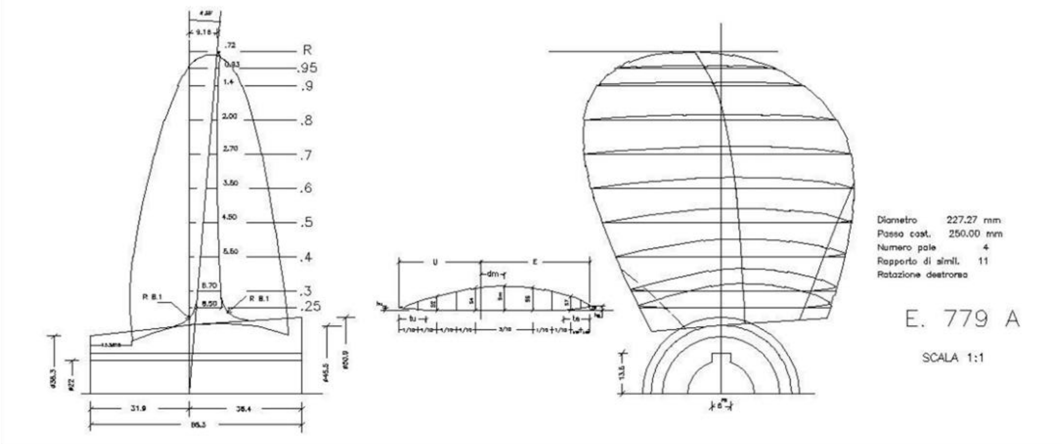
1. Introduction

The energy-saving device (ESD) is one of the ways to increase propeller performance by adding the device to the propeller or ship. ESD can minimize energy loss caused by propeller performance which can reduce energy loss imposed on a propeller performance, then improve ship performance. The study of ESD was performed by Trimulyono et al. for propeller B-series with the combination of ESD [1]. Later, The study was carried out with some variations in angle and fin diameter of PBCF [2]. The study of propeller B-series was conducted in open water schema using computational fluid dynamics (CFD) by Agung and Anita [3]. In addition, a comparison of blade area B-series propeller was conducted by Putra et al. [4]. Moreover, the study of propeller B-series in different advanced coefficients was performed by Fitriadi et al.[5]. Recently, a comparison study of propeller B-series with Kaplan using PBCF was conducted by Berlian et al.[6]. Furthermore, the study of the effect of the incline angle of PBCF using the B-series was performed by Akbar and Utama [7]. The previous research showed B-series propeller was commonly used to perform propeller studies because the empirical data was available compared to other propeller types. It was demonstrated many studies were performed for PBCF with B-series. However, there is a lot of ESD available in the market, such as Mewis duct, hull vane, vortex fin generator, etc.

The present study aims to improve propeller performance by installing the Mewis duct on the propeller. Propeller INSEAN e779a was used in this study, the study was carried out with CFD based on the volume of fluid method (VOF). The velocity advanced was based on the velocity speed service of the Kriso Container Ship (KCS). In addition, there are four combinations of Mewis duct, i.e., Mewis duct with four fins, five fins, six fins, and symmetrical four fins. The results showed that the Mewis duct increased the propeller performance by 5% by increasing propeller thrust.

2. Methods

This paper used a numerical computation of propeller performance in CFD based on Reynold Average Navier Stokes (RANS). Fig. 1 depicts propeller INSEAN e779a developed by Italian National Institute for Naval Architecture Studies and Testing (INSEAN)/ Italian Ship Model Basin [8]. The propeller itself was made for research aims. Fig. 2 shows Mewis duct installation in a stern hull ship; in this study, the mechanism of Mewis duct set up in the stern frame was ignored. In addition, only velocity of advance (v_a) was used based on before and after Mewis duct installation. After v_a is known, the next step is the value of v_a is used as inlet velocity in the computational propeller domain. It was used to simplify the geometry without a ship hull and decrease computation time. Fig. 3 depicts the numerical domain for fluid and propeller, consisting of stator and rotator. The stator is the static domain in which the fluid enters the tube. Then the rotator is the rotating domain that the propeller rotates likes in the ship. Table 1 indicates CFD's numerical setup for the fluid and propeller domain. The fluid domain remains static with a constant velocity of 0.61 m/s entering and rotating for the propeller domain. This study's propeller angular speed is 5.2 revolutions per second (RPS).

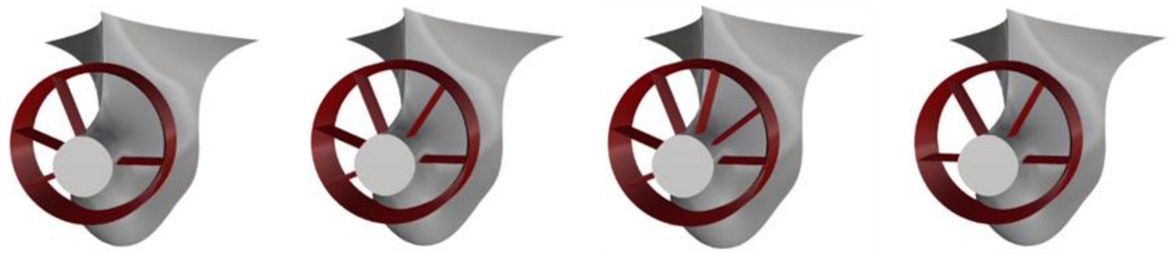


r/R	E	U	dm
.25	35.32	27.93	7.53
.3	39.40	31.37	7.00
.4	41.59	35.63	6.48
.5	43.16	39.44	5.67
.6	43.08	42.39	4.67
.7	42.18	44.57	3.14
.8	38.24	45.26	1.08
.9	28.54	41.72	−2.30
.95	14.25	30.95	−5.24
1	0.00	0.00	−8.67

te	tu	he	hu	r
8.61	8.41	1.30	0.80	0.40
8.20		1.08		0.20
6.98		0.92		
4.80		0.34		
0.81		0.04		

r/R	S1	S2	S3	S4	S5	S6	S7	S8	Tm
.25	3.09	4.74	6.28	7.40	7.60	6.40	4.86	3.06	8.20
.3	2.26	3.92	5.30	6.18	6.22	5.22	3.80	2.46	6.70
.4	1.97	3.40	4.46	5.10	5.10	4.40	3.32	2.23	5.50
.5	1.50	2.53	3.43	4.12	4.10	3.40	2.60	1.80	4.50
.6	1.18	1.97	2.62	3.19	3.22	2.78	2.17	1.68	3.50
.7	0.96	1.52	1.98	2.40	2.47	2.10	1.60	1.24	2.70
.8	0.78	1.21	1.54	1.78	1.82	1.50	1.14	0.90	2.00
.9	0.60	0.81	1.03	1.20	1.22	1.00	0.77	0.60	1.40
.95	0.46	0.60	0.76	0.82	0.82	0.78	0.60	0.41	0.90
1									0.00

Figure 1. Propeller geometry of INSEAN e779a



(a) (b) (c) (d)

Figure 2. Mewis duct model with (a) 4 fin, (b) 5 fin, (c) 6 fin, (d) symmetrical 4 fin.

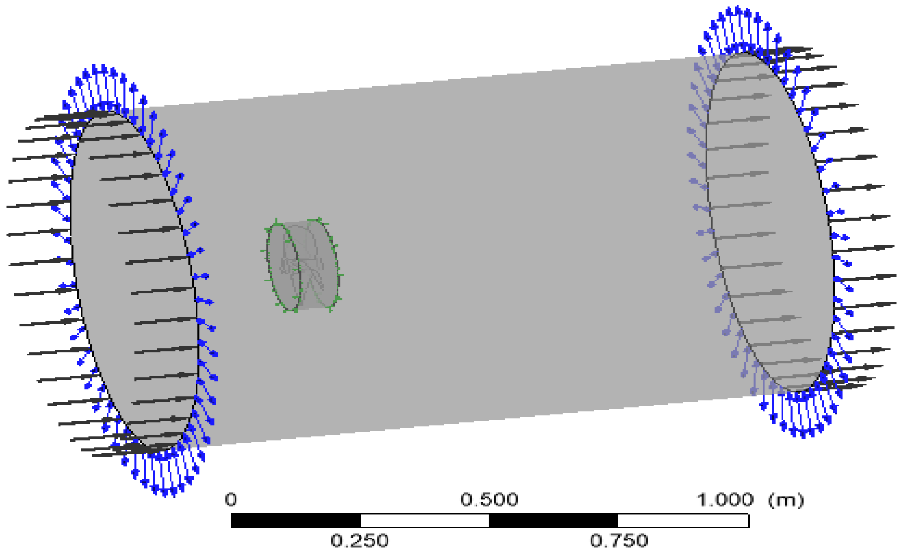


Figure 3. Computational domain of propeller

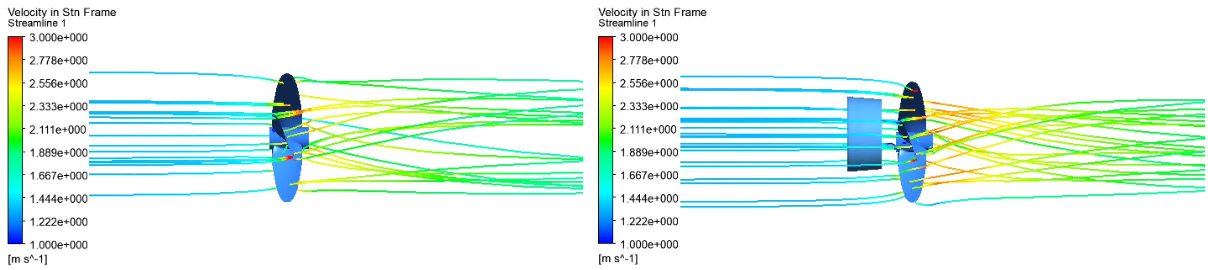
Table 1. Parameters setup for CFD computation

Domain	Fluid	Propeller
Type	Fluid	Fluid
Location	B1214	B38
Materials		
Water		
Fluid Definition	Material Library	
Morphology	Continuous Fluid	
Settings		
Buoyancy Model	Non Buoyant	
Domain Motion	Stationary	Rotating (5.2 RPS)
Reference Pressure	1 atm	

Heat Transfer Model	None
Turbulence Model	K-epsilon
Turbulent Wall Functions	Scalable

3. Results and Discussion

Mewis duct is one of the ESD to remedy stream flow in front of the propeller with a smaller nozzle diameter than the propeller diameter. In this study, several fin numbers and positions were carried out to increase propeller performance. Fig. 4 (a) shows the comparison of the propeller without the Mewis duct; the stream flow after passing the propeller is more divergent as the velocity decreases. Fig. 4 (b) indicates propeller with Mewis duct; the stream flow becomes convergent in front of the propeller; after passing the propeller, the stream flow shows a similar trend became convergent as a result, the velocity increases and then force acts in the propeller increases. Table 2 shows the validation results of propeller Wageningen B series for propeller thrust. It shows the CFD results has a good agreement with experiment, which the difference is below 3%. Table 3 indicates a comparison of ships without Mewis duct and with the installation of Mewis duct, which showed that Mewis duct in all variations improves the propeller performance by increasing the propeller thrust. The highest performance indicates by the Mewis duct using asymmetrical six fins inside the nozzle. The value of propeller thrust is similar for all cases in this study; some variations are needed to deepen the effect of advanced velocity and propeller revolution. Fig. 5 shows a similar trend to Fig. 4 that in all variations, the Mewis duct is improved the stream flow in front of the propeller. The velocity affected by the nozzle in front of the propeller that stream flow became convergent, and then the velocity increased; as a result, increasing the force act on the propeller.



(a) (b)

Figure 4. Comparison of propeller without (a) and with Mewis duct (b).

Table 2. Validation results for propeller thrust and torque

Parameters	Exp.	*CFD*	Error (%)
	22,91	23,17	1,35
	34,45	35,03	1,67
Thrust	50,23	50,91	1,99
	66,04	67,49	2,15
	91,63	93,19	2,32

Table 3. Thrust and torque propeller with and without Mewis duct

No	Propeller	v_a	Thrust (N)	%
1	Ship w/o Md		22.4555	0
2	Ship +Md1		23.5007	4.68
3	Ship +Md2	0,61	23.5338	4.80
4	Ship +Md3		23.5816	5.01
5	Ship +Md4		23.5218	4.75

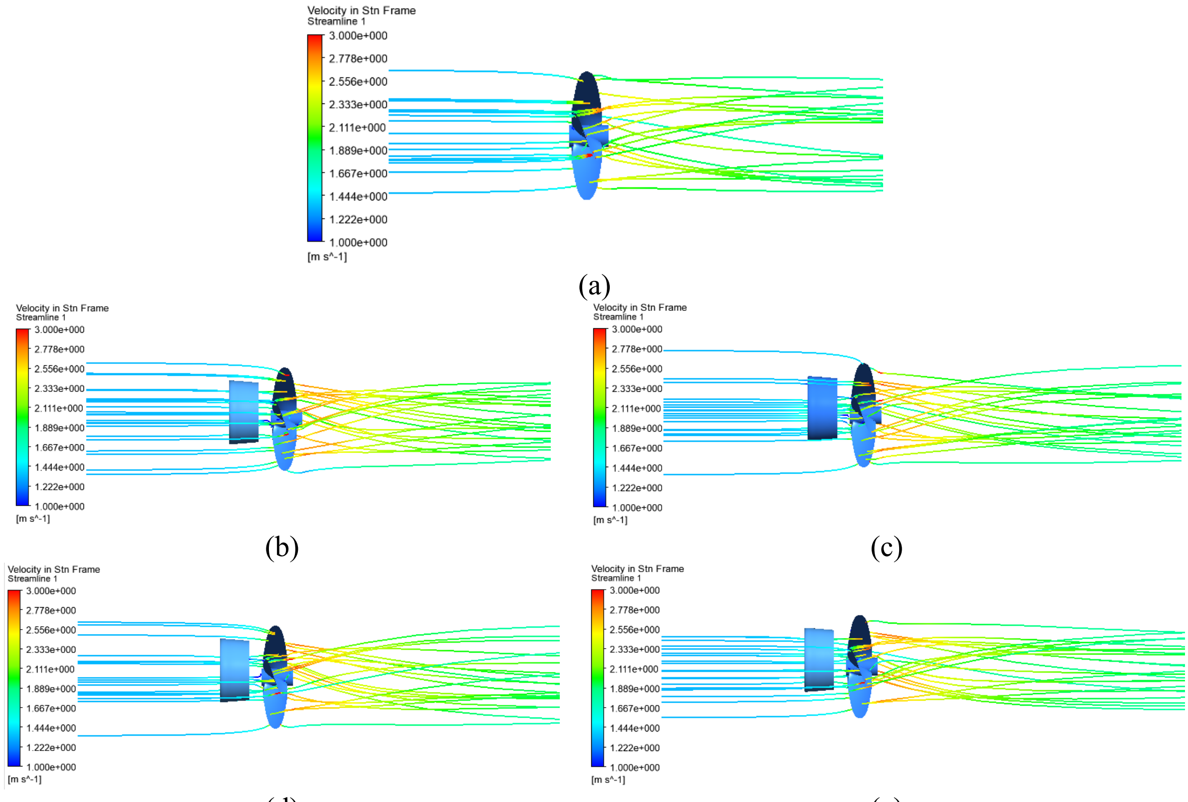


Figure 5. Comparison of propeller INSEAN e779a (a) and with Mewis duct (b).

4. Conclusion
Mewis duct as one of ESD for propeller can be one solution to improve propeller performance. The results show that the Mewis duct improved the propeller performance by 5% by increasing the thrust propeller. The best design of Mewis duct shows using six fins compares to other designs. Nevertheless, this study was preliminary for a combination of ESD such as PBCF or nozzles. Future work of optimization needs to carry out using a sophisticated method such Analytic Hierarchy Process (AHP) [9].

5. Acknowledgments
The authors are sincerely grateful to the Faculty of Engineering, Diponegoro University, for funding this work under scheme Penelitian Strategis with contract number No.3178/S/perkapalan/4/UN7.5.3.2/PP/2022.

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