Research on B30 fuel use in people's shipping

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Abstract. The usage of biodiesel is necessary to be more suited to manufacturing development, notably diesel engines, both addressing engine performance and exhaust emission issues. Biodiesel is a renewable, sustainable, and alternative fuel for internal combustion engines. The effects of using biodiesel, specifically on the content of PM, HC, and CO emissions, increasing fuel consumption and increasing NOx, as well as carbon deposits in the primary engine components, are brought on by the emergence of new regulations and standards with reference to international regulations. As a result, the B30 fuel mixture is anticipated to aid in the control of air pollution and the alleviation of resource shortages without considerably reducing engine power and being cost-effective. Comparable to 58 Kw, so the HSD-based SFOC is 0.162927 and the B30 value is 0.137527. For the same engine power, it can be stated that using B30 is more effective than using HSD. However, when diesel oil is totally replaced with biodiesel, the engine must be optimized and modified in terms of engine performance, instrumentation, and new testing procedures.

1 Introduction

Biodiesel is a mono alkyl ester compound which is produced through a trances verification reaction between triglycerides (vegetable oils, such as palm oil, castor oil, etc.) with methanol to become methyl esters and glycerol with the help of a base catalyst [1]. Biodiesel has a carbon chain between 12 and 20 and contains oxygen. The presence of oxygen in biodiesel distinguishes it from petroleum diesel (diesel) whose main component only consists of hydro carbon [10].

The energy produced by biodiesel is relatively no different from petroleum diesel (128,000 BTU vs 130,000 BTU), so the engine torque and horsepower produced are also the same [11]. Although the calorie content of biodiesel is similar to that of petroleum diesel, because biodiesel contains oxygen, the flash point is higher so it is not flammable [2].

Table 1. Characteristics of Fuel Properties

Oil	**Kinematic viscosity** (mm²/sec) **v**	**Heating value** (MJ/Kg) **HV**	**Flash Point** (°C) **FP**	**Density** (kg/l) **p**	**Cetane number**
Karanja	27.84	34.0	205	0.912	52.0
Babassu	30.30	37.5	150	0.946	38.0
Soyabean	32.60	39.6	254	0.914	37.9
Sunflower	33.90	39.6	274	0.916	37.1
Rapeseed	37.00	39.7	246	0.912	37.6
Peanut	39.60	39.8	271	0.903	41.8
Palm	39.60	39.5	267	0.918	42.0
Jatropha	52.76	38.2	210	0.933	38.0

Table 2. Properties of Vegetable Oil

Biodiesel	**Kinematic viscosity** (mm²/sec) **v**	**Heating value** (MJ/Kg) **HV**	**Flash Point** (°C) **FP**	**Density** (kg/l) **p**	**Cetane number**
Babassu	3.6	41.15	127	0.875	63
Rapeseed	4.2	41.55	80	0.882	54
Soyabean	4.5	41.28	178	0.885	45
Sunflower	4.6	41.33	96	0.860	49
Peanut	4.9	41.71	176	0.883	54
Palm	5.7	41.24	183	0.880	62

Biodiesel also does not produce harmful vapors at room temperature, so biodiesel is safer than petroleum diesel in storage and use. In addition, biodiesel does not contain sulfur and carcinogenic benzene compounds, so biodiesel is a cleaner fuel and easier to handle than petroleum diesel.

Table 3. Development of Fuel Sulfur Content Specifications

Name	**UE Directive**	**Sulfur Limit (ppm)**
Euro 2	93/12/EEC	500 (diesel)
Euro 3	98/12/EEC	350 (diesel); 150 (gasoline)
Euro 4	98/70/EC	50*
Euro 5	2003/17/EC	10, 10**

Source: https:/www.transportpolicy.net/standard/eu-fuels-diesel-and-gasoline/

The use of biodiesel can also reduce emissions of carbon monoxide, total hydrocarbons, particulate matter, and sulfur dioxide.

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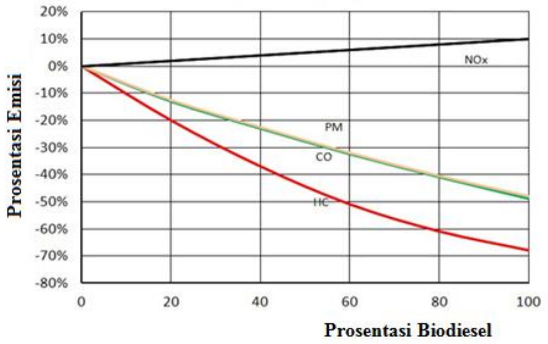

Fig 1. Emission Value of Biodiesel in Engine

The emission of nitrous oxide can also be reduced by the addition of a catalytic converter. Another advantage from an environmental point of view is its toxicity level which is 10 times lower than table salt and the same level of biodegradability as glucose, making it very suitable for use in water for fuel for ships/motorcycles. Studies show that biodiesel can be biodegraded four times faster than petroleum diesel, reaching 98% in three weeks [3]. As a result of being biologically degraded emissions and unpleasant odors can be reduced. Biodiesel does not explode quickly or ignite under normal circumstances because it has a high burning point of 150oC, this is different from petroleum diesel fuel which has a burning point of only 52oC [12]. The energy contained in biodiesel is 12% less than petroleum fuel. Biodiesel contains about 42 MJ/kg energy [4]. The energy reduction was offset by an increase in biodiesel combustion efficiency of 7%. Biodiesel does not add to the greenhouse effect like petroleum diesel because the carbon produced is still in the carbon cycle [13]. The volumetric energy density of biodiesel is about 33 MJ/L. This is 9% lower than petrodiesel on regulation.

Table 4. Low energy percentage value for each fuel

Type of Fuel	kcal/kg	Percentage
Diesel	10,797	
Biodiesel (B20)	10,317	- 4,4%
Biodiesel (B30)	10,274	- 4,8%
Biodiesel (B100)	8,895	- 17,6%

The energy density of biodiesel varies widely, tends to the raw materials used rather than from the production process. However, the variety of biodiesel types is less than that of petrodiesel [20]. It has been claimed that biodiesel provides better lubrication and provides a more complete combustion so that it can increase engine energy output and is an alternative to petrodiesel.

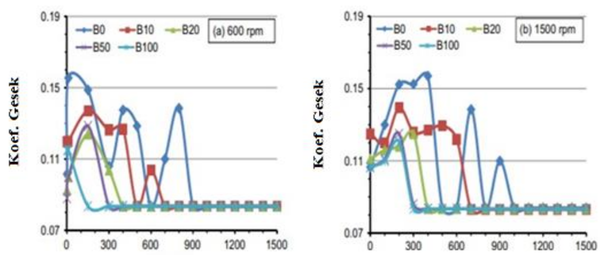

Fig 2. Friction Coefficient Value At 1500 s With Speed 600 rpm and 1500 rpm

Biodiesel is a liquid with a color that varies from golden yellow to dark brown depending on the raw material used. Biodiesel does not mix with water. It has a high boiling point and a low vapor point. The burning point of biodiesel (>130 °C, >266 °F) is significantly higher than that of petrodiesel (64 °C, 147 °F) or premium (−45 °C, -52 °F). Biodiesel has a density of ~ 0.88 g/cm³, lower than water [14]. Characteristics of biodiesel that is easily oxidized which results in the formation of peroxide compounds, acids, gums and deposits. Compatibility materials which are a mixture of copper such as brass, tin, zinc and rubber are indicated to have potential problems, as well as the solvency effect which has the ability to dissolve sludge and rust [15]. Microbial growth as a layer between water and biodiesel will make it easier for microbes to grow. Biodiesel which is made by chemical reaction between alcohol and vegetable oil, using the transesterification process, can be used easily [16]. This feedstock is miscible with diesel oil of all compositions, has physical properties similar to ordinary diesel, and therefore can be applied directly to diesel engines and almost without modification [5].

B30 fuel as a renewable, sustainable and alternative fuel for internal combustion engines, the use of biodiesel is required to be increasingly adapted to manufacturing development, especially diesel engines, both regarding engine performance and exhaust emission issues [17]. B-30 fuel regulations, since the issuance of Law no. 30 concerning the Improvement of the Supply and Utilization of New Renewable Energy in 2007, followed by the issuance of the Minister of Energy and Mineral Resources Regulation NO. 32 with an Implementation Target in 2010 = 5%, 2015 = 10%, in 2020 = 15% and followed in 2015, the Minister of Energy and Mineral Resources Regulation No. 12 which contains the Revision of Implementation Targets, in 2015 increased to 15%, in 2016 to 20%, in 2020 to 30%, so that the Minister of Energy and Mineral Resources Regulation No. 41 of 2018 which mandates expansion into the NPSO sector and this is reinforced by the results of research and studies from various sources and stakeholders who have provided input related to the issue of national energy supply [6]. Below are the specifications for the B-30 fuel.

Table 5. B-30 Specifications

Parameters	Unit	Limit		Test Method (ASTM)
		Min	Max	
Calculated Cetane Number		48	-	D613
Density @ 15ºC	Kg/m³	815	880	D4052/D1298
Viscosity Kinematic @ 40 ºC	cSt	2,0	5,0	D445
Sulphur content	% m/m		0,25	D4294/D5453
Distillation 90%	ºC	-	370	D86

Flash Point	ºC	52	-	D93
Cloud Point	ºC	-	18	D2500
PourPoint	ºC	-	18	D97
Carbon Residue	% m/m	-	0,1	D189
Water Content	Mg/kg	-	425 and reportable	D6304/D744
Biological Growth		Nihil		
FAME Content	% v/v	-	30	D7806/D7371
Corrosion copper strip	Class	-	Class 1	D130
Ash Content	% m/m	-	0,01	D482
Sediment Content	% m/m	-	0,01	D473
Total Acid Number	Mg KOH/gr	-	0,6	D664
Strong Acid Number	Mg KOH/gr	-	0	D664
Appearance		Clear & Bright		
Colour ASTM		-	3,0	D1500
Lubricity (HFFR wear scardia @ 60 ºC)	Micron	-	460	D6079
Oxidation Stability	Hour	35		EN15751

Source : SK Dirjen Migas No. 0234.K/10/DJM.S/2019

The effect of the use of B30 on the design and construction of ships, some of the effects on the design and construction of the use of B30 fuel on people's shipping vessels are as follows; Fuel tank volume, At the same voyage distance, B30 consumption will be greater when compared to MFO. However, it is smaller than HSD, therefore the design and construction of the fuel tank volume will have an effect [18]. It can be bigger or smaller and the layout of the fuel tank and its supporting system; Support systems will also have an effect, such as piping systems, oil heating is needed or not, pumping and valve systems and fuel checking systems [19]. Likewise, the layout of the design of the tanks and these systems will change. and the volume and layout of the space around the fuel tanks and engine bays of the ship; As the fuel tank shrinks or enlarges, it changes the space around it [7]. Likewise, the fuel support systems will change the surrounding system, both in the use of space or in its layout. Regarding the readiness of engine manufacture regarding government regulations that require the application of the use of B30 fuel and strict attention to MFM, the implementation of the use of B30 is a national energy saving solution and truly a renewable energy whose continuity is maintained [8]. fuel quality assurance: biodiesel, diesel oil, and biodiesel blends, fuel handling techniques starting from the sampling, testing, receiving, mixing, storage, and distribution stages, including compliance with established operating standards, monitoring of fuel quality since the sampling activity, testing and processing of test results data that can be accounted for, selecting infrastructure materials that are suitable for biodiesel [21].

2 Methods

Technical analysis of the use of B30 fuel, this study is a descriptive study that examines the differences in the use of B30, HSD, MFO fuels on the resistance of ship engines to thermodynamic parameters at the main points of the diesel engine work cycle and the performance of the diesel engine. The population data in this study refers to the number of engine operations for two months when the engine uses B30, HSD, MFO fuel.

At this stage, what you want to know are several conditions in the work cycle, including: The state of the suction stroke consists of the final pressure of the suction stroke (Pa) and the final temperature of the suction stroke (Ta), The state of the compression stroke consists of the final pressure of the compression stroke (Pc).), the final temperature of the compression stroke (Tc), the final pressure of the combustion stroke (Pz), the final temperature of the combustion stroke (Tz), the final pressure of the expansion stroke (Pb) and the final temperature of the expansion stroke (Tb).

Second, enter several equations into the diesel engine performance analysis. At this stage, what you want to know is the achievement of engine performance as measured by: power indicator (Ni), effective specific fuel (BSFC), thermal efficiency (ηth), and volumetric efficiency (ηv) effective power (Ne), indicator specific fuel consumption (SFC), effective specific fuel consumption (BSFC), thermal efficiency (ηth), and volumetric efficiency (ηv)

3 Results and Discussion

3.1 Machine Spesification

Table 6. Machine specifications

Specifications	Description
Type	Mitsubishi Man 18 V52/55A
Manufacturing Factory	Mitsubishi Heavy Industries LTD Japan
Step Cycle	4
Piston Diameter	520 mm
Step Length	550 mm
Compression Comparison	11.5
Number of cylinders	18
Round	428 rpm

By using the following equation :

$$V_L = \frac{3{,}14 \cdot D^2 \cdot L}{4} \ (cc) \quad (1)$$

Obtained the value of the capacity of each cylinder is 11647, 2 cc or 116.745 liters. The engine has 18 cylinders so that the total capacity of one engine unit is 2101413.6 cc or 2101.41 liters.

3.2 Comparison of the use of B30, HSD, MFO fuel to thermodynamic parameters at the main points of the diesel engine work cycle

Based on the results of the state analysis at the main points of the diesel engine work cycle when using B30, HSD, MFO fuel, it can be seen the difference in pressure and temperature achieved, including: 1) the final pressure of the suction stroke (Pa), 2) the final temperature of the suction stroke (Ta), 3) the final pressure of the compression stroke (Pc), 4) the final temperature of the compression stroke (Tc), 5) the final pressure of the combustion stroke (Pz), 6) the final temperature of the combustion stroke (Tz), 7) the final pressure of the expansion stroke (Pb) and 8) the final temperature of the expansion step (Tz). This shows the difference in the achievement of pressure and temperature when the engine uses B30, HSD, MFO fuel based on the mean value.

Table 7. Comparison of Engine Pressure and Temperature on The Use of Fuel B30, HSD, MFO

Parameter	B30	HSD	MFO
End suction stroke pressure (Pa), kg/cm2	0.999139	1.05	1.10
Suction stroke final temperature (Ta), K	363.3249	381.82	380.75
End compression stroke pressure (Pc), kg/cm2	27.76654	29.18	30.52
The final temperature of the compression stroke (Tc,K)	875.2835	919.84	917.26
Final combustion stroke pressure (Pz),kg/cm2	49.97596	52.52	54.94
Final combustion stroke temperature (Tz), K	1587.451	1668.26	1704.66
End pressure of expansion stroke (Pb), kg/cm2	2.055371	2.16	2.26
End pressure of expansion stroke (Pb), kg/cm2	0.999139	881.57	901.18

The obtained values shown in the table above, show a significant difference, when it is at the point where the combustion takes place until the end of the expansion. This is indicated by the difference in the content of the combustion value of the calorific value (Qb) in the three types of fuel.

3.3 Comparison of ship engine performance with the use of B30, HSD, MFO fuel.

Based on the results of the analysis of the performance of the ship's engine when using B30, HSD, MFO fuel, it can be seen the difference in the values of the diesel engine performance parameters. The differences in question include: indicator power (Ni), effective power (Ne), thermal efficiency (ηth), volumetric efficiency (ηv), use of specific indicator fuel (sfc) and use of effective specific fuel (bsfc). This shows the difference in the achievement of diesel engine performance when the fuel is B30, HSD, MFO based on the mean value.

Table 8. Comparison of Ship Engine Performance With The Use of B30, HSD, MFO. Fuel

Parameter	B30	HSD	MFO
Power indicator (Ni), PS	2928.979	3078.079	3244.7064
Effective power (Ne), PS	2489.632	2616.367	2758.0004
Thermal efficiency (ηth), %	29.89803	31.42	44.58
Volumetric efficiency (ηv). %	72.14733	75.82	57.40
Specific fuel usage indicator (sfc), kg/HP-Hour	0.401654	0.4221	0.3075
Effective specific fuel use (bsfc), kg/HP-Hour	0.472545	0.4966	0.3618

The data obtained in the table above, shows differences in the performance of the ship's engine on the level of power, efficiency and fuel use. The engine power produced by the engine when using MFO fuel is proven to be higher than when using HSD and B30 fuel. It is also seen that the use or consumption of fuel is greater when the engine operates using HSD fuel compared to when using B30 and MFO fuel. Related to the level of efficiency, it is proven that the use of heat from the engine system, the use of MFO fuel is greater than the use of HSD and B30 fuel.

3.4 Differences in the use of B30, HSD, MFO fuel on the Parameters of the Main Points of the Work Cycle and Diesel Engine Performance..

Analysis of the parameters of the main points of the diesel engine work cycle which consists of analyzing the state of pressure and temperature when using B30, HSD, MFO fuel. Likewise, engine performance consists of several analyzes, namely analysis of power, efficiency and fuel use when operating with fuel. burn B30, HSD, MFO [9]. Furthermore, it can be seen in table 4, the difference in the use of B30, HSD, MFO fuel on the parameters of the main points of the work cycle and diesel engine performance as shown in the following table:

Table 9. Differences in the use of fuel B30, HSD, MFO on the parameters of the main points of the work cycle and diesel engine performance, effective power (Ne), specific fuel (bsfc), thermal efficiency (ηth) and volumetric efficiency (ηv).

Measurement Parameters		Fuel Type		
Main Point of Ship's Engine Cycle		B30	HSD	MFO
State	End pressure of suction stroke (Pa)	0.999139	1.05	1.1
Pressure	Compression stroke end pressure (Pc)	27.76654	29.18	30.52
Cycle	Compression stroke end pressure (Pc)	49.97596	52.52	54.94
Work (kg/cm2)	Compression stroke end pressure (Pc)	2.055371	2.16	2.26
state	Suction stroke final temperature (Pa)	363.3249	381.82	380.75
Temperature	Compression stroke end temperature (Pc)	875.2835	919.84	917.26
Cycle	Compression stroke end temperature (Pc)	1587.451	1668.26	1704.66
Work (K)	Compression stroke end temperature (Pc)	838.8673	881.57	901.18

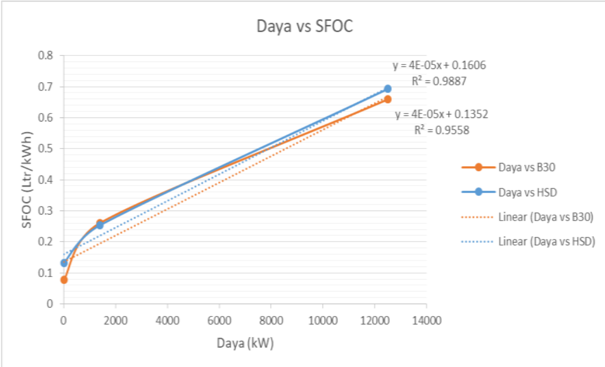

Fig 3. Power linear regression vs SPOC of B30 and HSD

Table 10. Engine power and SFOC using HSD and B30

Power (kW)	SFOC (Ltr/kWh)	
	HSD	B30
12498	0.692587	0.659038
1400	0.2536	0.2606
16	0.13191	0.077327

With Y being the SFOC value in Ltr/KWh and X being the power input in KW units, the linear regression equation for HSD is Y=4E-05x + 0.1606, and for B30 is Y= 4E-05x + 0.1352, for people's shipping ships, assuming an engine with a power of 80 HP or equivalent to 58 Kw, then the SFOC when using HSD is 0.162927 and B30 is 0.137527. It can be concluded that the use of B30 is more efficient than HSD for the same engine power, some of the effects on design and construction if the use of B30 fuel on people's shipping vessels are as follows:

a. The volume of the fuel tank, at the same cruise distance, the consumption of B30 will be greater when compared to MFO. However, it is smaller than HSD, therefore the design and construction of the fuel tank volume will have an effect. It can be bigger or smaller.

b. The layout of the fuel tank and its supporting system, the support system will also have an effect, such as the piping system, oil heating is needed or not, the pumping system and valves and the fuel checking system. Likewise the layout of the design of these tanks and systems will change.

c. The volume and layout of the space around the fuel tank and engine bay of the ship, as the fuel tank shrinks or enlarges, changes the space around it. Likewise for fuel support systems, it will change the surrounding system, both in the use of space or in its layout.

With the data analysis results from the use of various fuels as described above, it can be concluded that the engine performance when using MFO fuel is better than when using B30 and HSD fuel. Therefore, if you want to use B30 fuel in the operation of ship engines, especially engines used on people's shipping, a more in-depth study needs to be done to get better results.

4 Conclusion

For people's shipping vessels, assuming an engine with a power of 80 HP or equivalent to 58 Kw, then the SFOC when using HSD is 0.162927 and B30 is 0.137527, it can be concluded that the use of B30 is more efficient than HSD for the same engine power. Some of the effects on design and construction when using B30 fuel on people's shipping vessels are as follows :

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b. The layout of the fuel tank and its supporting system; Support systems will also have an effect, such as piping systems, oil heating is needed or not, pumping and valve systems and fuel checking systems. Likewise the layout of the design of these tanks and systems will change.

c. The volume and layout of the space around the fuel tank and engine room of the ship, considering that the fuel tank is shrinking or expanding, will change the surrounding space. Likewise, the fuel support systems will change the surrounding system, both in the use of space or in its layout.

References

1. R. Akbar, "Karakteristik Biodiesel Dari Minyak Jelantah Dengan Menggunakan Metil Asetat Sebagai Pensuplai Gugus Metil," Digital Library Institut Teknologi Sepuluh Nopember, pp. 1–13, 2011.
2. H. Prasutiyon, "Analisa Penambahan Spring PressurePlate Sebagai Usaha Untuk Memperpendek Ignition Delay Time Terhadap Performance Diesel Engine," dalam Prosiding Seminar Nasional Kelautan Universitas Hang Tuah 11 Juli 2019, ISBN: 978-602-71063-5-2.
3. "Biodiesel Sebagai Alternatif Pengganti Bahan bakar Fosil pada Motor diesel," dalam Laporan Riset Unggulan Terpadu VIII, Bidang Teknologi Energi, Kementrian Riset dan Teknologi RI, Lembaga Ilmu Pengetahuan Indonesia, 2003.
4. H. Prasutiyon, "Penghematan Bahan Bakar Kapal Penangkap Ikan Untuk Meningkatkan Kesejahteraan Nelayan," dalam Prosiding Seminar Nasional Kelautan Universitas Hang Tuah 11 Juli 2019, ISBN: 978-602-71063-5-2.
5. M. Elma, S. A. Suhendra, dan W. Wahyuddin, "Proses Pembuatan Biodiesel Dari Campuran Minyak Kelapa Dan Minyak Jelantah," Konversi, vol. 5, no. 1, hal. 8, 2018. [Online]. Available: https://doi.org/10.31213/k.v5i1.23.
6. N. Padilla, S. Subaer, dan M. Muris, "Analisis Penggunaan Bahan Bakar High Speed Diesel (Hsd) Dan Marine Fuel Oil (Mfo) Terhadap Parameter Titik Utama Siklus Kerja Dan Performa Mesin Diesel Mitsubishi Man Type 18V52/55a," Jurnal Sains Dan Pendidikan Fisika, vol. 15, no. 1, hal. 8–15, 2019. [Online]. Available: https://doi.org/10.35580/jspf.v15i1.9402.
7. H. Prasutiyon, "Pengaruh Angka Iodin Terhadap Ketahanan Komponen- Komponen Utama Motor Diesel Dengan Bahan Bakar Jelantah Methyl Ester B20," pp. 98, 2017.
8. "Produksi dan karakteristik Biodiesel serta Teknik Pencampurannya dengan Minyak Solar (Gas Oil)," Dipublikasikan pada Prosiding Seminar Nasional Teori dan Aplikasi Teknologi Kelautan 2002, 29 Oktober 2002, Fakultas Teknologi Kelautan ITS Surabaya.
9. S. Semin, A. Iswantoro, dan G. C. Hadi, "Analysis of Biodiesel Cotton Seed Oil on Diesel Engine Performance," International Journal of Marine Engineering Innovation and Research, vol. 2, no. 4, 2018. [Online]. Available: https://doi.org/10.12962/j25481479.v2i4.3444.
10. "Supply Chains Management in the Planning of BBM (Fuel Oil) Distribution in Anambas Island of Kepri Province," dalam The Conferences Of Theory and Aplication On Marine Technology, pp. 144–163, 2016.
11. J. Xue, T. E. Grift, dan A. C. Hansen, "Effect of biodiesel on engine performances and emissions," Renewable and Sustainable Energy Reviews, vol. 15, no. 2, hal. 1098–1116, 2011. [Online]. Available: https://doi.org/10.1016/j.rser.2010.11.016.
12. A. Zuhdi, "The Characteristics of Castor Oil as a Bio-diesel Fuel and its Effects on the Diesel Engine’s Performance," pp. 1–
13. A. Zuhdi, M. F. Abstrak, dan P. B. Indonesia, "Aplikasi Penggunaan Waste Methyl Ester Pada High Speed Marine Diesel Engine."
14. E. Sugianto dan J. H. Chen, "'Buy Marine Debris': A Digital Platform for Sustainable Marine Debris Management Involving Fishermen," International Journal of Humanities and Social Sciences, vol. 3, hal. 36-48, 2021. [Online]. Available: https://doi.org/10.6936/NIJHSS.202106.
15. E. Sugianto, A. Winarno, R. Indriyani, dan J. H. Chen, "Hull Number Effect in Ship Using Conveyor on Ocean Waste Collection," Kapal: Journal of Marine Science and Technology, vol. 18, hal. 129-142, 2021. [Online]. Available: https://doi.org/10.14710/kapal.v0i0.40744.

16. E. Sugianto, J. H. Chen, dan N. P. Purba, "Numerical investigation of conveyor wing shape type effect on ocean waste collection behavior," E3S Web of Conferences, vol. 324, hal. 01005, 2021. [Online]. Available: https://doi.org/10.1051/e3sconf/202132401005.
17. E. Sugianto, J. H. Chen, dan N. P. Purba, "Cleaning technology for marine debris: a review of current status and evaluation," Int. J. Environ. Sci. Technology. [Online]. Available: https://doi.org/10.1007/s13762-022-04373-8.
18. E. Sugianto, J. H. Chen, dan N. P. Purba, "Effect of Monohull Type and Catamaran Hull Type on Ocean Waste Collection Behavior Using OpenFOAM," Water, vol. 14, no. 17, hal. 2623, 2022. [Online]. Available: https://doi.org/10.3390/w14172623.
19. E. Sugianto dan J. H. Chen, "Experimental Study of the Effect of a Solid Wing Conveyor on Marine Debris Collection," Journal of Marine Science and Technology. [Online]. Available: https://doi.org/10.51400/2709-6998.2584.
20. E. Sugianto dan J. H. Chen, "Hollow Wing Technique to Enhancing Conveyor Performance on Marine Debris Collection," EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, vol. 9, no. 4, 2022.
21. E. Sugianto, J. H. Chen, R. Sugiono, dan H. Prasutiyon, "Effect of portable conveyor placement in ship on ocean waste collection behavior," IOP Conf. Ser.: Earth Environ. Sci., vol. 1095, hal. 012015, 2022. [Online]. Available: https://doi.org/10.1088/1755-1315/1095/1/012015.