International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 3, Issue 7 (July 2014), PP.32-38

MDO and LNG as Fuels (Duel Fuel) to Support Sustainable Maritime Transport (A Case Study in KM. Ciremai)

Mochamad Furqon Rochyana[1], M. Yamin Jinca[2], Jusuf Siahaya[3]

[1]*Students of the Postgraduate Program in Transportation Engineering, Hasanuddin University, Makassar-Indonesia,*
[2]*Professor, Dr. Ing., MSTR, In transportation Engineering of Postraduate Program, Hasanuddin University, Makassar-Indonesia,*
[3]*Professor, Dr. Ir., MSME, In Mechanical Engineering of Postgraduate Program, Hasanuddin University Makassar, Indonesia,*

Abstract:- The rising fuel prices are a problem swelling of vessel operating expenses, so the shipping companies are trying to use LNG as an alternative energy on the main engine and auxiliary engine. This research aims to know the cost of investment process the implementation of the system dual fuel MDO and LNG, and economize operational costs. Research methods Using libraries study operational data weather, in analysis of economically about the ratio of LNG and MDO. It was Found that fuel use MDO to LNG need modification process without the replacement machine, adding to some of the equipment based on the rule class, including Bureau Types of Indonesia (BKI), Nippon Kaiji Kyokai (classnk) and so on. The systems use duel fuel combustion produces a perfect; the emissions from the womb by sulphur oxide (SOX) can be sent down to 90-95% and low levels of carbon dioxide (CO2) to 20 % to 25 %.

Keywords:- Duel Fuel, operational costs, emissions and efficiency

I. INTRODUCTION

Indonesia is a maritime nation and the world's largest archipelago, between the islands with other islands separated by sea, is not a barrier for people to interact with other people. As mandated by Law no. 17 of 2008 on a cruise (Article 24, 25 and 26). To realize it requires huge cost. The high cost of transport can reduce intensity of the public to interact with people in other islands. However, it is not easy to lower ticket prices in the absence of a balance between operating costs and revenue costs, especially fuel costs are high in the operation of a ship at sea. Fuel consumption can be calculated from the performance of ship propulsion. The composition of fuel on board, consisting of fuel and the main propulsion engine and auxiliary engine.

A great fuel consumption is determined by the length of time a ship at sea and in port, and a high main propulsion and auxiliary machinery. KM. Ciremai by PELNI owned shipping company, the shipping took a diesel fuel as much as 70 tons, a day to pay to ship as many as 2 billion, depending on the cruise. The high fuel consumption made many companies finally slowly turning to use gas-fuelled ships with duel fuel technology, fuel ratio and fuel type of MDO gas (LNG) ranges from 30% to70%.

The efforts mentioned above, should be supported by all the parties concerned, because it can reduce operating costs and prevention of air pollution, according to the rules of maritime organizations world (IMO) set out in MARPOL Annex VI, and Presidential Decree no.12 of 2012 on pollution prevention regulations air from the ship.

II. CONSTRUCTION AND MODIFICATION

The diesel engine is one type of motor fuel, unlike gasoline engines, the combustion process rather than by electric sparks, but with a compression ignition engine to produce exhaust emissions are high enough to be harmful to health and the environment. High levels of nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO2) and other emissions of particles associated with diesel fuel is an issue that has been a long time coming. [1]

The duel fuel engine is a machine that uses two refuelling system that LNG fuel system as the main fuel and MDO as a backup fuel, meaning MDO is used only at certain times, for example when manouver the ship or simply test the engine when the engine will be operated. [2]

The process of obtaining LNG vapour from liquid to be used in the system duel fuel, liquid LNG from the LNG tank bunkers added to the temperature of the LNG -162^0C. LNG liquid is inserted into the evaporator and heated to a temperature of 0^0C so it turns into a vapour phase, and then distributed through the GVU (Gas Valve Unit) are located between the LNG tank and the engine, with a maximum distance of 10 meters from the

machine. When GVU is closed, then the combustion system uses fuel oil, LNG vapour that has been distributed through the GVU, passed to the engine for combustion to produce energy to drive the boat propeller. [3]

Gas is the main fuel, so the exhaust emissions produced better than diesel, dual fuel engines act according to the Otto principle, natural gas with low pressure (less than 5 bar) inserted through the hole of air intake duct (water inlet channels) of each cylinder at when the charging step (intake stroke), for spraying the beginning of the (mixed) air and less gas (to create a lean pre-mixed water-gas moistures) in the combustion chamber ignition at the end of compression in a conventional diesel engine. The spraying is done by using a nozzle known as Pilot Injection Valve shown on the picture, where the pilot injection valve is mounted on the engine. [4]

Ship Operating Costs

The calculation of the cost of the boat approached the ship cost component groupings per day during the ship were in port and during cruise ship activities. The number of operating days on which the calculation is 365 (three hundred and sixty-five) calendar days minus the ship-operating days. In this case the average time used for ship repair and maintenance activities, which rose dock at the shipyard. [7]

High consumption of fuel in the vessel is determined by the length of time a ship at sea and in port. Fuel consumption for engines used in marine propulsion and auxiliary machinery aboard the ship, while in port fuel used for propulsion engine generator. Fuel for ship propulsion apparatus used fuel standard in the range of 205-211 g / kW-hour. [5]

At a certain point power fuel consumption is at the lowest point on the graph the specific fuel oil consumption (SFOC), the units used gr / kWh. Liquefied Natural Gas (LNG) is natural gas that is liquefied and cooled to -162^{0}C temperature at a pressure of 1 atm. LNG has a chemical composition slightly was last Methane ethane, Propane, Butane and Pentane and very little nitrogen.[8]

Gaseous fuels because of the form of gas, no need to first be evaporated as the fuel (gasoline), so that the excess emissions as much fuel-air mixture at the start can be minimized.[3]

The advantages in terms of fuel gas combustion process in the combustion chamber as fuel gas has the atomic ratio of carbon to hydrogen atoms are low, so it becomes more perfect combustion.

Table 1. Emission Engines in kWh [5]

Fuel Type	SO_x (g/kWh)	NO_x (g/kWh)	PM (g/kWh)	CO_2 (g/kWh)
Residual oil 3.5% sulphur	**13**	**9-12**	**1,5**	**580-630**
Marine Diesel Oil, 0,5%S	**2**	**8-11**	**0,25-0,5**	**580-630**
Gasoil, 0,1% sulphur	**0,4**	**8-11**	**0,15-0,25**	**580-630**
Natural Gas	**0**	**2**	**~0**	**430-480**

The use of LNG as fuel is expected to improve the environment and be more cost effective. The biggest advantage is the lower emissions and cleaner air in the ports and cities along the sea. Here is a technical reason that natural gas can be used as ship fuel:

1. The high methane content so that the ratio of high-power,
2. Easily mixed with air and burned at high speeds even on the air intake that much. This is to avoid the high temperature and pressure during combustion, thereby reducing NOx emissions by 90% compared to petroleum diesel and MDO (marine diesel oil). It is also possible to obtain high efficiency.
3. Contains Sulphur therefore no SOx emissions and no particulate.

Natural gas combustion efficiency higher than other fossil fuels. This is because any fuel that burned a gas phase, so if using the fuel it requires energy to change into a new gas combustion process occurs. [9]

Other studies have shown that the use of LNG as a proven low cost fuel (TCOO) and are environmentally friendly, SOx and particulate emissions could be almost 0%, NOx was reduced by 90% and reduced CO2/GHG 15%.[10]

Ship engine built on January 1, 2016, if the engine power over 750 kW. Implementation will be undertaken by the IMO will be done as shown below:

Figure 1. Proliferation of ECA (Emission Control Area) [5]

Emissions Control Areas (ECAs) are regions bounded emission levels. In this case, the ship had to limit SOx emissions and emissions of other gases. Limitation of emissions of NOx, SOx set in Maritime Pollution (MARPOL) Annex VI, the IMO will limit future emissions of SOx in the fuel as shown in the following table:

Table 2. Limits of Fuel Sulphur in [6]

Period	Global	ECA
Nowadays	4.50%	1.50%
1st July 2010		1.00%
1st January 2012	3.50%	
1st January 2015		0,10%
1st January 2020	0,50%	

III. DUEL FUEL AND TECHNOLOGY APPLICATION

In this case study, take a sample of KM. Ciremai, where the magnitude of the company's operating costs so high that it will apply the concept of duel fuel, to suppress it, and implement the regulations issued by the world maritime organization (IMO) set out in MARPOL Annex VI and Presidential Decree 12 of 2012 on the prevention regulations air pollution from ships. Fuel system that uses LNG and MDO at once in an auxiliary motor and main drive motor, through the use of LNG conversion kit. Conversion kit is the conversion equipment fuel gas pressure. LNG fuel system consists of pipe assemblies and other valves.

LNG tanks are generally designed double shell vacuum with a pressure of 5-10 bar. The shape is a prism tanks and equipment for vaporization of LNG, natural gas heating and pressure regulator. This system would be adopted to be applied to the main engine of the vessel, owned by PELNI as a pilot project. This ship can be operated using fuel oil and fuel gas.

The use of fuel gas in the vessel has been arranged in the classification rule. DNV classification is a classification of very concern in conducting research and making rules about the use of LNG as fuel on board. This can be seen on the ships using LNG fuel either full or duel system. However, due to KM. Ciremai using the BKI classification rules for planning and duel fuel system installation should be subject to the BKI rules.

The BKI itself has also been developing regulations regarding the installation of equipment, system installation and placement schemes LNG tank safe. The regulation is also supported by the existing rules as shown below.

- Role Classification of Indonesian Laborer, Volume I Rules for Classification and Survey
- Role Classification of Indonesian Laborer, Volume II Rules for Hull Construction
- Role Classification of Indonesian Laborer, Volume. III Rules for Machinery Installation
- Role Classification of Indonesian Laborer, Volume IV Rules for Electrical Installation
- Role Classification of Indonesian Laborer, Volume V Rules for materials
- Role Classification of Indonesian Laborer, V**o**lume VI Rules for welding
- Other IMO Regulations SOLAS, ISM code, Gas MSC,285,etc
- Role Classification of Indonesian Laborer, Volume IX Rules for ships carrying Liquid gases in bulk

- Guideline of the use of Gas as Fuel

The existing regulations in the ICC rules and IMO resolution MSC.285 (86)-adopted on 1st June 2009 on the interim guidelines on safety for natural gas-Fuelled engine installation in the ship. So that of the reference system equipment installation for LNG to the parent machine can do with two alternatives:

Alternative 1 (double-wall piping)

Installation of LNG fuel systems to the ultimate main engine in alternative 1 (the first) is simple where the safety of the gas leak is done by isolating the pipe with double wall piping. Double wall was used to track/gas pipeline that goes to the ultimate driving machine. While the space is given additional gas regulation unit detector to detect gas in the event of a leak.

Gas detectors are connected to the valve to anticipate if a gas leak occurs, then the valve will immediately shut down and stop the flow of gas/LNG engine. In a double-wall piping systems also require additional tools such as a positive force draft fan that serves to remove gas trapped in a double-wall if the pipe leaking gas lines.

Alternative 2 (engine room insulation)

In contrast to alternative 1 (one), the alternative 2 (two) isolation performed on the entire engine room. In the engine room insulation scheme requires more gas detector and must be placed in the right place, where the concentration of the gas collected in the event of a leak. The function of the gas detector is the same as in Alternative 1. With this system also requires a crew ship cautious while in the engine room. On the other hand for access in and out of the engine room to also require additional space of approximately 1, 5 meters with air resistant doors (air lock). This door serves to prevent the gas out and into another room in case of leakage.

IV. INVESTMENT COST USE OF DUAL FUEL

Estimated investment costs the use of dual fuel (MDO and LNG) in KM Ciremai based on the components necessary to support the dual fuel. The costs incurred due to procurement of spare parts engine currently used in KM. Ciremai cannot support the use of fuel gas, so it requires additional parts.

KM. Ciremai main engine with MAK 6 M 601 C model, 2 units with each unit power of 8,500 HP, while the auxiliary engine using Daihatsu 6 DL-24 (4 units).

The additional equipment to be able to use dual fuel as fuel is good for Main engines, addition of equipment is also needed equipment Regasification Units which are operational.

Table 3. Investment costs for modifications ships. [11]

Item	Main Engine	Aauxiliary Engine	Total (Rp)
System Spare part	3.330.000.000	2.200.000.000	5.530.000.000
System Optional	837.000.000	835.000.000	1.672.000.000
Container/Tank	837.000.000	835.000.000	1.672.000.000
Total	4.167.000.000	3.035.000.000	8.874.000.000

V. COST FUEL EFFICIENCY

To simplify the calculation of fuel requirements, need to know in advance about the specifications of the engine and the vessel trip, which is the object of study. As explained before that, KM. Ciremai is Three in one generation two, capable of carrying passengers, vehicles and containers. In terms of KM. Ciremai performance still capable of sailing at a speed of 16 knots resulting from main engines 2 x 8,500 HP. 4 engine equipped with auxiliary engine 4 x 1200 HP. These after modification operations are Tanjung Priok - Jayapura, via Tanjung Priok - Surabaya - Makassar - Sorong - Jayapura - Serui - Sorong - Namela - Makassar - Surabaya – Tanjung Priok with a total distance of 4779 Nm every one round trip times. But in fact later use fuel not entirely using LNG, and LNG fuel only on certain ports, and ports with supporting infrastructure for LNG transportation activities of the mother station.

Based on these explanations, this study calculated the fuel requirements for a distance of Jakarta - Surabaya and Surabaya - Jakarta. The amount of fuel consumption is determined by the amount of power of main engine and auxiliary engine owned by the fleet as well as the speed factor. The level of fuel consumption will be calculated based on SFOC (Specific fuel oil consumption). Based on the performance data of the main engines of KM. Ciremai SFOC value is equal to 0.149 liters/hp hours. SFOC unit is kg/kW hours, and to get the fuel needs further multiplied by the engine power and a long sail.

Energy requirements with a variety of assumptions to use the fuel composition assuming 40% MDO and 60% LNG, then the price of LNG for 16 USD/mmbtu or equivalent to Rp 182,000.00 /mmbtu, in 2014 obtained the costs to government subsidize 100% per trips is Rp 370,594,130.00 for MDO and LNG Rp 405,603,105.97. the total is Rp 776,197,235.97. This is the cost incurred for fuel duel fuel. After the simulated assuming MDO price increase of 15% per three (3) years, or an average of 5% per year and a decrease in the price of LNG was 1.5% per year.

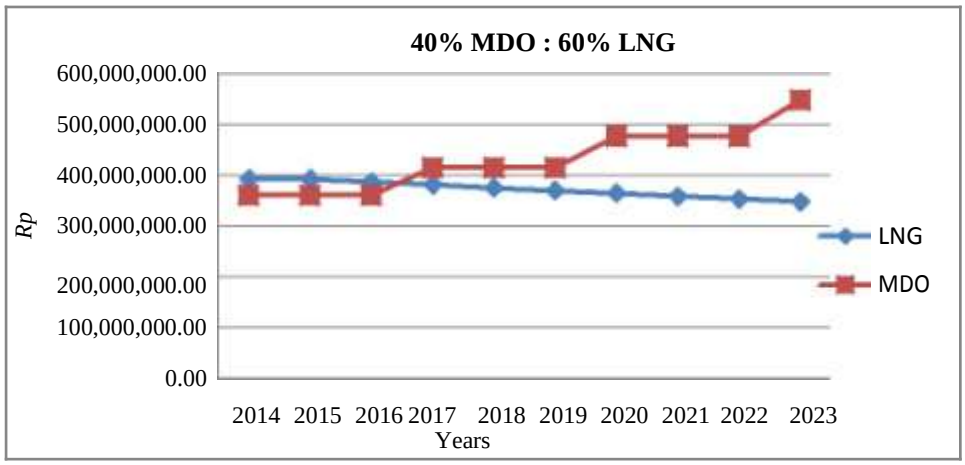

Figure 2. Graphs Fuel Costs 40% MDO : 60% LNG

Use of 20% to 80% MDO and LNG

Based on calculations using the assumption of a fuel composition of 20% to 80% MDO and LNG, then the price of LNG for 16 USD / mMBtu, equivalent to Rp. 182.100 / MmBtu in 2014 found it cost the government to subsidize 100% per trips amounted Rp 185,297,065.00 for MDO and LNG Rp 540,804,141.29. If the total is USD 726,101,206.29. This is the cost incurred for fuel duel fuel. After the simulated assuming MDO price increase of 15% per three (3) years and a decrease in the price of LNG 1.5% per year, then the data obtained as in the following table.

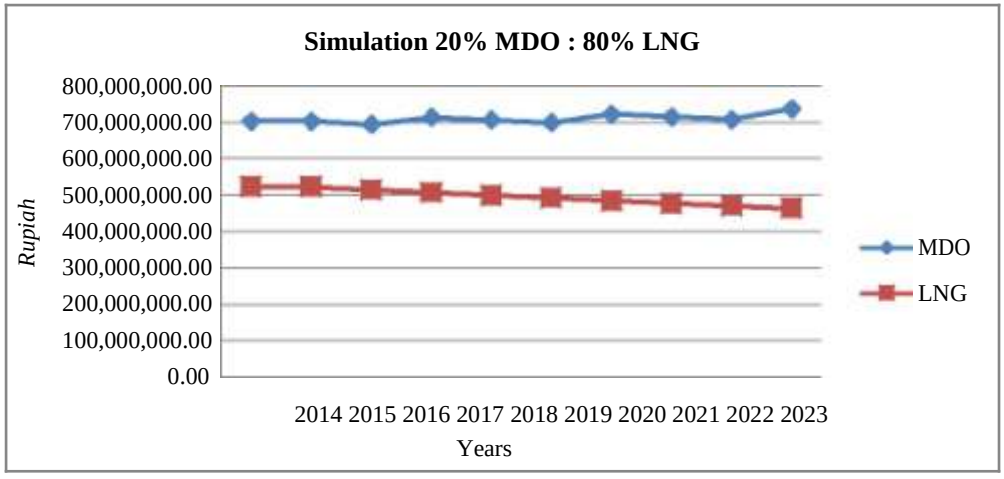

Figure 3. Cost Energy with the assumption of 20% MDO to 80% LNG

The graph above illustrates the energy costs to be borne by the government were simulated assuming MDO price increase of 15% per three (3) years and a decrease in the price of LNG by 1.5% per year. The above results indicate that the use of LNG fuel will be economically viable in the operation of the ship. The LNG is relatively cheaper than the use of MDO as a source of energy in general and in particular on the ship KM. Ciremai. Behind it we must also realize that the vessel KM. Ciremai intended for passenger ships, containers and other items that need space efficiency is also taken into account.

The addition of various types of system installation and the addition of an LNG tank will be placed in a special container in another container load, so the capacity of the vessel will be affected. In this context it can be known through calculation of opportunity cost and calculation of sensitivity loss.

Opportunity loss calculation

Opportunity loss is the incurred cost due to the room that should be filled cargo, but replaced with LNG fuel tanks. This causes the loss of revenue from container that should fit. In previous assumptions regarding the use of LNG fuel tank, found that the tank is used as much as 3 tanks when the ship sailed from Jakarta to Surabaya, then from Surabaya to Jakarta also use 3 tank containers. The results of the calculation of the cost of opportunity loss. Opportunity loss calculation refers to the observations by officers in PELNI, the authors can assume that the rate of containers on the ship KM. Ciremai is approximately USD 3,000,000.00 from the Jakarta-Surabaya and Jakarta to Papua Rp 24,000,000.00 assuming a 5% annual increment and tariff assumptions for three LNG tanks from Surabaya to Jakarta is Rp. 9,000,000.00 each trip. Finally obtained a total loss due to the use of the LNG tank space at the beginning of the year is Rp. 99,000,000.00 per trip. When averaged 23 trips / year, meaning a loss in 2014 of Rp 2,277,000,000.00. The development cost of the opportunity loss for the years 2014 - 2023 can simply be described as the following table:

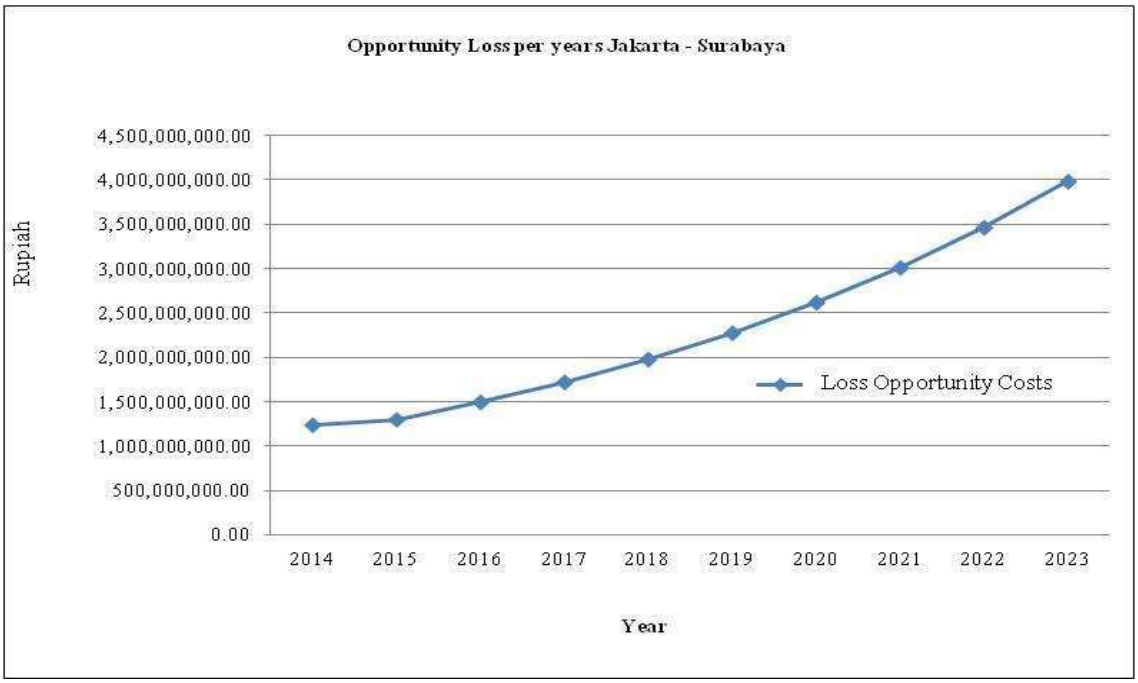

Figure 4. Graph application opportunity loss for the year (2014-2023)

Based on the above chart gives a clear picture that LNG fuel use is to reduce operating costs. but it must also be realized that there was something missing. The loss of the opportunity to load more containers because the room is occupied by equipment for installation of LNG on board. Several variables/assumptions previously used to calculate the costs do change scenario sensitivity analysis scenario, which in this sensitivity analysis variables used is MDO subsidized price difference with the price of LNG to be used, and then distinguished between the use of calculation and opportunity loss without using it.

Opportunity loss as a result of the placement of the LNG tank, so the opportunity to load the container becomes lost and can be considered as a loss. By using LNG and MDO 80% - 20% to reduce the cost of operations such as Jakarta-Surabaya was still more gain at around about 20.66%. It could be argued that if the loss of nine million dollars but takes advantage of hundreds of millions. Therefore, through this study has indicated that for the time being, as long as the price of LNG is still present, the use of energy sources KM. Ciremai forward very likely to cruise the cheap and environmentally friendly.

VI. CONCLUSION

The use of MDO and LNG fuel modification process requires the installation of the fuel system, although not to the process of replacing the engine, just to add some equipment based on the rule BKI (Bureau Classification Indonesia). LNG equipment installation system to the main engine is done with a double-wall piping and insulation system of the engine room. The investment cost for modifying fuel use MDO to LNG is considered quite high, especially procurement of spare parts for the main engine and auxiliary engine, in order to use dual fuel and LNG fuel is MDO which amounted to Rp 5,530,000,000.00 (rough estimate KM. Ciremai) the cost of optional equipment and tanks amounting to Rp 167,200,000.00 total investment cost of about Rp.

8,874,000,000.00. Cost the energy requirements of KM. Ciremai 2014 using MDO 100% necessary expenses of Rp 926,485,325.02 per trip. With the increase of about 15% per year, then the year 2023, vessel operating expenses of Jakarta - Surabaya each trip will swell to Rp 1,409,068,368.69, if using a 40% + 60% MDO to LNG, the efficiency can be achieved cost around 18.71 %, with 20% scenario MDO + 80% efficiency of LNG costs about 24.02% of each trip, and if you use it 100% LNG, cost of efficiency can be achieved by 97.8%. SOx and particulate emissions could be almost 0%, NOx was reduced by 90% and reduced CO2/GHG 15%

REFERENCE

[1]. Khovakh, M, 1977, Motor Vehicle Engines, Mir Publishers, Moscow, USSR 59 Henry, J-M, 2012, Retrofit Moteur Diesel Wartsila Dual Fuel, Wartsila France

[2]. Pasandang, Heni, 2013, Study of Use of Liquefied Natural Gas (LNG) as Dual Fuel In Engineering Drive Kilometers. Nggapulu. Makassar: Program of Mechanical Engineering, Postgraduate of Hasanuddin University, Makassar-Indonesia.

[3]. Lavender, Oscar, 2011, Duel Fuel Engines Latest Developments, Concept design MLS, Humburg Stenersen, Dag, 2011, LNG-Fuelled Engines and Fuel System for Medium-Speed Engines in Maritime Applications, GTS Technical Seminar, SINTEF, MARINTEK IMO, Second IMO GHG Study 2009.International Maritime Organization,London. 2009

[4]. Jinca M.Y. , 2011. Sea Transportation. System Analysis and Case Studies. Brilliant International. Surabaya

[5]. Rachmanto, Tri. , 2008. Specific Fuel Consumption and Efficiency Thermal IDI Diesel Dual Fuel Multisilinder Solar-LPG with Low Load Variation Storey. Professional Journal Vol 9, 1, 2008.

[6]. Hardzik, Jerzy. 2011. LNG as a Marine Fuel-Possibilities and Problems, Gdyna Maritime University, Journal of KONES Powertrain and transport, Vol. 18 No.2

[7]. www.migas-indonesia.com/2013/ 02/penggunaan-Ing-sebagai-bahan-bakar-gas

[8]. PELNI, PT., 2013, Study of Use of Natural Gas as an Alternative Fuel Source for Passenger Ships, ITS Partnership, Surabaya