BACHELOR THESIS (ME 141502)

Effect of The use of Water in Fuel Emulsion on Performance and NOx on The Diesel Engine

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DOUBLE DEGREE PROGRAM OF
MARINE ENGINEERING DEPARTMENT
FACULTY OF MARINE TECHNOLOGY
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
SURABAYA
2016

SKRIPSI (ME 141502)

Pengaruh Penggunaan Bahan Bakar Emulsi air pada Performa dan NOx pada Mesin Diesel

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FAKULTAS TEKNOLOGI KELAUTAN
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APPROVAL FORM

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on
Laboratory of Marine Power Plant (MPP)
Bachelor Program Department of Marine Engineering
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Institut Teknologi Sepuluh Nopember

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Effect of The use of Water in Fuel Emulsion on Performance and NOx on The Diesel Engine

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ABSTRACT

NOx one of the exhaust emissions is harmful to human health. Many methods can reduce NOx emission, one of them is water in fuel emulsion. By using experiment, research has been conducted in surfactant selection. The results of experiment show 4 surfactant, which is best used to the diesel engine is tween 80 and span 80. This experiment needs some water contents variation emulsifier with 10%, 15%, and 20%. In this different variation of water is very influential on performance and NOx emissions. Using water fuel emulsion of 10% in SFOC can increase 216,2 g/Kwh or 11.6% compared to Pertamina Dex of fuel. However, the water used in fuel emulsion of 15% and 20% in SFOC increased to compare 10% emulsion. The effect of water use in fuel emulsion can reduce NOx emission. Water in fuel emulsion can be decreased to 0.216 g/Kwh or 50.5%. Generally, the emission level of a diesel engine that has been using water in fuel emulsion can be improved until entering on Tier 3 specification of IMO rules.

Keywords*— *Water emulsion, Engine performance, NOx emissions

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Pengaruh Penggunaan Bahan Bakar Emulsi air pada Performa and NOx pada Mesin Diesel

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ABSTRAK

NOx salah satu emisi gas buang yang berbahaya bagi kesehatan manusia. Banyak metode yang ditawarkan untuk mengurangi emisi NOx salah satunya adalah bahan bakar emulsi air. Dengan menggunakan percobaan, penelitian telah dilakukan pemilihan surfaktan. Hasil percobaan menunjukkan dari 4 surfaktan, yang baik digunakan untuk mesin diesel yaitu tween 80 dan span 80. Dalam percobaan ini diperlukan beberapa kandungan variasi air untuk pengemulsi terdiri dari 10%, 15%, dan 20%. Dalam variasi air yang berbeda ini sangat berpengaruh terhadap performa dan emisi NOx. Menggunakan emulsi bahan bakar air 10% di SFOC dapat meningkat 216,2 g / Kwh atau 11,6% dibanding bahan bakar Pertamina Dex. Namun, air yang digunakan dalam emulsi bahan bakar 15% dan 20% di SFOC meningkat untuk membandingkan emulsi 10%. Pengaruh pada penggunaan bahan bakar emulsi dapat mereduksi emisi NOx. Bahan bakar emulsi dapat menurun hingga 0,216 g / Kwh atau 50,5%. Umumnya, tingkat emisi mesin diesel yang telah menggunakan bahan bakar emulsi dapat ditingkatkan sampai masuk pada peraturan IMO spesifikasi Tier 3.

Kata kunci* — *bahan bakar Emulsi air, Engine performa, Emisi NOx

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PREFACE

Alhamdulillah, Praise to Allah Subhanahu wa ta'ala for the presence of plenty of mercy and his grace, so that the writer can complete the bachelor thesis with the title of "**EFFECT OF THE USE OF WATER IN FUEL EMULSION ON PERFORMANCE AND NOx ON THE DIESEL ENGINE**

This Bachelor Thesis were submitted in order to comply with one of the requirements to obtain a Bachelor Degree in Department of Marine Engineering, Institut Teknologi Sepuluh Nopember

Also I would like to express my gratitude for those who always give their best support and attention:

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5. Dr. Badrus Zaman, S.T., M.T., as a Head Department of Marine Engineering.
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My high school mates, who always give their craziness and great support through any situation.

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CHAPTER I
INTRODUCTION

1.1 Background

Emissions are a toxic gas that can endanger and threat human life on this earth. On the ship, the emissions are formed due to the combustion of fuel carried by diesel engines that occur in the combustion chamber. Diesel engine are the type of internal-combustion engine which atomized fuel oil is sprayed into the cylinder and ignited by the heat generated by compression. In the Diesel engine are efficient, because it has a low level of carbon di-oxide, carbon monoxide and hydrocarbon emissions. However, the emissions are high in nitrous oxides. Marine engines use residual bunker fuels which contain sulphur, asphaltenes and ash. Due to these components in the fuel, the exhaust emissions contain oxides of sulphur and particular matter which are formed during the combustion process.

Fuel is injected at high pressure (through fuel injectors which atomize the fuel) into the combustion chamber towards the end of the compression stroke. The fuel ignites, thereby increasing the pressure in the combustion chamber and pushes the piston downward on the power stroke. When the fuel ignites the flame front travels rapidly into the combustion space and uses the compressed air to sustain the ignition. Temperatures at the envelope of the flame can exceed 1300 degrees C, although the mean bulk temperature in the combustion chamber is much lower. At these localized high temperatures molecular nitrogen in the combustion air is oxidized and Oxides of Nitrogen (NO_x) are formed in the combustion chamber. Oxidation of molecular nitrogen in the combustion air comprises of about 90% of NO_x, the other 10% is the result of oxidation of the organic nitrogen present in the residual fuel oil.

In recent years emissions of NO_x, SO_x and particulate matter from ships has increased. International shipping now contributes about 15% of the global NO_x emissions and there is a substantial pressure to reduce NO_x emissions from ships. Europe and USA have established air quality standards with maximum levels of fine particles. These levels are exceeded in many coastal and harbor area. However it is not likely that particulate matter emissions from ships will be regulated, but it is still an important objective to minimize these emissions. NO_x emissions from ships are regulated and the limits on NO_x emission are getting stricter. The limitation on NO_x emission means that different measures for NO_x reduction will have to be used. These measures might have adverse effects upon the levels of other emissions likeCO_2, CO, unburned hydrocarbons and particulate matter. The magnitude of the effect upon CO_2 is widely known; while the effects upon particulate matter are largely unknown.

The use of water in diesel engine has a number of possible benefits. It has been found that it has an influence on reducing the peak flame temperature and hence reducing the NO_x emissions.The technique concerned with introducing water into engine combustion chamber was proposed by Prof. B. Hopkinson in 1913, to make better internal cooling of the gas engine and to increase the engine output. Furthermore, the technique was developed to improve the thermal efficiency and reduce exhaust emissions, or used as the safety fuel.

1.2 Problem Statement

The issues that have discussed in this research thesis is:

1. How to emulsify water into diesel fuel?
2. How is the performance of the diesel engine produced after mixing fuel with water and emulsify?
3. How the value content of NOx emissions produced after the use of water in fuel emulsion?

1.3 Research limitation

The research limitation applied in this bachelor thesis is:

1. Without calculating economical aspect
2. Without considering fuel properties

1.4 Research Objectives

The purpose of this research thesis is:

1. To determine what kind of water can be emulsified into diesel fuel.
2. To determine the performance test results of a diesel engine using a water emulsion fuel.
3. To determine the value of the emissions produced in the diesel engine fuel made from water in the emulsion.

1.5 Research Benefits

Benefits to be gained from this research are:

1. To increase knowledge on water in fuel emulsion on the diesel engine.
2. To increase knowledge on the working of Performance diesel engine fuel made from water in the emulsion.
3. To increase knowledge of the emissions released by water in fuel emulsion

CHAPTER 2
LITERATURE REVIEW

2.1 State of The Art

The use of water in diesel engines have a number of possible benefits. It has been found that it has an influence on reducing the peak flame temperature and hence reducing the NOx emissions. The technique concerned with introducing water into engine combustion chamber was proposed by Prof. B. Hopkinson in 1913, to make better internal cooling of the gas engine and to increase the engine output. Furthermore, the technique was developed to improve the thermal efficiency and reduce exhaust emissions, or used as the safety fuel.(Dan, 2013)

Water-in-oil emulsion is defined as a form of water in oil mixture that is not intermingled forced mixed stably or temporarily with the help of chemical surfactant (emulsifier) so that the water in the form of granules distributed in the oil phase. Emulsifier level is determined by the ability of surfactant, fluid viscosity, grain size, material composition and temperature of the mixture. In particular, the grain size of smaller water desired is submicron size. Submicron grain size of water helps keep the liquid emulsion stable in the long term. Water-in-oil emulsion is formed when the volume of water in amounts far less than the volume of oil that is mixed. Chemical surfactants (emulsifiers) are the key factor to get the oil in water emulsion to be stable for a long time. Water-in-oil emulsion can be used as a fuel where this emulsion can certainly burn. (Yazid, 2015). In an emulsion usually there are three main parts:

1. Section dispersed consist of grains which usually consists of fat.
2. Media dispersant which is also known as the continuous phase, which usually consists of water.
3. Emulsifiers which serves to keep the oil grains had remained suspended in the water.

Factors that affect the stability of the emulsion is the type of emulsifier, emulsifier concentration, droplet size, pH, viscosity, stabilizers, heating, cooling, freezing, or mixing

1. Emulsions may occur permanently and temporarily.
2. Permanent Emulsion is a material capable of forming membranes or films around the dispersed droplets thereby preventing the re-unification of these items. Such materials are known as an emulsifier.
3. The temporary emulsion occurs for example in oil and water are shaken together, will form beads of fat and then form an emulsion, but if

allowed particles of oil will be joined again and broke away from the water molecules. This is referred to as a temporary emulsion. Because it must quickly be used, or should be in the shake again before the time of usage.

2.2 Blending

As shown in figure 2.1 blending process is the addition of additive materials into petroleum fraction in order to improve the quality of the product. To mix wine oil with diesel oil. there are two ways to blend emulsion and solution technique. The emulsion is a mixture of particles of a liquid substance (the dispersed phase) with other liquids (dispersing phase). The emulsion is composed of three main components, namely: the dispersed phase, the phase of dispersant and emulsifier. In the manufacture of an emulsion, emulsifier selection is an important factor to be considered because of the quality and stability of an emulsion is heavily influenced by the emulsifier used. One surface active emulsifier or better known as surfactants. (Alriga, 2012)

Solution technique is done by heating the fuel mixture. Both fuels can be dissolved without separation when heated to a temperature of 50 ° C

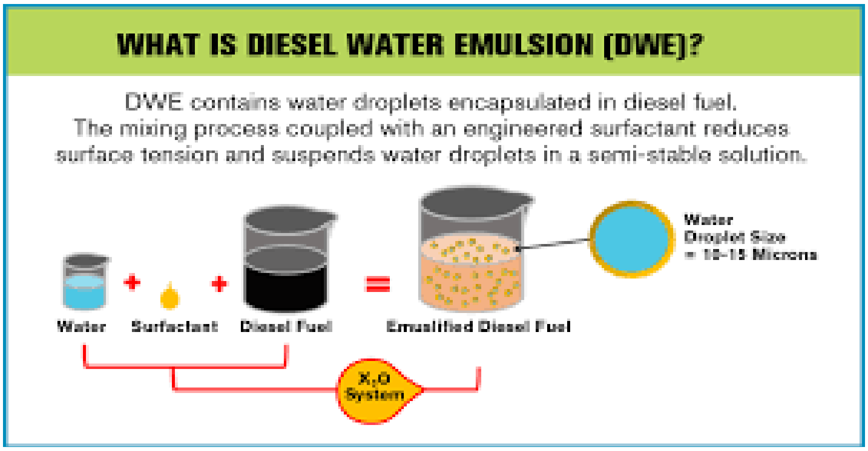

Figure 2. 1 Mixing Process water fuel

(http://www.fiercefuelsystems.com)

2.3 History of internal combustion engines

From the first application of open fire to provide heating, lighting, and cooking, combustion science has evolved to providing distributed electricity generation and mechanical energy for most modes of transportation. Combustion is described as either external or internal. External combustion is defined as combustion in which the process fluid is external to, or different from, the mechanical energy-producing fluid. For example, coal-fired power plants operate as external combustion because the coal is combusted to generate steam, and the steam then turns a turbine to generate electricity. If the fluid undergoing combustion also generates mechanical energy in the system, the process is defined as internal combustion. For example, in reciprocating internal combustion engines the gas expansion from combustion of the air and fuel mixture moves a piston, which turns a crankshaft, generating mechanical power for propulsion, electricity generation, etc. Gas turbines and rocket engines are also defined as internal combustion, since, in both cases, the air and fuel mixtures after combustion and compression provide mechanical power through thrust. Advances in the understanding of the thermodynamic cycles of combustion have improved the design of combustion engines. Improvements in materials science also support improvements in engine performance and durability. For example, advances in materials and design have improved the compressor ratio of gas turbines from 3:1 to 30:1, and increased the efficiencies from 3.5% to 30%. Similarly, computer modeling and simulation has supported advanced intake, combustion cylinder, and exhaust systems design on modern automobiles resulting in higher thermal and mechanical efficiencies with reduced air pollutant emissions. (Canfield, 1999)

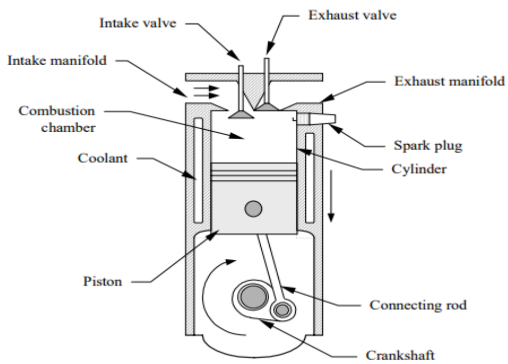

Figure 2. 2 Spark ignition engine cross section

(Source: http://citeseerx.ist.psu.edu)

2.4 Water Fuel Emulsion

Water fuel emulsion system is based on mixing of water into the fuel with additive substances mixture. The emulsion is injected into the engine cylinder using the fuel injection system. Therefore additional injecting equipment is not needed. This is of course depends on the installed injection system and the desired effect. A system for WFE consists of different components. Foremost there is the water supply. This system needs to be able to feed water of a good enough quality with a high enough quantity. Water emulsified fuel is one of the promising emission reduction techniques with the potential to reduce NOX in diesel engines. (Abdulaziz, 2010).

As show in figure 2.2 explain the comparation between the straight diesel combustion and a water-in-diesel emulsion The water-in-diesel fuel burns significantly cleaner. Emulsion is obtained by mechanical and ultrasound micronization process that results in micro-drops formed by the three basic elements of the product: water in the core, hydro fuel covering the water particles and finally the emulsifier between both previous elements with a membrane that also helps in binding them to other micro-drops. The nature of the new resulting fuel modifies the traditional combustion sequence. Engine injectors ignite the fuel by compressing hydro fuel in such a way that the explosion overheats the water particles trapped in the core of the micro-drops. This overheating results in water vapour that generates turbulence inside the engines combustion chamber. This vapour breaks up the hydrofuel molecules resulting in complete burning of the fuel that compensates the loss of energy due to the presence of the water particles added. The vapour also eliminates un-burnt residual particles and helps the cleaning of engine parts and exhaust system. (Fuelia, 2014)

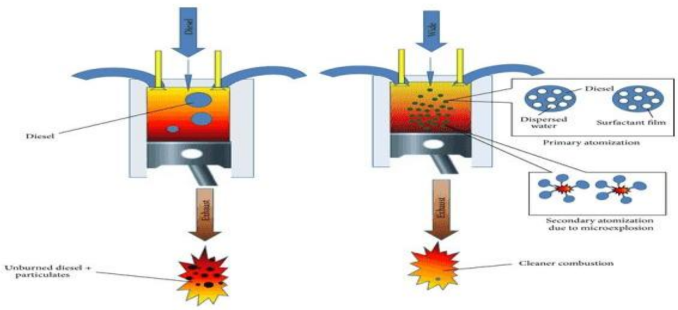

Figure 2. 3 primary and secondary atomization in spray flame of emulsified

(https://www.hielscher.com/)

2.5 Diesel engine performance

Torque, power, and SFOC are a measurement parameter to determine the performance on the diesel engine. Measurements performed using a dynamometer to measure the value of the torque generated by diesel engines. According to (Heywood, 1998) in calculating the performance of the diesel engine to measure the following parameters:

a) Torque

Total multiplication force with an arm's length measurement to determine the value of torque. As in the following formula:

$$T = \frac{P\ x\ 60000}{2\ \pi\ x\ rpm}$$

Where : T = Torque (kN.m)
P = power (kW)
Rpm = rotation of diesel engine (rpm)

b) power

power is one parameter in determining the performance on the diesel engine. Definition of power is the sense power magnitude on the diesel engine work for a certain period. As in the following formula:

$$P = \frac{v\ x\ i\ x\cos\emptyset}{eff\ gen\ x\ eff\ slip}$$

Where :

P	: power (kW)
V	: voltage(Volt)
I	: current (Ampere)
Cos Ø	: 0.9
Eff Gen	: generator efficiency (0.85)
Eff Slip	: slip efficiency (calculate)

c) SFOC

Measurement of fuel mass flow rate is needed in diesel engine performance test on fuel consumption.

$$FCR = \frac{v\ x\ \rho}{t} \qquad SFOC = \frac{FCR}{P}$$

Where : FCR = fuel flow (gr/h)
ρ= density of fuel (gr/h)
V = Volume of fuel (m^3)
t = time (h)
P = power (kW)
SFOC = specific fuel oil consumption (gr/kwh)

2.6 Rules and Regulation Emission

With more than 90% of global trade now carried by sea, the shipping industry has played a crucial role in shaping the integrated global economy. It is estimated that if the growth trend of the last 150 years continues, nearly 23 billion tons of cargo that will be transported by ship by 2060, compared to 8.5 billion tones in 2010. The environmental impact of shipping operations – whether at sea or in port– have been known for decades. But it is only in recent years that the damaging effects on human health and biodiversity have been demonstrated. This has led both international and regional organizations – most notably the International Maritime Organization (IMO) and the European Union (EU) – to regulate shipping emissions more stringently.

While pollutant emissions from land-based sources are gradually coming down, those from shipping show a continuous increase. Emissions from ships engaged in international trade in the seas surrounding Europe – the Baltic Sea, the North Sea, the north-eastern part of the Atlantic, the Mediterranean and the Black Sea – were estimated at 2.3 million tons of sulphur dioxide (SO2), 3.3 million tones of nitrogen oxides (NO_x), and 250,000 tonnes of particulate matter (PM) a year in 2000.Under a business-as-usual scenario, it is expected that shipping emissions of SO2and NO_x will increase by 40–50 per cent between the year 2000 and 2020. By 2020 the emissions from international shipping around Europe are expected to equal or even surpass the total from all land-based sources in the 27 EU member states combined.

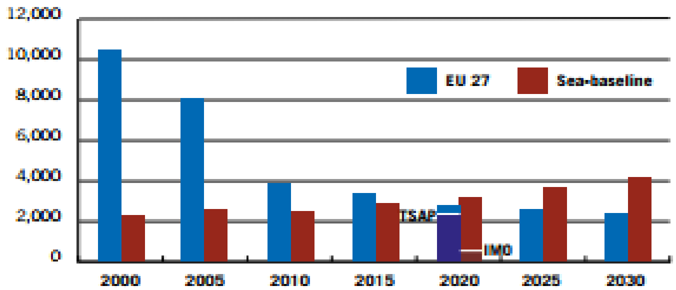

Figure 2. 4 Emission of SO2

Source: Air Pollution from Ships

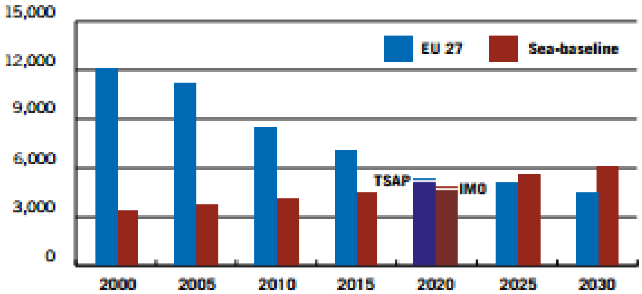

Figure 2. 5 Emissions of NOx

Source: Air Pollution from Ships

Shipping has, in general, been able to maintain its image of an environmentally friendly mode of transportation. In some respects this is accurate: shipping is in most cases relatively fuel efficient, it can ease problems with road congestion. It uses relatively little land and there are relatively few accidents. However, there are also significant problems: high emissions to air of noxious substances such as NO_x, $SO_2$and PM in addition to polycyclic aromatic compounds and other toxic organic substances.

Figure 2.6 below described the emissions calculation that carried out from a South American perspective for transporting 1000 tons of cargo between Manaus, Brazil and either Buenos Aires, Argentina or Santos, Brazil. For shipping this means that the international rules apply, that is, a maximum fuel sulphur content of 3.5% and, for ships constructed after 2000, tier 1 NO_x levels. It is assumed that the fuel sulphur content is 2.7%. Two ships are studied: a container ship of 10,000 dwt and a bulk ship of 60,000 dwt. Train 2 emissions are for the most part unregulated in South America. It is assumed that the train is pulled by a diesel engine with emissions typical for unregulated large diesel engines. Truck regulations in South America vary from country to country, but generally newer trucks follow, approximately, the Euro III emission standard. The sulphur limits for diesel fuel used by train engines and trucks also vary across the continent. Of great importance for the results is the capacity utilization, or the load factor. It is assumed that the truck, the train and the container ship carry containers that are filled to 75% of the maximum weight capacity. In addition, the ships and the train are assumed to have load factors of 75% when it comes to the number of containers that are loaded. *(Source:* www.cepal.org/transporte *(Issue No. 324 - Number 8 / 2013))*

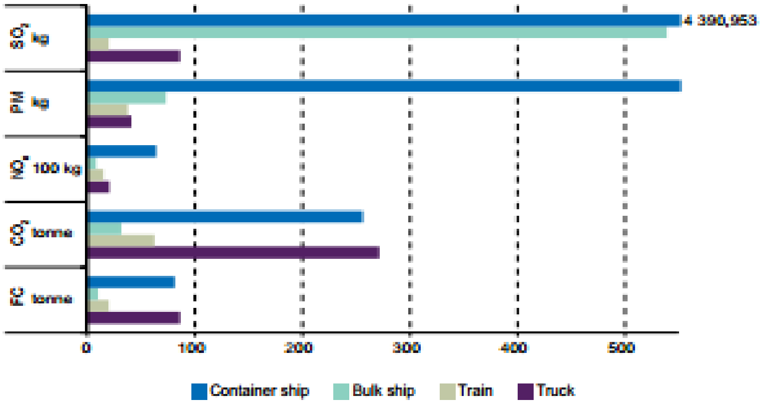

Figure 2. 6 Result from Emissions Calculation for Transporting 1000 Tones of Goods Using Different Vessels and Vehicles

Source: www.cepal.org/transporte (Issue No. 324 - Number 8 / 2013)

From figure 2.3 above described that vessels has the highest contents of SO_2 and NO_x. One can immediately see the difference between the two ships, as the emissions are much lower for the bulk ship. This is due to its larger size, but also to bulk ships being more efficient thanks to lower speed and the fact that a higher fraction of the deadweight is cargo compared with a container ship. Fuel efficiency is highest for bulk ship transportation and lowest for the truck. The train has relatively high fuel efficiency and is clearly more efficient than the container ship. CO_2 emissions are directly proportional to fuel efficiency in these examples, the reason being that the assumed fuels have similar CO_2 emissions related to the energy content in the fuels. NO_x emissions are highest for the container ship. This is related to the low degree of abatement normally found for ships. The train is also responsible for relatively high NO_x emissions, since train diesel engines are normally unabated. For PM, emissions are similar among the various alternatives in this example except for the container ship, which has much higher emissions. The ships have high SO_2 emissions because of the high sulphur content of marine fuel.*(Source:* www.cepal.org/transporte *(Issue No. 324 - Number 8 / 2013))*

Ships emit almost 8% of global sulphur oxide (SO_X) emissions and 15% of global nitrogen oxide (NO_x) emissions annually. When marine engines burn fuel, they also emit dust, soot and small particles known as Particulate Matter (PM). Air pollution emissions from ships are continuously growing. If they continue at the

current rate, by 2020 shipping will be the biggest single emitter of these pollutants in Europe, surpassing all land-based sources combined. While emissions on land are generally falling, shipping emissions are expected
to increase by 5% by 2020 due to the growth of international shipping traffic in the northern hemisphere. Despite falling health costs in Europe from air pollution in Europe between 2000 and 2020, the contribution of shipping to overall health costs is likely to increase from 7% (€58.4 billion) to 12% (€64.1 billion) by 2020. For instance, PM emissions related to shipping activities contribute to approximately 60,000 deaths annually at a global scale, with impacts concentrated in coastal regions on major trade routes. *(Source: The Costly Future of Green Shipping, March 2015)*

2.7 NOx Emissions Standards

NOx emission limit stocks geared diesel engines Depending on round (n, RPM) Maximum used these machines as show in Table 2.1

Table.2 1 MARPOL Annex VI NOx Emissions Limits

Tier	Date	NOx Limit, g/kWh		
		n<130	$130 \le n < 2000$	$n \ge 2000$
Tier I	2000	17.0	$45.n^{-0.2}$	9.8
Tier II	2011	14.4	$44.n^{-0.23}$	7.7
Tier III	2016	3.4	$9.n^{-0.2}$	1.96

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CHAPTER III
METHODOLOGY

3.1 General

The selected research methodology in this study was the experimental method. Experiments were divided into 3 sub-sections, namely the process of making water fuel in emulsion, performance, and emissions. To test the performance of the diesel engine, the engine must be set up to a diesel engine which can be test bed and exhaust emission analyzer. Experiment details can be seen in the flow diagram 3.1

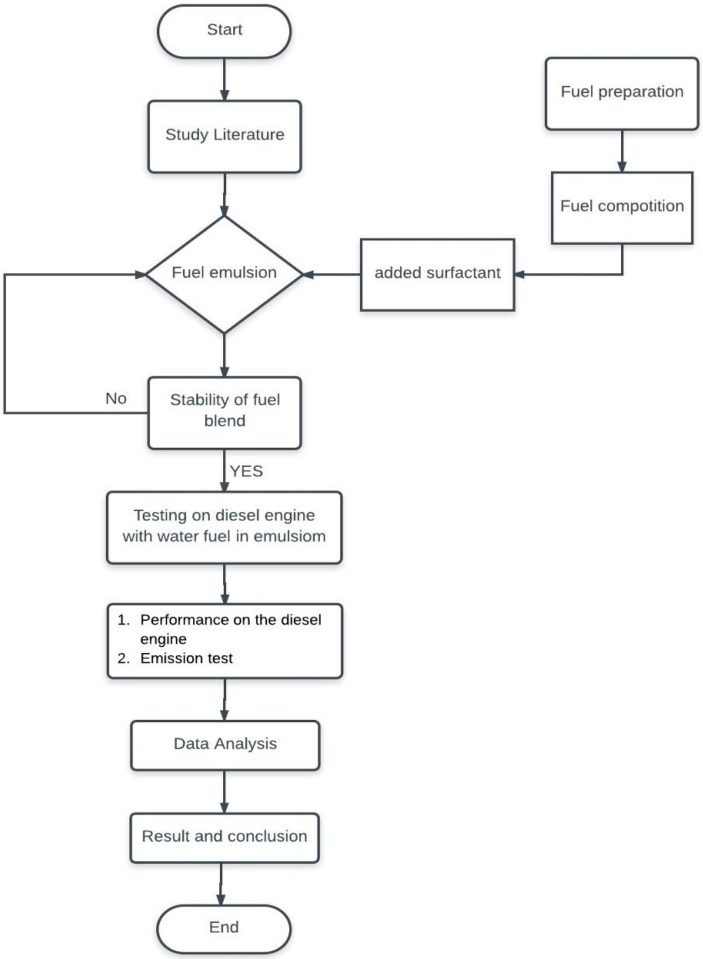

Figure 3. 1 Flowchart Research

3.2 Start

In this first stage the materials were prepared before the experiments carried out as tools for the manufacturing process and to prepare these materials.

3.3 Study literature

At this stage, before the experiment conducted the literature was read firstbeforehand in the manufacturing process and type of materials to be used during the trial.

3.4 Fuel preparation

At this stage before the experiment, fuel used for mixing with water was needed to prepare. The type of fuel used was Pertamina Dex. The materials and tools used in the experiment were as follows::

1. Aquades water
2. Diesel oil
3. Span 80
4. Tween 80
5. Aquades water
6. Mixer
7. bucket
8. graduated cylinder
9. Computer as data processing
10. Diesel engine Shanhai MD180

3.5 Fuel emulsion

At this stage, there was the process of making water in fuel emulsion to conduct fuel composition variation with water and the addition of emulsifier which serves to lower the surface tension (surface tension) of a medium and lower the interfacial tension (interfacial tension) between two different phases degree of polarity. In the process of mixing, mixer was used.

3.6 Engine and its Specifications

in this stage before performing the test on a diesel engine, the first to be set-up diesel engine first by following existing procedures. Here are the specifications of the diesel engine is used and engine set-up

Merk	: Shanhai diesel engine
Type	: Horizontal, 4 stroke
Model	: R180
Cooling System	: Hopper
Displacement	: 402
Stroke diameter	: 80x80 mm
Dimension	: 658x341x463 mm
Weight	: 70 Kg
Cylinder	: 1 cylinder
Combustion System	: Indirect
Max. Torque	: 8 / 2600
Continue Torque	: 7 / 2200
Compression Ratio	: 21 **:** 1
System governor	: Mechanic

Figure 3. 2 Diesel Engine Shanhai

3.7 Engine Set-up

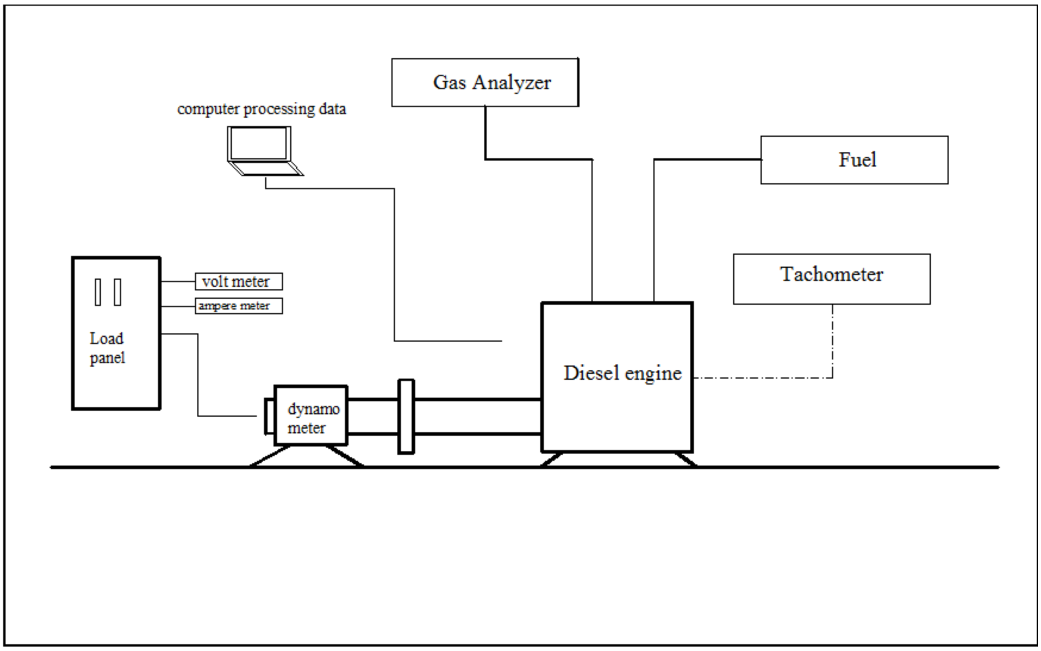

Figure 3. 3 Engine set-up

Equipment used:

- Shanhai MD175A
- Electric dynamometer
- Control panel
- Fuel
- Amperemeter
- Voltmeter
- Tachometer

3.8 Test performance

- Fixed variable :
  - Engine used Water fuel emulsion
  - Engine speed (RPM)

- Variable result :
  - Power
  - Torsi
  - Load

1. Emission test:
    - Fixed variable:
      Engine used Water fuel emulsion
    - Variable change:
        - Engine speed (RPM)
        - Load

    - Variable result:
        - NOx,

For testing methods at emission test, RPM and load points follow the procedures on Marpol Annex VI IMO rules. Type of test selected is test cycle type E2, this type was chosen because the motor tested can function as the main driving force of the ship. The test method for type E2 is as shown in Table 3.1 below:

Table 3. 1 *MARPOL Annex VI, Appendix II Test Cycle*

Test Cycle Type E2	Speed	100%	100%	100%	100%
	Power	100%	75%	50%	25%
	Weight Factor	0.2	0.5	0.15	0.15

*)where:

- For a constant speed diesel motor and used for the prime mover or used as electric diesel using Test Cycle E2.
- For controllable-pitch propellers using Test Cycle E2.
- For auxiliary engines constant speed using Test Cycle D2

3.9 Data analysis

In this section the data was analyzed after the test diesel engine with performance parameters consisting of a diesel engine with a rotation comparison generator and additional burdens and knows the value of torque and SFOC.

3.10 Result and Conclusion

At this stage, namely the results of the data analysis by using fuel experiments were compared with diesel fuel and determined the efficient use of fuel and the results of exhaust emissions in diesel engines. After the conclusion and the underlying answer from this study answers.

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CHAPTER IV
RESULTS AND DISCUSSIONS

Based on the research objectives previously described, it is desirable to produce a water fuel in an emulsion having nanometer particle size, giving the best stability condition and providing efficient diesel engine performance and reducing NOx exhaust emissions. This research was divided into several research variables, a namely variation of water content, surfactant types, and mixing process.

4.1 Procedure experiment

Based on the variables that have been done, then the discussion of research results was divided into several points, namely:

1. Preparation of water fuel in emulsion with variation of water content for emulsion fuel
2. Preparation of surfactant solution with variations of surfactant type used.
3. water fuel mixing during the process water emulsion.

4.1.1 Preparation of water fuel in emulsion with variation of water content for emulsion fuel

this stage was the preparation stage of Pertamina Dex with a variety of water content of 10%, 15% and 20%. Provide graduated cylinder, Pertamina Dex of fuel and aquades as the object of mixing. Pour aquades into a graduated cylinder of 45 ml and diesel as much as 209 ml and for the next stage pour surfactant solution as an additive.

.

Figure 4. 1 Fuel + Water 15%

4.1.2 Preparation of surfactant solution with variations of surfactant type used.

Figure 4. 2 Surfactant types used making process water fuel in emulsion

Provide a surfactant solution of span 80 and tween 80 levels of 2% and 2% by using the mixer as mixing tool. The stage of making with span 80 as much as 6 mL and a solution of tween 80 as much as 6 mL, then mix the solution twen 80 and span into the diesel and water by using mixers for ± 10 minutes until the mixture is evenly distributed.

4.1.3 Making water fuel in emulsion with a mixer during the process of making fuel.

this stage was the process of pre-emulsion, which is the process of mixing the material of solar-water emulsion using a mixer with a speed of 400 rpm for 10 minutes. The mixing stage of pre-emulsion on the use of surfactants tween 80 and Sorbitan monooleate (span 80) by mixing Pertamina Dex that has been mixed with water and surfactant solution.Several variables were used to obtain the best-operating conditions in creating solvent emulsion

4.2 The determination of the composition of the water in fuel emulsion

Determining the composition is an important thing to do given the availability of raw materials which unlimited. In the present study three variations of the composition were is determined with the number of mix :

- Diesel fuel 90%+ water 10%
- Diesel fuel 85% + water 15%
- Diesel fuel 80% + water 20%

4.3 Determining the composition of emulsifier

After determined the composition of diesel fuel with water to consider mixing with emulgator. Because we still do not know what is the appropriate mix to able to mix between diesel fuel and water. That after we can do variations mix emulgator to water in the fuel. The following variations are to be used:

1. Solar 300 ml + water 10 % + 2% tween 80 + 2% span 80
2. Solar 300 ml + water 15 % + 2% tween 80+ 2% span 80
3. Solar 300 ml + water 20 % + 2% tween 80+ 2% span 80

4.4 Determination of surfactant

The water of fuel in emulsion stability depends on the type of emulsifier used because it will affect the permanent and non-permanent emulsion. The following is the type of emulsifier used in the experiments of fuel in water emulsion.

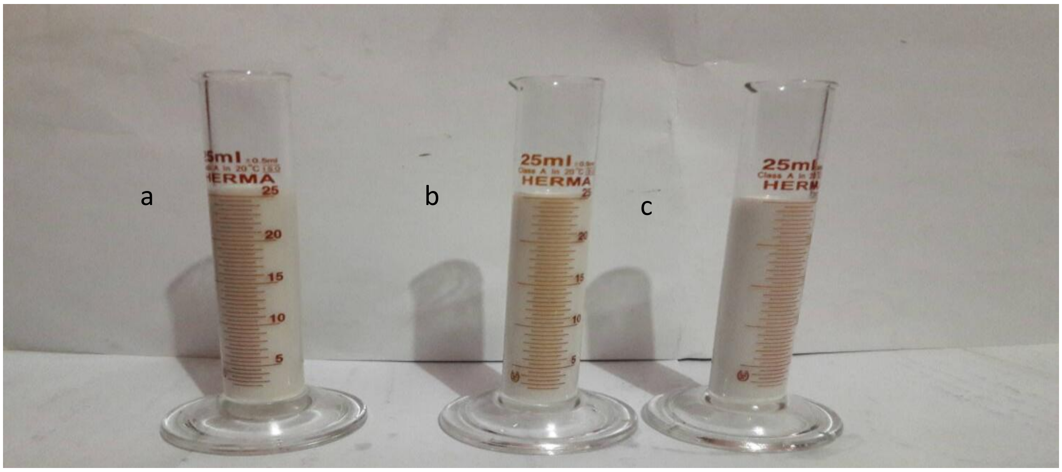

Figure 4. 3 Result of mixture water fuel in emulsion with additive tween 80 dan span 80

This is the result of a mixing process of emulsified fuel with varying water content. The material used in the manufacture of solar-water emulsions is Pertamina Dex Pertamina which has a cetane number of 53 with sulfur content below 300 ppm. This cetane number indicates the quality of fuel for diesel engine. This figure affects the combustion process that occurs in a diesel engine. The higher the value, the easier the combustion process will reduce the load of the engine and the diesel will be smoother. This material is chosen because it has a cetane number that is high and good for a diesel engine. The emulsion made in this research is a water-in-fuel emulsion known as water fuel in the emulsion. This emulsion is carried out by the addition of moisture content in the diesel by emulsification process using a surfactant. In this type of emulsion, water (water) is the dispersed phase (inside) while diesel (oil) is the dispersant phase (outside).

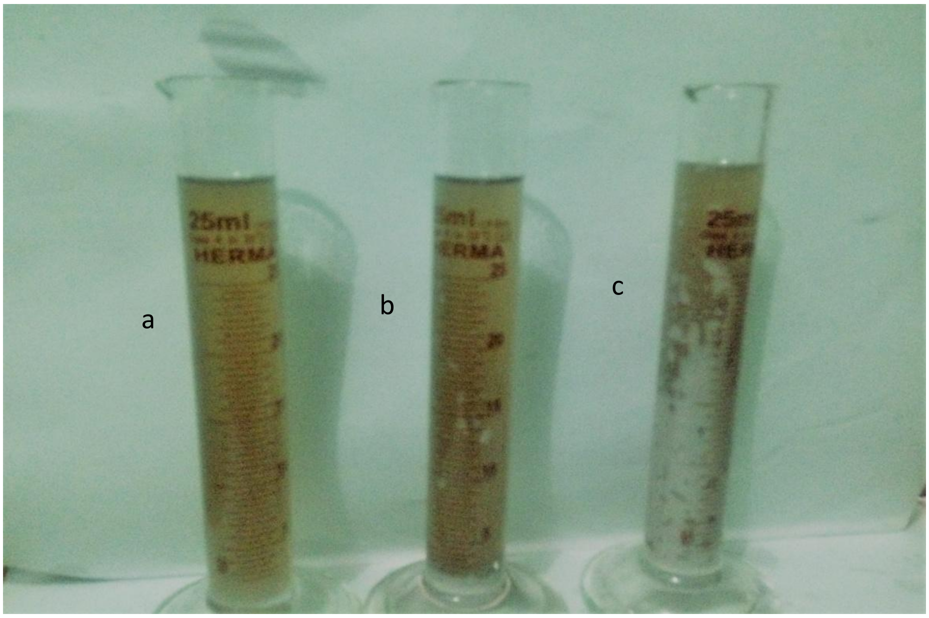

Figure 4. 4 Result of mixture water fuel in emulsion with additive span 80, ABS and CMC

This is one of the non-homogeneous emulsifying fuels. In this case due to poor surfactant mixing and the type of surfactant used during the fuel mixing process. In the selection of surfactants used at the time of mixing this fuel greatly affects the stability of water fuel in emulsion

4.5 The process mixing diesel fuel with water

First prepare the water, fuel and additive materials. then blend both fuel with a mixer while slowly pouring the emulsifying additive until well blended. Let it stand for 1 hours, until the diesel regains its color and transparency. After that, the next steps are mixing the first mixture (diesel-additive) while adding water very slowly until the mixture gets an intense and homogeneous white. Then continue mixing for a few minutes (in the case of larger amounts, mix to at least three complete cycles of The total volume of emulsion). The whiter \the emulsion, the better the stability.

As shown in figure 4.3, the result of experiment mixture of fuel with 10% water and 4% additive, figure b the mixture of fuel with 15% water and 6% additive, and figure c fuel mixture of 20% water with 8% additive and to settling for 5 days. As in figure 4.4, the result experiment mixture of fuel with water added additive span 80, ABS, and CMC are less than perfect. The types of additive will affect permanent and non permanent emulsion of water in the fuel. Additive ABS and CMC is typed additive for water with fuel is unstable additive mixing.

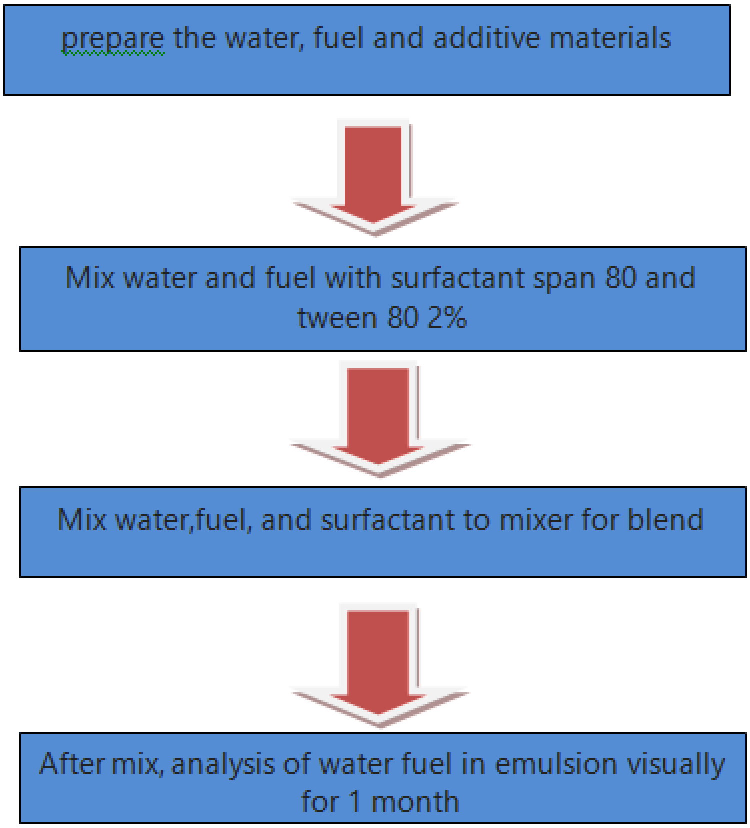

Figure 4. 5 Chart the process of making water in fuel emulsion

4.6 Performance on the diesel engine using water in fuel emulsion

Analysis performance is a comparison of power, torque, SFOC and BMEP graphs of performance data. Performance data obtained through the experimental process using water in fuel emulsion 10%, 15%, and 20% on the diesel engine

The first step in forming a graph is to determine the SFOC value of power. After the SFOC graph at each RPM is formed, the valley point graph showing the lowest SFOC value at each RPM is considered 100% diesel engine power value. In this study, the RPM variables were determined at 1800, 1900, 2000, 2100 and 2200.

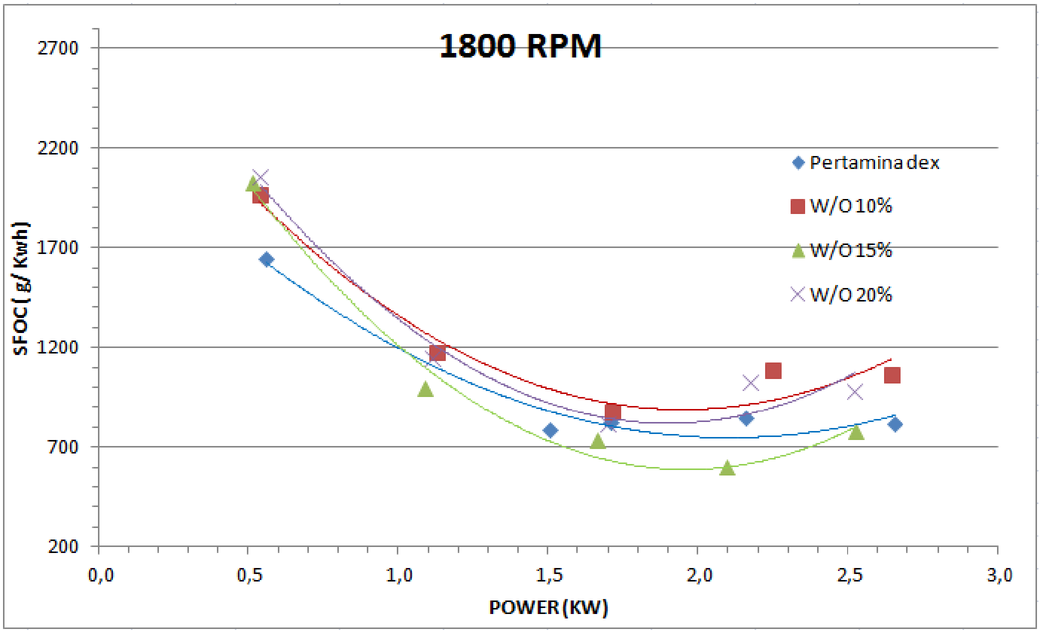

Figure 4. 6 Graph Comparision of Power with SFOC of different fuel Composition at 1800 RPM

Based on the graph above we can see the value of water content in the emulsion fuel affecting the SFOC value. The greater the value of the fuel content of the emulsion, the smaller the SFOC value. At low load, 10% water fuel in emulsion produces the low SFOC value. However, at 15% and 20% water in fuel emulsion when large load produces highest SFOC values. The value of SFOC at water fuel in emulsion 10% at low load 1966.4 g / Kwh, Water fuel in emulsion on content 15% produce SFOC value of 2029 g / Kwh, Water fuel in emulsion content 20% produce SFOC value of 2052.5 g/Kwh and Pertamina Dex

Of fuel produce SFOC value of 1642.6 g / KWh. Then on the graph above can be concluded that the greater value the smaller SFOC value at 1800 round water in fuel emulsion. It can be concluded that on Pertamina Dex fuel is more efficient SFOC value than water in fuel emulsion for at low load and at 1800 rpm.

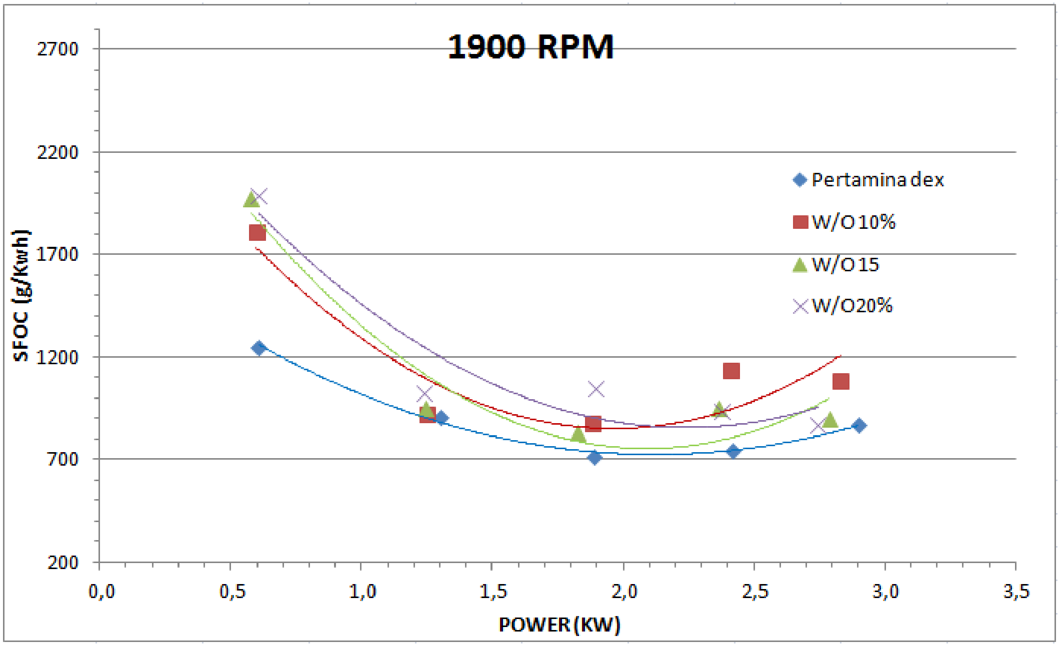

Figure 4. 7 Graph Comparision of Power with SFOC of different fuel Composition at 1900 RPM

Based on the graph above we can see the value of water content in the emulsion fuel affect the SFOC value. The greater the value of the fuel content of the emulsion, the smaller the SFOC value. At low load, 10% emulsion fuel produces the low SFOC value. However, at 15% and 20% emulsion fuel when large load produces highest SFOC values. At load 5000 watt on water fuel emulsion, 10% produce in large SFOC values. The value of SFOC at water fuel in emulsion 10% at low load 1808.4 g/Kwh, Water fuel in emulsion on content 15% produce SFOC value of 1970.6 g/ Kwh, Water fuel in emulsion content 20% produce SFOC value of 1985.8 g/Kwh, and Pertamina Dex Of fuel produce SFOC value of 1250,6 g /KWh. Then on the graph above can be concluded that the greater value the smaller SFOC value at 1900 round emulsion fuel. It can be concluded that on Pertamina Dex fuel is more efficient SFOC value than emulsion fuel for at low load and on 1900 rpm.

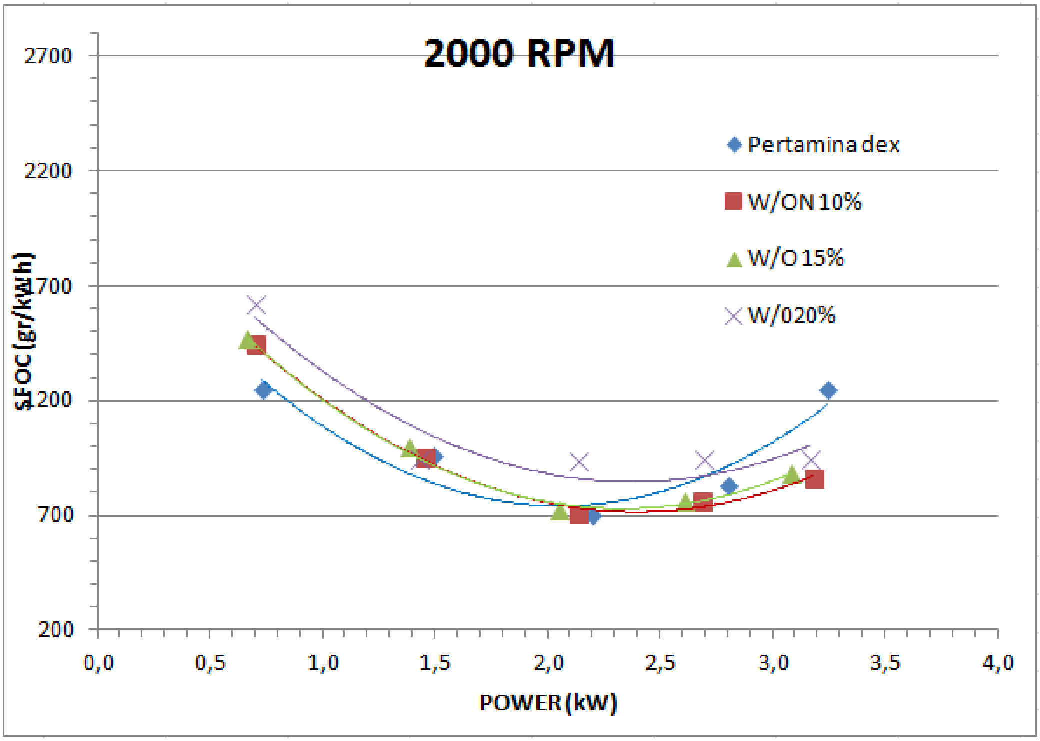

Figure 4. 8 Graph Comparision of Power with SFOC of different fuel Composition at 2000 RPM

Based on the graph above we can see the value of water content in the emulsion fuel affecting the SFOC value. The greater the value of the fuel content of the emulsion, the smaller the SFOC value. At low load, 10% emulsion fuel produce the highest SFOC value. However, at 15% water fuel in emulsion when large load produces very low SFOC values. On the Pertamina Dex fuel of 2000 rpm produce SFOC value highest. The value of SFOC at water fuel in emulsion 10% at low load 1444 g/Kwh, Water fuel in emulsion on content 15% produce SFOC value of 1468.5 g/ Kwh, Water fuel in emulsion content 20% produce SFOC value of 1613.9 g/Kwh, and Pertamina Dex Of fuel produce SFOC value of 1248.3 g /KWh. Then on the graph above can be concluded that the greater value the smaller the SFOC value at 2000 round emulsion fuel. It can be concluded that on Pertamina Dex fuel is more efficient SFOC value than water in fuel emulsion for at low load and at 2000 rpm.

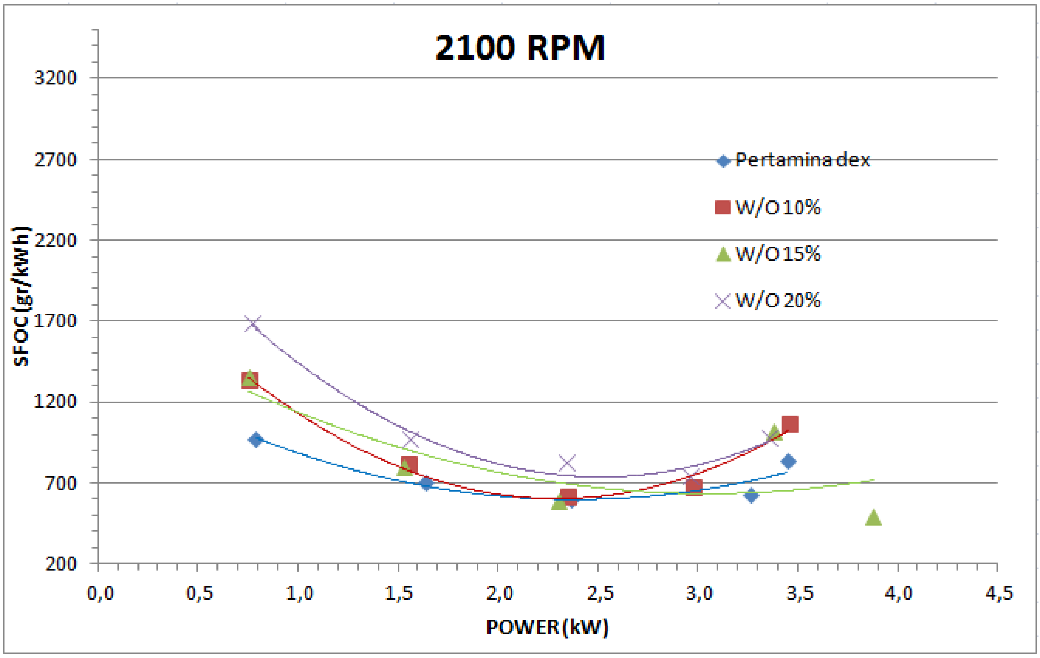

Figure 4. 9 Graph Comparision of Power with SFOC of different fuel Composition at 2100 RPM

Based on the graph above we can see the value of water content in the emulsion fuel affecting the SFOC value. The greater the value of the fuel content of the emulsion, the smaller the SFOC value. At low load, 10% emulsion fuel produces the low SFOC value. However, at 20% water fuel in emulsion when large load produces highest SFOC values. The value of SFOC at water fuel in emulsion 10% at low load 1332.6 g/Kwh, Water fuel in emulsion on content 15% produce SFOC value of 1348.2 g/ Kwh, Water fuel in emulsion content 20% produce SFOC value of 1628.2 g/Kwh, and Pertamina Dex Of fuel produce SFOC value of 970,6 g /KWh. Then on the graph above can be concluded that the greater value the smaller the SFOC value at 2100 round emulsion fuel. It can be concluded that on Pertamina Dex fuel is more efficient SFOC value than water in fuel emulsion for at low load and on 2100 rpm.

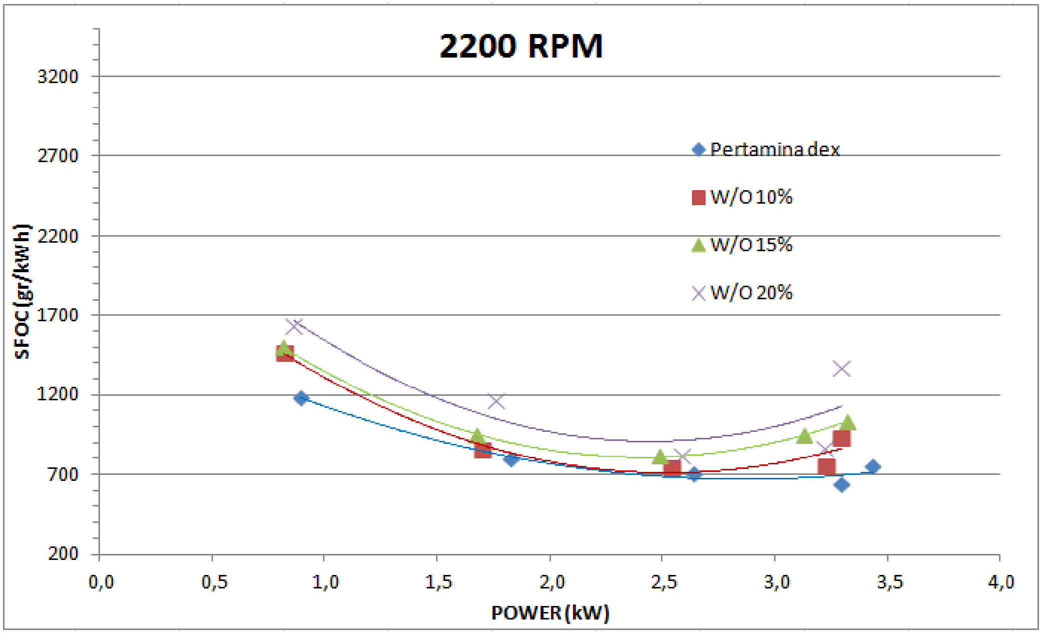

Figure 4. 10 Graph Comparision of Power with SFOC of different fuel Composition at 1800 RPM

Based on the graph above we can see the value of water content in the emulsion fuel affecting the SFOC value. The greater the value of the fuel content of the emulsion, the smaller the SFOC value. At low load, 10% emulsion fuel produces the low SFOC value. However, at 20% water fuel in emulsion when large load produces the highest SFOC values. On the Pertamina Dex fuel of 2100 rpm produce low SFOC value. The value of SFOC at water fuel in emulsion 10% at low load 1464.3 g/Kwh, Water fuel in emulsion on content 15% produce SFOC value of 1498.2 g/ Kwh, Water fuel in emulsion content 20% produce SFOC value of 1628.2 g/Kwh, and Pertamina Dex Of fuel produce SFOC value of 1185.5 g /KWh. Then on the graph above can be concluded that the greater value the smaller the SFOC value at 2200 round emulsion fuel. It can be concluded that on Pertamina Dex fuel is more efficient SFOC value than water in fuel emulsion for at low load and at 2200 rpm.

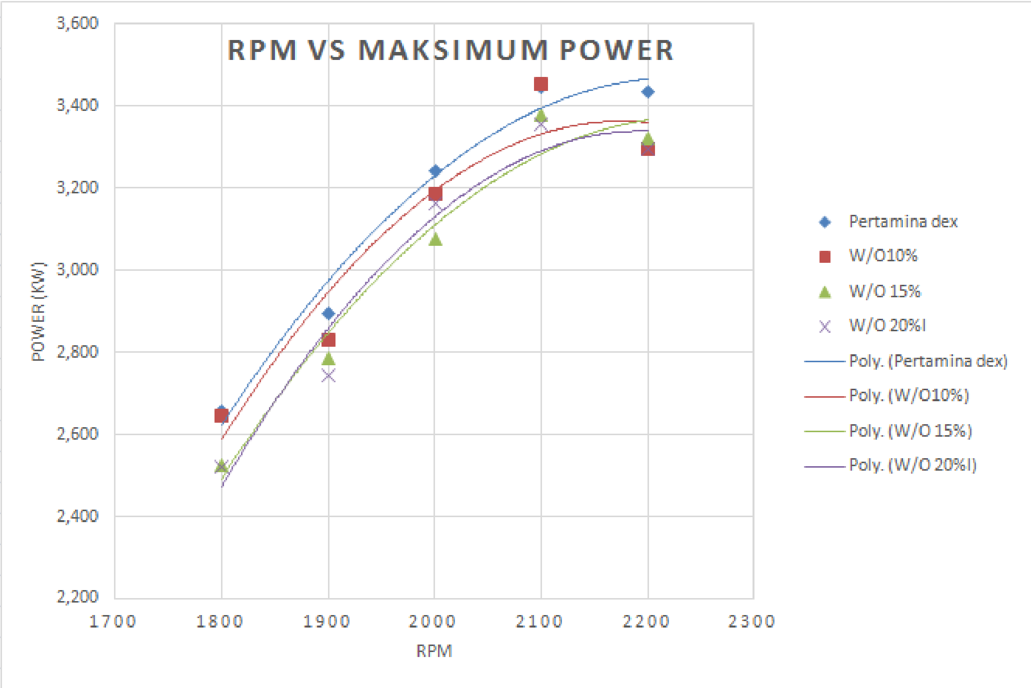

Figure 4. 11 Graph Comparision of Power with RPM of different fuel Compotition content 10%,15%,20%

Figure 4.6 is a graph of power performance comparison to RPM on water fuel in emulsion content of 10%, 15%, 20% and Pertamina Dex of fuel. The above graph is the value of 100% power. This value is derived from the lowest SFOC point described in the previous graphs. In the power chart above, seen in the initial RPM when using water fuel in emulsion 15% power increased about 2.93% compared to water fuel in emulsion 10% and 20%. At 1800 RPM on water fuel in emulsion, 10% maximum power is at 2.646 kW, water fuel in emulsion 15% of 2.526 kW, and water fuel in emulsion 20% power value is at 2.52 kW. However, in the final RPM, the power value in water fuel in emulsion 10%, 15%, and 20% are at different points. From this graph can be analyzed that at the beginning of RPM should use water fuel in emulsion 10%.

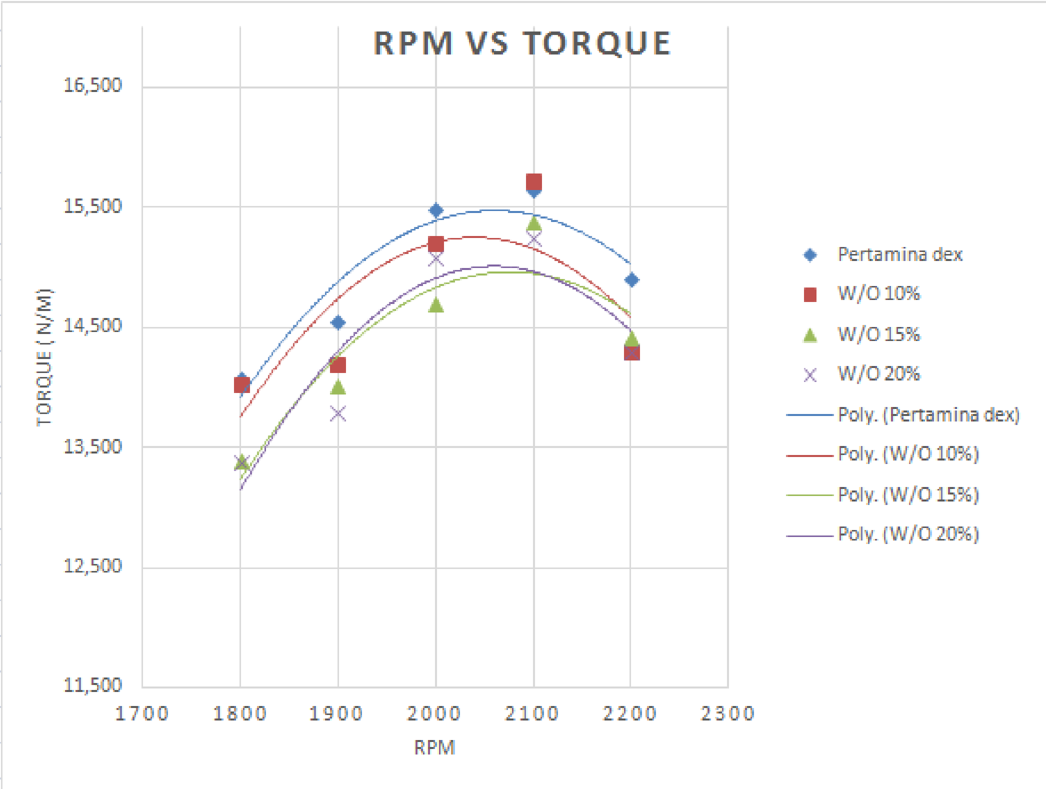

Figure 4. 12 Graph Comparision of RPM with Torque of different fuel Compotition content 10%,15%,20% at 1800 RPM

The graph above is a comparison graph of torque and engine speed at maximum power. Pertamina Dex fuel produces a torque of 14,90 Nm, water in fuel emulsion content 10% produces 14,027 Nm of torque, water in fuel emulsion content 15% produces 13,384 Nm of torque, and water in fuel emulsion content 20% produces 13,37 Nm of torque. From the graph above can be seen that the larger the water content of fuel then the resulting torque can be greater, But the influence of the water content of fuel on the engine power is not too significant because the difference from the torque on water in fuel emulsion 10%,15% and 20% only 0.5 Nm.

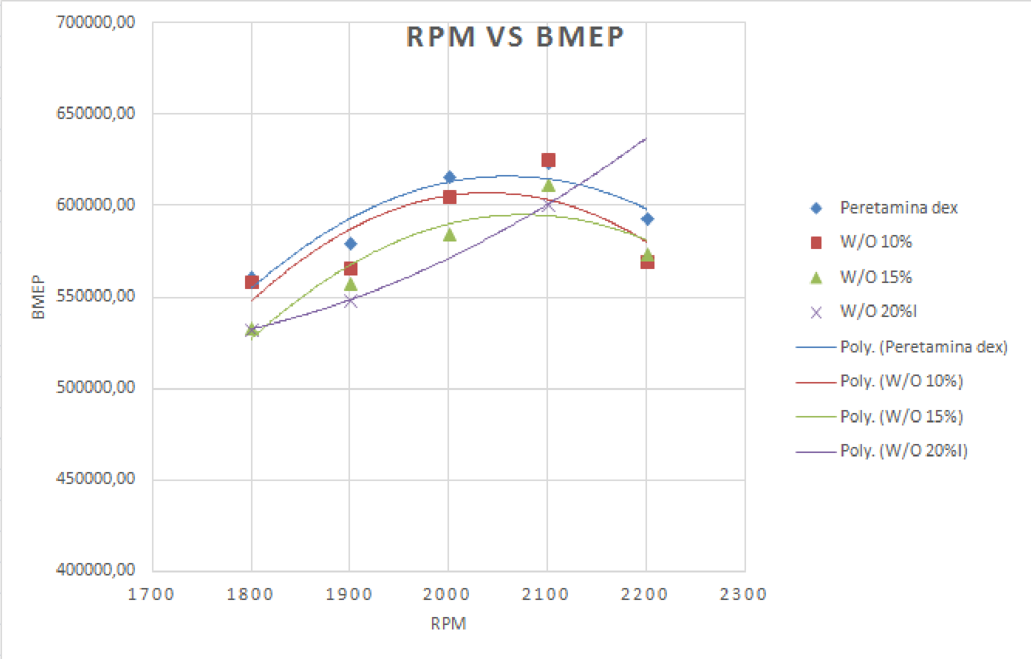

Figure 4. 13 Graph Comparision of RPM with BMEP of different fuel Composition at 1800 RPM

The graph above is a comparison graph between BMEP and engine speed at maximum power. Pertamina Dex of fuel produces BMEP of 593120 N/m2, water in fuel emulsion content 10% produces BMEP 569506 N/m2, water in fuel emulsion content 15% produces BMEP 591356 N/m2, and water in fuel emulsion content 20% produces BMEP 569506 N/m2. BMEP produced Pertamina Dex of fuel is the largest, while water in fuel emulsion contents 10%,15% and 20% produce a smaller BMEP, from the graph above, can be seen the greater water content of fuel the BMEP value generated can be greater. But the effect of the water content of fuel on engine power is not too significant.

4.7 NOx Emission

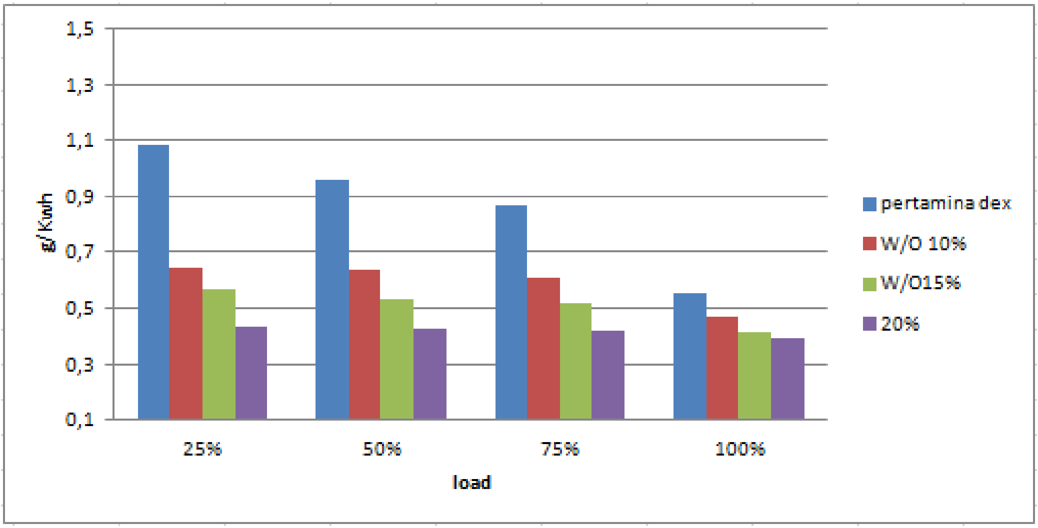

Figure 4. 14 bar chart of NOx content at 100% RPM and load conditions various

Water fuel in emulsion (WTF) is one of the alternative fuels used to reduce NOx emissions. Water fuel in the emulsion. in combustion, there will be a phenomenon called microexplosion or secondary breakup where the fuel droplet will break up again due to the gas pressure from the hot water vapor contained in the emulsion fuel. This phenomenon can produce a smoother droplet of fuel so that combustion becomes more perfect and reduce exhaust emissions. NOx emission results obtained from the experimental process of diesel engine is like graph

Levels of NOx emissions generated in water fuel in emulsion 10% standard diesel motor conditions ranging from 25% -100% load are 0,642 g / kWh, 0.639 g / kWh, 608 g / kWh and 0.467 g / kWh, respectively. At load conditions 25% - 100% of TIER 3 qualified NOx emissions, making it safe for the environment. As explained in Chapter II earlier that TIER 1 qualification is NOx 7.7 - 9.8 g / kWh emission at a turn of more than 2000 RPM. The qualification of TIER 2 is the emission of NOx diesel engine between 1.96 to 7.7 g / kWh at 2000 RPM. The TIER 3 qualification is an NOx emission of a diesel motor that is less than 1.96 g / kWh in turn over 2000 RPM.

Levels of NOx emissions generated in water fuel in emulsion 15% ranging from 25% -100% load are 0.566 g / kWh, 0.530 g / kWh, 0,515 g / kWh and 0.414 / kWh, respectively. When load conditions 25% - 100% of NOx emissions are included in TIER 3 qualification.

Levels of NOx emissions generated in water fuel in emulsion 20% ranging from 25% -100% load are 0.434 g / kWh, 0.427 g / kWh, 0.423 g / kWh and 0.392 g / kWh, respectively. When load conditions 25% - 100% of NOx emissions are included in TIER 3 qualification.

Levels of NOx emissions produced in Pertamina Dex of fuel ranging from 25% -100% load are 1082 g / kWh, 961 g / kWh, 868 g / kWh and 555 g / kWh, respectively. When the load condition is 25%, - 100% of NOx emissions are included in the TIER 3 qualification.

4.8 Discussion

This chapter is a general discussion of the results of making water fuel in emulsion, performance results, and NOx as described in sub chapters 4.1 until 4.7. The discussion is the process of making water fuel in emulsion by determining the type of surfactant and analysis of the graph obtained during experiment step on diesel motor using water fuel in emulsion with a variation of percentage of water content 10%, 15, and 20%. The analysis based on the experimental results can be compared with the basic theories and the results that already existed in the previous research reference.

The experimental results of water fuel in emulsion using a surfactant as an additive are tween 80 and span 80 with 10%, 15%, and 20% water content composition and 2% surfactant mixture. The use of water in emulsified fuel is to determine the performance and emission of NOx on a diesel engine.

the experimental results have been obtained SFOC graphics as shown in Figures 4.6 to 4.13. On the graph shows that the use of water fuel in emulsion 15% can improve the value of SFOC on diesel motor performance. In the use of water fuel in emulsion 10%, the SFOC value is reduced by about 10%. However, on the water fuel in emulsion chart, 20% of SFOC values are increasing. Several previous studies have suggested that the addition of water fuel emulsion on the diesel engine can lead to increased SFOC values. When associated with experimental results in this study, there are limits to the addition of water content that can lead to increased SFOC values.

Reduced performance is an indication that the use of water in fuel emulsion is less efficient. However, functionally, water in fuel emulsion is an NOx to reduced technology. NOx emission results in this experiment are shown in Figure 4.14. On the graph it is seen significantly that the use of water in fuel emulsion can reduce NOX levels up to 50.5%. This is in line with the basic theory and reference of previous researchers who explained that the use of water in fuel emulsion able to reduce levels of NOx

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CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the results of research that has been done, the application of water fuel in emulsion the diesel engine with a water content of 10%, 15%, and 20%. The following temporary conclusions can be drawn:

a. In the process of producing water fuel in the emulsion, the determination of surfactant type greatly influences the emulsion stability. In this case, it can be seen that comparison of surfactant tween 80, 80 span with 80, ABS span in the range of 7 days looks different. In the use of ABS surfactant type and span 80 is not homogeneous. In this case, the type of surfactant used is not good in the process of producing water fuel in the emulsion.
b. The use of water fuel in emulsion 10% resulted in SFOC increased 323.8 g/kWh or fuel consumption improvident 16.5% compared to diesel engine using Pertamina Dex. However, the use of water fuel in emulsion 15% and 20% resulted in SFOC increase compared to water fuel in emulsion 10%. In comparison of power, torque, and BMEP on water fuel in emulsion decreased compared to Pertamina Dex fuel at conditions 1800-2000 RPM.
c. By using water fuel in emulsion with a variation of water content 10%, 15%, and 20% NOx emission level produced can decrease to 0.216 g / kWh or reduced by 50.5%. Generally, the emission level of a diesel engine that has been using water fuel in the emulsion can be improved until entering TIER 3 specification.

5.2 Recommendation

Research on the use of water fuel in the emulsion on the diesel engine suggested that it can be more useful and better. Suggestions to be conveyed are as follows:

a. For the Research, addition of variation surfactant in the processes of making water fuel in the emulsion in order to know the economic value can be observed.
b. For the Research, the mixing of biodiesel and water to emulsify in order to produce better performance value can be observed.
c. For the Research, the use of water fuel in emulsion find value properties to know the characteristics of water fuel emulsion and combustion process on the diesel engine can be investigated.

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BIBLIOGRAPHY

Abdulaziz H. EL-Sinawi, K. T. (2012). The effect of High Water Content of Fuel on Diesel Engine Emission. *Global Journals Inc (USA)*.

Abdulaziz, H. E.-s. (2010). Water surrogate fel emulsion combustion effect on CO and NOx emissions. *King faisak university*, 1.

Bindar, Y. (2015). Tinjauan Penggunaan Air teremulsi dalam Minyak Bakar sebagai Bahan Bakar Industri dan Mesin Diesel. *Researchgate*.

Canfield, C. A. (1999). *Effects of Diesel- Water Emulsion Combution on Diesel Engine NO Emission.* Florida: University of Florida.

D.R Emberson, B. I. (2015). Optical Charactrization of Diesel and Water Emulsion Fuel Injection Sprays using Shadowgraphy. *Sciencedirect* , 253-256.

DeborahLockridge. (2014). *Alternative Fuels*. Retrieved from Heavy Duty Trucking: http://www.fiercefuelsystems.com/

Fuelia, C. (2004). *Operating instruction*. Retrieved from www.fueliachemicals.com

IMO. (2016). NOx (Nitrogen oxide). In *Marpol Annex VI.*

Julia, A. (2012). *Pengaruh Penggunaan bahan bakar emulsi dari metanol dengan diesel oil terhadap performa, NOx dan combustion process pada diesel engine.* Surabaya: Institut teknologi sepuluh nopember surabaya.

Measures to improve energy efficiency in shipping. (2013). Retrieved from Natural resources and infrastructure division: www.cepal.org/transporte

Nilson, A. M. (2000). *Air polution from ships*. Retrieved from http://www.cleanshipping.org/

Scarpete, D. (2013). Diesel-Water Emulsion, An Alternative Fuel to Reduce Diesel Engine Emissions a Review. *Sciencedirect*, 1.

Suresh, V. (2016). The role of water-in diesel emulsion and its additives on diesel engine performance and emissions levels: A retrospective review. *Sciencedirect*.

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ATTACHMENT

Pertamina dex of fuel during experiment

This is a performance data retrieval table on the diesel engine with 5 variations of RPM and load on pertamina dex of fuel.

RPM ENGINE		Load	RPM Alumin	Alternator Voltage	Alternator Current	Volume Diesel	Time	Time	Time	Density
(rpm) Control	(rpm) actual	(watt)	(rpm)	(volt)	(ampere)	(m3)	(S)	(minutes)	(hr)	(gr/m3)
1800	1802	1000	1209	167	3,3	0,00004	131	2,183	0,0364	840000
1800	1803	2000	1196	164	8,9	0,00004	102	1,700	0,0283	840000
1800	1802	3000	1192	162	10,2	0,00004	86	1,433	0,0239	840000
1800	1801	4000	1184	156	13,3	0,00004	66	1,100	0,0183	840000
1800	1805	5000	1184	151	16,9	0,00004	56	0,933	0,0156	840000
1900	1903	1000	1257	178	3,3	0,00004	159	2,650	0,0442	840000
1900	1902	2000	1254	177	7,1	0,00004	102	1,700	0,0283	840000
1900	1904	3000	1252	173	10,5	0,00004	90	1,500	0,0250	840000
1900	1902	4000	1250	167	13,9	0,00004	67	1,117	0,0186	840000
1900	1903	5000	1244	161	17,2	0,00004	48	0,800	0,0133	840000
2000	2003	1000	1327	196	3,6	0,00004	133	2,217	0,0369	840000
2000	2002	2000	1322	192	7,5	0,00004	85	1,417	0,0236	840000
2000	2004	3000	1321	189	11,2	0,00004	79	1,317	0,0219	840000
2000	2001	4000	1316	182	14,8	0,00004	52	0,867	0,0144	840000
2000	2003	5000	1307	171	18,1	0,00004	30	0,500	0,0083	840000
2100	2106	1000	1397	207	3,7	0,00004	158	2,633	0,0439	840000
2100	2103	2000	1391	203	7,8	0,00004	105	1,750	0,0292	840000
2100	2101	3000	1386	198	11,5	0,00004	85	1,417	0,0236	840000
2100	2104	4000	1275	190	15,2	0,00004	59	0,983	0,0164	840000
2100	2105	5000	1265	186	16,3	0,00004	42	0,700	0,0117	840000
2200	2203	1000	1458	222	3,9	0,00004	114	1,900	0,0317	840000
2200	2204	2000	1449	217	8,1	0,00004	83	1,383	0,0231	840000
2200	2201	3000	1443	211	12	0,00004	65	1,083	0,0181	840000
2200	2203	4000	1435	200	15,7	0,00004	57	0,950	0,0158	840000
2200	2202	5000	1430	194	16,8	0,00004	47	0,783	0,0131	840000

Pertamina dex of fuel result data

This is a calculation performance data retrieval table on diesel engines with 5 variations of RPM and load on pertamina dex of fuel

RPM ENGINE		Load	Alumin	Efficiency Slip	Power	FCR (mf)	SFOC	Torque	BMEP
(rpm) Control	(rpm) actual	(watt)	(rpm)		(kw)	(gr/h)	(gr/kwh)	(Nm)	(N/m2)
1800	1802	1000	1209	1,038	0,5621	923,36	1642,6	2,9804	118624
1800	1803	2000	1196	1,0269	1,505	1185,9	787,95	7,9751	317593
1800	1802	3000	1192	1,0234	1,7095	1406,5	822,74	9,0639	360751
1800	1801	4000	1184	1,0166	2,161	1832,7	848,07	11,464	456029
1800	1805	5000	1184	1,0166	2,658	2160	812,65	14,069	560893
1900	1903	1000	1257	1,0224	0,6083	760,75	1250,6	3,054	121609
1900	1902	2000	1254	1,02	1,3045	1185,9	909,05	6,5529	260797
1900	1904	3000	1252	1,0184	1,8887	1344	711,62	9,4771	377571
1900	1902	4000	1250	1,0167	2,4174	1805,4	746,84	12,143	483269
1900	1903	5000	1244	1,0119	2,8977	2520	869,65	14,548	579298
2000	2003	1000	1327	1,0254	0,7286	909,47	1248,3	3,4753	138374
2000	2002	2000	1322	1,0215	1,4925	1423,1	953,44	7,1229	283465
2000	2004	3000	1321	1,0208	2,1957	1531,1	697,33	10,468	417009
2000	2001	4000	1316	1,0169	2,8046	2326,2	829,4	13,391	532654
2000	2003	5000	1307	1,01	3,2449	4032	1242,6	15,478	616265
2100	2106	1000	1397	1,0281	0,7888	765,57	970,56	3,5785	142674
2100	2103	2000	1391	1,0237	1,6378	1152	703,4	7,4405	296232
2100	2101	3000	1386	1,02	2,3637	1423,1	602,06	10,749	427531
2100	2104	4000	1275	0,9383	3,2589	2050,2	629,09	14,799	589461
2100	2105	5000	1265	0,931	3,4482	2880	835,21	15,651	623703
2200	2203	1000	1458	1,0242	0,8951	1061,1	1185,5	3,8817	154535
2200	2204	2000	1449	1,0179	1,8284	1457,3	797,07	7,9259	315678
2200	2201	3000	1443	1,0137	2,6448	1860,9	703,62	11,48	456631
2200	2203	4000	1435	1,0081	3,2981	2122,1	643,43	14,304	569437
2200	2202	5000	1430	1,0045	3,4353	2573,6	749,17	14,905	593121

Water fuel emuslsion 10% during experiment

This is a performance data retrieval table on the diesel engine with 5 variations of RPM and load on water fuel emulsion 10%.

RPM ENGINE		Load	RPM Aluminator	Alternator		Volume Diesel Fuel	Time	Time	Time	Density
				Voltage	Current					
(rpm) Control	(rpm) actual	(watt)	(rpm)	(volt)	(ampere)	(m3)	(S)	(minutes)	(hr)	(gr/m3)
1800	1808	1000	1196	163	3,2	4E-05	122	2,033	0,0339	896000
1800	1801	2000	1193	163	6,7	4E-05	97	1,617	0,0269	896000
1800	1806	3000	1190	162	10,2	4E-05	86	1,433	0,0239	896000
1800	1808	4000	1189	157	13,8	4E-05	53	0,883	0,0147	896000
1800	1802	5000	1178	156	16,2	4E-05	46	0,767	0,0128	896000
1900	1902	1000	1261	176	3,3	4E-05	119	1,983	0,0331	896000
1900	1905	2000	1257	175	6,9	4E-05	112	1,867	0,0311	896000
1900	1901	3000	1247	172	10,5	4E-05	78	1,300	0,0217	896000
1900	1901	4000	1246	166	13,9	4E-05	47	0,783	0,0131	896000
1900	1906	5000	1243	159	17	4E-05	42	0,700	0,0117	896000
2000	2004	1000	1326	193	3,5	4E-05	128	2,133	0,0356	896000
2000	2005	2000	1321	189	7,4	4E-05	94	1,567	0,0261	896000
2000	2005	3000	1316	185	11,1	4E-05	85	1,417	0,0236	896000
2000	2002	4000	1302	176	14,5	4E-05	63	1,050	0,0175	896000
2000	2002	5000	1294	169	17,8	4E-05	47	0,783	0,0131	896000
2100	2107	1000	1390	203	3,6	4E-05	128	2,133	0,0356	896000
2100	2104	2000	1386	199	7,5	4E-05	102	1,700	0,0283	896000
2100	2101	3000	1381	196	11,5	4E-05	89	1,483	0,0247	896000
2100	2106	4000	1378	189	15,1	4E-05	64	1,067	0,0178	896000
2100	2101	5000	1364	179	18,3	4E-05	35	0,583	0,0097	896000
2200	2201	1000	1456	215	3,7	4E-05	107	1,783	0,0297	896000
2200	2206	2000	1453	211	7,8	4E-05	88	1,467	0,0244	896000
2200	2201	3000	1442	206	11,8	4E-05	68	1,133	0,0189	896000
2200	2202	4000	1433	197	15,6	4E-05	53	0,883	0,0147	896000
2200	2204	5000	1425	189	16,5	4E-05	42	0,700	0,0117	896000

Water fuel emuslsion 10% result data

This is a calculation performance data retrieval table on diesel engines with 5 variations of RPM and load on water fuel emulsion 10%

RPM ENGINE		Load	RPM Aluminator	Efficiency Slip	Power	FCR (mf)	SFOC	Torque	BMEP
(rpm) Control	(rpm) actual	(watt)	(rpm)		(kw)	(gr/h)	(gr/kwh)	(Nm)	(N/m2)
1800	1808	1000	1196	1,0269	0,5378	1057,6	1966,4	2,8421	113494
1800	1801	2000	1193	1,0243	1,1289	1330,1	1178,2	5,9888	238226
1800	1806	3000	1190	1,0217	1,7124	1500,3	876,12	9,059	361357
1800	1808	4000	1189	1,0209	2,2472	2434,4	1083,3	11,875	474204
1800	1802	5000	1178	1,0114	2,6457	2804,9	1060,2	14,027	558293
1900	1902	1000	1261	1,0257	0,5996	1084,2	1808,4	3,0117	119861
1900	1905	2000	1257	1,0224	1,2505	1152	921,25	6,2715	249988
1900	1901	3000	1247	1,0143	1,8853	1654,2	877,41	9,4751	376894
1900	1901	4000	1246	1,0135	2,4106	2745,2	1138,8	12,115	481918
1900	1906	5000	1243	1,0111	2,8307	3072	1085,2	14,189	565904
2000	2004	1000	1326	1,0246	0,698	1008	1444	3,3279	132571
2000	2005	2000	1321	1,0208	1,4507	1372,6	946,14	6,913	275524
2000	2005	3000	1316	1,0169	2,1381	1517,9	709,93	10,189	406076
2000	2002	4000	1302	1,0061	2,6858	2048	762,54	12,817	510079
2000	2002	5000	1294	0,9999	3,1854	2745,2	861,79	15,202	604979
2100	2107	1000	1390	1,0229	0,7564	1008	1332,6	3,43	136821
2100	2104	2000	1386	1,02	1,5493	1264,9	816,46	7,0353	280233
2100	2101	3000	1381	1,0163	2,3483	1449,7	617,35	10,679	424745
2100	2106	4000	1378	1,0141	2,9797	2016	676,57	13,518	538961
2100	2101	5000	1364	1,0038	3,4552	3686,4	1066,9	15,712	624968
2200	2201	1000	1456	1,0228	0,8235	1205,8	1464,3	3,5747	142183
2200	2206	2000	1453	1,0207	1,7073	1466,2	858,79	7,3941	294767
2200	2201	3000	1442	1,013	2,5408	1897,4	746,77	11,029	438684
2200	2202	4000	1433	1,0067	3,2325	2434,4	753,11	14,025	558101
2200	2204	5000	1425	1,001	3,2985	3072	931,32	14,299	569507

Water fuel emuslsion 15%
during experiment

This is a performance data retrieval table on the diesel engine with 5 variations of RPM and load on water fuel emulsion 15%.

RPM ENGINE		Load	RPM Aluminator	Alternator		Volume Diesel	Time	Time	Time	Density
				Voltage	Current					
(rpm) Control	(rpm) actual	(watt)	(rpm)	(volt)	(ampere)	(m3)	(S)	(minutes)	(hr)	(gr/m3)
1800	1805	1000	1197	162	3,1	4E-05	124	2,067	0,0344	904000
1800	1800	2000	1186	161	6,5	4E-05	120	2,000	0,0333	904000
1800	1804	3000	1185	160	10	4E-05	106	1,767	0,0294	904000
1800	1802	4000	1178	153	13,1	4E-05	104	1,733	0,0289	904000
1800	1803	5000	1164	149	16	4E-05	66	1,100	0,0183	904000
1900	1904	1000	1258	175	3,2	4E-05	114	1,900	0,0317	904000
1900	1900	2000	1253	174	6,9	4E-05	110	1,833	0,0306	904000
1900	1903	3000	1250	170	10,3	4E-05	86	1,433	0,0239	904000
1900	1904	4000	1237	164	13,7	4E-05	58	0,967	0,0161	904000
1900	1901	5000	1224	157	16,7	4E-05	52	0,867	0,0144	904000
2000	2003	1000	1324	188	3,4	4E-05	134	2,233	0,0372	904000
2000	2004	2000	1323	186	7,2	4E-05	94	1,567	0,0261	904000
2000	2003	3000	1312	182	10,8	4E-05	88	1,467	0,0244	904000
2000	2005	4000	1305	175	14,2	4E-05	66	1,100	0,0183	904000
2000	2002	5000	1286	168	17,2	4E-05	48	0,800	0,0133	904000
2100	2102	1000	1387	202	3,6	4E-05	128	2,133	0,0356	904000
2100	2102	2000	1385	199	7,4	4E-05	106	1,767	0,0294	904000
2100	2102	3000	1379	195	11,3	4E-05	96	1,600	0,0267	904000
2100	2100	4000	1360	186	19,7	4E-05	68	1,133	0,0189	904000
2100	2100	5000	1326	177	17,6	4E-05	38	0,633	0,0106	904000
2200	2203	1000	1456	214	3,7	4E-05	106	1,767	0,0294	904000
2200	2202	2000	1450	210	7,7	4E-05	82	1,367	0,0228	904000
2200	2204	3000	1441	205	11,6	4E-05	64	1,067	0,0178	904000
2200	2203	4000	1411	194	15,1	4E-05	44	0,733	0,0122	904000
2200	2201	5000	1347	181	16,4	4E-05	38	0,633	0,0106	904000

Water fuel emuslsion 15%
result data

This is a calculation performance data retrieval table on diesel engines with 5 variations of RPM and load on water fuel emulsion 15%

RPM ENGINE		Load	RPM Alumina	Efficiency Slip	Power	FCR (mf)	SFOC	Torque	BMEP
(rpm) Control	(rpm) actual	(watt)	(rpm)		(kw)	(gr/h)	(gr/kwh)	(Nm)	(N/m2)
1800	1805	1000	1197	1,0277	0,5174	1049,8	2029	2,7387	109182
1800	1800	2000	1186	1,0183	1,0882	1084,8	996,91	5,7758	229627
1800	1804	3000	1185	1,0174	1,6651	1228,1	737,54	8,8185	351374
1800	1802	4000	1178	1,0114	2,0983	1251,7	596,54	11,125	442777
1800	1803	5000	1164	0,9994	2,5258	1972,4	780,9	13,384	532993
1900	1904	1000	1258	1,0233	0,5795	1141,9	1970,6	2,9077	115845
1900	1900	2000	1253	1,0192	1,2473	1183,4	948,79	6,272	249353
1900	1903	3000	1250	1,0167	1,8235	1513,7	830,11	9,1548	364539
1900	1904	4000	1237	1,0062	2,3644	2244,4	949,26	11,864	472675
1900	1901	5000	1224	0,9956	2,7884	2503,4	897,78	14,014	557446
2000	2003	1000	1324	1,0231	0,6615	971,46	1468,5	3,1554	125637
2000	2004	2000	1323	1,0223	1,387	1384,9	998,44	6,6127	263423
2000	2003	3000	1312	1,0138	2,0529	1479,3	720,59	9,792	389879
2000	2005	4000	1305	1,0084	2,6092	1972,4	755,92	12,433	495546
2000	2002	5000	1286	0,9937	3,0789	2712	880,84	14,693	584743
2100	2102	1000	1387	1,0207	0,7543	1017	1348,2	3,4286	136441
2100	2102	2000	1385	1,0193	1,5298	1228,1	802,79	6,9531	276696
2100	2102	3000	1379	1,0148	2,299	1356	589,83	10,449	415831
2100	2100	4000	1360	1,0009	3,8764	1914,4	493,85	17,636	701146
2100	2100	5000	1326	0,9758	3,3801	3425,7	1013,5	15,378	611379
2200	2203	1000	1456	1,0228	0,8197	1228,1	1498,2	3,5548	141521
2200	2202	2000	1450	1,0186	1,6809	1587,5	944,46	7,293	290208
2200	2204	3000	1441	1,0123	2,4874	2034	817,74	10,782	429453
2200	2203	4000	1411	0,9912	3,1293	2958,5	945,45	13,571	540281

Water fuel emuslsion
20% during experiment

This is a performance data retrieval table on the diesel engine with 5 variations of RPM and load on water fuel emulsion 20%.

RPM ENGINE		Load	RPM Alumina	Alternator		Volume Diesel	Time	Time	Time	Density
				Voltage	Current					
(rpm) Control	(rpm) actual	(watt)	(rpm)	(volt)	(ampere)	(m3)	(S)	(minutes)	(hr)	(gr/m3)
1800	1800	1000	1179	162	3,2	4E-05	118	1,967	0,0328	912000
1800	1801	2000	1178	159	6,7	4E-05	103	1,717	0,0286	912000
1800	1802	3000	1181	158	10,3	4E-05	95	1,583	0,0264	912000
1800	1801	4000	1180	154	13,5	4E-05	59	0,983	0,0164	912000
1800	1803	5000	1169	145	16,5	4E-05	53	0,883	0,0147	912000
1900	1904	1000	1262	173	3,4	4E-05	109	1,817	0,0303	912000
1900	1903	2000	1256	171	7	4E-05	103	1,717	0,0286	912000
1900	1902	3000	1250	170	10,7	4E-05	66	1,100	0,0183	912000
1900	1900	4000	1240	163	13,9	4E-05	59	0,983	0,0164	912000
1900	1901	5000	1226	152	17	4E-05	55	0,917	0,0153	912000
2000	2002	1000	1322	188	3,6	4E-05	116	1,933	0,0322	912000
2000	2000	2000	1321	186	7,4	4E-05	98	1,633	0,0272	912000
2000	2003	3000	1316	183	11,2	4E-05	66	1,100	0,0183	912000
2000	2001	4000	1309	176	14,6	4E-05	52	0,867	0,0144	912000
2000	2004	5000	1280	166	17,8	4E-05	44	0,733	0,0122	912000
2100	2104	1000	1398	202	3,7	4E-05	101	1,683	0,0281	912000
2100	2104	2000	1384	197	7,6	4E-05	87	1,450	0,0242	912000
2100	2103	3000	1380	195	11,5	4E-05	68	1,133	0,0189	912000
2100	2104	4000	1371	187	15,1	4E-05	60	1,000	0,0167	912000
2100	2104	5000	1326	171	18,1	4E-05	40	0,667	0,0111	912000
2200	2205	1000	1464	216	3,9	4E-05	93	1,550	0,0258	912000
2200	2205	2000	1451	212	8	4E-05	64	1,067	0,0178	912000
2200	2204	3000	1440	206	12	4E-05	62	1,033	0,0172	912000
2200	2202	4000	1429	196	15,6	4E-05	47	0,783	0,0131	912000
2200	2204	5000	1425	189	16,5	4E-05	29	0,483	0,0081	912000

Water fuel emuslsion
20% result data

This is a calculation performance data retrieval table on diesel engines with 5 variations of RPM and load on water fuel emulsion 20%

RPM ENGINE (rpm) Control	(rpm) actual	Load (watt)	RPM Alumina (rpm)	Efficiency Slip	Power (kw)	FCR (mf) (gr/h)	SFOC (gr/kwh)	Torque (Nm)	BMEP (N/m2)
1800	1800	1000	1179	1,012273	0,542239	1112,949	2052,505	2,878128	114424,6
1800	1801	2000	1178	1,011414	1,115235	1275,029	1143,283	5,916221	235339,5
1800	1802	3000	1181	1,01399	1,699356	1382,4	813,4848	9,009923	358601,8
1800	1801	4000	1180	1,013131	2,172763	2225,898	1024,455	11,52631	458501,3
1800	1803	5000	1169	1,003687	2,52393	2477,887	981,7574	13,37436	532605,4
1900	1904	1000	1262	1,026507	0,606718	1204,844	1985,84	3,044467	121292,5
1900	1903	2000	1256	1,021627	1,240582	1275,029	1027,767	6,228426	248012
1900	1902	3000	1250	1,016746	1,894278	1989,818	1050,436	9,515349	378696,1
1900	1900	4000	1240	1,008612	2,378492	2225,898	935,8444	11,96023	475498,1
1900	1901	5000	1226	0,997225	2,743614	2387,782	870,3054	13,78899	548491,8
2000	2002	1000	1322	1,021545	0,701498	1132,138	1613,887	3,347756	133228,5
2000	2000	2000	1321	1,020773	1,427707	1340,082	938,6249	6,820258	271150,2
2000	2003	3000	1316	1,016909	2,134079	1989,818	932,4012	10,17938	405304,4
2000	2001	4000	1309	1,0115	2,68982	2525,538	938,9247	12,84304	510850,7
2000	2004	5000	1280	0,989091	3,163119	2984,727	943,6027	15,08028	600739,6
2100	2104	1000	1398	1,028831	0,769188	1300,277	1690,454	3,492838	139127,8
2100	2104	2000	1384	1,018528	1,556433	1509,517	969,857	7,06767	281521,7
2100	2103	3000	1380	1,015584	2,337976	1931,294	826,0539	10,62166	422884,2
2100	2104	4000	1371	1,008961	2,963246	2188,8	738,6494	13,45593	535980,8
2100	2104	5000	1326	0,975844	3,358287	3283,2	977,6413	15,24978	607434,2
2200	2205	1000	1464	1,02843	0,867296	1412,129	1628,197	3,757944	149742,6
2200	2205	2000	1451	1,019298	1,761767	2052	1164,74	7,633637	304177,1
2200	2204	3000	1440	1,01157	2,587474	2118,194	818,6337	11,21647	446739,2
2200	2202	4000	1429	1,003843	3,225065	2794,213	866,4051	13,99306	556822,2
2200	2204	5000	1425	1,001033	3,298534	4528,552	1372,898	14,29884	569506,9

RESULT EMISSION NOx DATA

PEMERINTAH PROVINSI JAWA TIMUR
DINAS TENAGA KERJA DAN TRANSMIGRASI
UNIT PELAKSANA TEKNIS KESELAMATAN DAN KESEHATAN KERJA
(UPT K3)
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LHU ini merupakan hasil pada lokasi dan saat pengukuran
LAPORAN HASIL PENGUJIAN
No. PT.06 / VII /2017

I	Nama Pengguna Jasa	: MAHASISWA ITS (NOUVAL PAHLEVI)
II	Alamat	: Kampus ITS, Sukolilo - Surabaya
III	Jenis Pengukuran	: Kualitas Udara Emisi
IV	Tanggal Pengukuran	: 5 Juli 2017
V	Lokasi Pengukuran	: Mesin Diesel Shanhai R 180
VI	Alat Yang Digunakan	: Exhaust Gas Analysis, ECOM J2KN
VII	Hasil Pengukuran	:

NO	Bahan Bakar	Variasi W/O	Beban (%)	Hasil Pengukuran (NO_X, mg/kwh)
1	Water Fuel Emulsion	10 %	25	642
			50	639
			75	608
			100	467
2	Water Fuel Emulsion	15 %	25	566
			50	530
			75	515
			100	414
3	Water Fuel Emulsion	20 %	25	434
			50	427
			75	423
			100	392

Surabaya, 10 Juli 2017
MANAJER TEKNIK

PEMERINTAH PROVINSI JAWA TIMUR UPT KESELAMATAN DAN KESEHATAN KERJA SURABAYA DISNAKERTRANS

SLAMET, SKM.
NIP. 19630111 198803 1 012

AUTHOR'S BIOGRAPHY

The author named Nauval Pahlevi Tambunan was born in Surabaya,23 April, 1995. The author studied Elementary School at SDN Sidokare II, Junior High School at SMP PGRI 1 Buduran Sidoarjo in 2007 and Senior High School at SMA Antartika Sidoarjo in 2010. Then the author continued the education at Double Degree at Department of Marine Engineering, Institut Teknologi Sepuluh Nopember - Hochschule Wismar in 2013 with registered number 4213101039. During the study, the author active become organizing committe YES SUMMIT during 2014 and than become orginizing Marine Icon period 2016. On the Job Training experience has already done in PT. Anggrek Hitam and PT Samudera Indonesia Ship Management. In the 3 years of study, the author joined with the marine power plant (MPP) laboratory and completed studies in 8 semesters.