# THE IMPLEMENTATION OF ENGINE TELEMETRY DATA TO THE IMPROVEMENT OF A DUAL FUEL DIESEL ENGINE MAINTENANCE SCHEME

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## ABSTRACT

Ship main engine failure can lead to a major hazard and may endanger the safety of crews, passengers, cargoes, the environment as well as the ship itself. As a prime mover of the ship, the condition of the main engine needs to be ensured in its best condition. To help the ships keeping their uptime as long as possible, a maintenance scheme should be carried to prevent the main engine from failing. This paper reviewed about the usage of main engine telemetry data that can be used as a tool for condition based maintenance. Telemetry is a process of data collection that can be conducted remotely and transferred automatically. The telemetry data can be gathered from the transducer attached to the main engine's components by giving it the input voltage and the transfer function will produce the output signal. The data were collected and then transmitted to the data analyzer. The transducers were used to measure the torque and power in the propeller shaft as well as on the engine coupling shaft, temperature on vibration dampers, piston temperature and pressure, valve temperature. Moreover, transducers were installed to test the timing of the gear drive, the turbocharger, and to monitor the diesel fuel pump. Those parameters were monitored and if there was a deviation in the components, the output signal showed a different signal compared to its input. This method was considered as a better approach to do the condition based maintenance as the crews do not need to physically attend the engine room to monitor the main engine.

***Keywords:*** condition-based maintenance, dual fuel, marine engine, telemetry data.

## INTRODUCTION

Operational causes (fire and explosions 20%, collisions and groundings 35%, and machinery damage 5%) and design and maintenance causes (water ingress 40%, hull breaking in two 0% and capsize of intact ship 0%) are two main causes that lead to ship casualties at the last two decades (Faulkner, 2013). It can be inferred that machinery failure gives a contribution to a ship accident. This accident may endanger the crew, passengers, cargoes, environment, and also the vessel itself. Major losses will also be suffered by the owner of the ship, thus making the company profits decreased. (Handani and Uchida, 2012) mentioned that when the ship is in the operating condition, it is important to make sure that the main engine is successfully operated because the engine is the prime mover of the ship.

Diesel engine is generally used as the main engine of the ship, considering its advantages over the other type of engine, such as its reliability and low operating cost. However, despite all the advantages of the diesel engine, it also has a disadvantage that should be mitigated, that is emission. The combustion process of the diesel engine produces the exhaust gas that consists of carbon monoxide (CO), carbon dioxide ($CO_2$), nitrogen oxide ($NO_x$), sulphur oxide ($SO_x$) and particulate matters (PM). Those molecules are can threaten human's health and harm the environment. The CO and $CO_2$,

can affect human respiration system, while $NO_x$ can react with oxygen producing a gas that can damage the surface ozone. Furthermore, $SO_x$ has the worst effect which can cause an acid rain and destroying the building as well as the trees. It also can burn human skin. Many researches have been carried to find the solution in reducing the emission, and some solutions have been proposed to tackle this problem.

The addition of $H_2$ mixture that generated from the water electrolysis process found to the fuel consumption is reduced along with the increasing amount of hydrogen, it also reduces the emission of $CO_2$ and CO (Jhang et al., 2016). Moreover, a study shown that hydrogen can reduce the $NO_x$ emission by using the $H_2$ in the selective catalytic reduction (SCR) process (Resitoglu and Keskin, 2017). Another way to decrease the emission production is by combining the diesel fuel. The diesel fuel can be combined with vegetable oils, fuel additives or natural gas. Recent researches that focus on the effect of biofuel on exhaust gas emissions outlined that the addition of cooking oil waste can reduce the emission of CO and HC (Ghobadian et al., 2009). Although some biofuels can result on a significant reduction of $NO_x$ emission, but several researches do not drop the emission or even increase it. A research conducted by (Qi et al., 2010) used crude soybean seed oil biodiesel fuel with the diesel oil. The results showed that by adding more biodiesel in the fuel, the amount of $NO_x$ increases. Natural gas is also considered as one of the alternative fuel that can contribute to the emission reduction. Particulate matters (PM) and $NO_x$ emission was dropped significantly along with the substitution of diesel fuel with natural gas (Li et al., 2015). Although, in that research, the emission level of CO and HC slightly increased. A research done by (Ariana et al., 2017) investigated about the benefits of liquefied natural gas (LNG) usage in passenger ships in Indonesia and the result turned that with the ratio of natural gas and high speed diesel (HSD) oil equals to 95 to 5 percent, the $NO_x$ emission level is only 37% compared with the diesel engine that only utilising HSD oil.

It is not expected that the assets are in a downtime for a long-time due to a severe fault. If such condition occurs, the company has to spend a lot of money to do the corrective maintenance and it also cannot fulfil its duty because the ship cannot be operated at that time. It can be said that the company would loss both money and time. To prevent such condition to be occurred, such maintenance management should be conducted to manage the assets of the ship. Based on Mobley (2002) there are three common types of maintenance management employed by industrial and process plant, they are: run-to-failure management, preventive maintenance, or predictive maintenance. The first one does not require any maintenance action unless a component is already failed to operate. The second one, is based on the operation time. In this maintenance scheme, the component will be repaired or rebuilt according to the schedule that based on the mean time to failure (MTTF) statistic. This can cause on either unnecessary repair or severe failure. The last is predictive maintenance, which is based on regular condition monitoring to obtain the actual data to optimise the interval between repairs and minimise the number and cost of unscheduled outages due to the failure of one component.

Telemetry data can be utilized as a mean to monitoring the condition of the main engine. Telemetry enables data gathering from a remote or inaccessible area and then the data transmitted to be monitored and then analyzed. This principle can be applied in the diesel engine, where some of its components cannot be reached when the engine is operating. In term of condition monitoring of a diesel engine, there are some way that are usually used to monitor the condition of the engine, for example, lubricating oil analysis and vibration signal analysis. A sensor or transducer is attached to the

component that is going to be monitored, then the signal will be captured by the receiving device. The data processed from the signal then compared with the new or a known-to-be-good condition. When the deviation is found and it exceeds the threshold, then an action should be taken to improve the condition of the component.

## STATE-OF-THE-ART ON CONDITION BASED MAINTENANCE

Condition based maintenance (CBM) is considered as a best practice in achieving that objective. This maintenance strategy has been applied for a long time for a wide range of application. Wind turbine that usually built in the remote area, for sure, needs a condition based maintenance to avoid spending extra cost to do unnecessary maintenance actions. The telemetry data can be gathered from the site where the turbine located, while the receiver can be anywhere, within the range of the device, to receive the signal transmitted. Lube oil condition monitoring was used by (Zhu et al.) to predict the remaining useful life of the components. They combine the results of two sensors that measures the kinematic viscosity and dielectric constant. In fact, for the oil analysis, there are number of indicators that can be used as a measurement for the engine health. As mentioned by (de Almeida and ENERGIA), at least six methods are known to do the oil analysis in term of wear analysis. Those are elemental analysis, ferrous density, particle counting, x-ray fluorescence, analytical ferrography, and LaserNet fines.

Another condition monitoring method that can be applied to the rotating machines is vibration analysis. Vibration analysis principle work is to compare the signal made by engine in the present condition with the vibration of a new engine or an engine that is in the good condition. A research has been performed on a wind turbine condition monitoring analysis by using envelope analysis as a demodulation technique (Romero et al., 2017). In that paper, future faults of a turbine can be detected through comparing the signal sent by gearbox and generator with the baseline signal. Furthermore, a research has investigated about the way to reduce the volume of data collected and number of sensors used in the vibration analysis in a mechanical system (Ganesan et al., 2017). Those can simplify the analysis by applying Compressive Sensing (CS).

The diesel engine is usually used as a prime mover in the ship. To keep the performance of the main engine to be in a good condition, the classification society requires a survey that must be carried in a five-year period. According to the Nippon Kaiji Kyokai (Class NK, 2013), for a diesel engine, some items need to be checked, these include cylinder covers, cylinder liners, pistons (piston pins and piston rods to be accompanied) crosshead pins and their bearings, connecting rods, crank pins and their bearings, crank, journals and their bearings, camshafts and their driving gears, turbochargers, auxiliary blowers, air inter-coolers, attached essential pumps and coolers (e.g. bilge pumps / lubricating oil pumps / fuel oil pumps / cooling water pumps / lubricating oil cooler / central fresh water cooler, hydraulic oil pumps for electric control system). Those components mentioned above need to be checked in every overhaul survey. This paper will only focus on the components in the diesel engine.

A maintenance scheme is absolutely needed for the main engine. The purpose of choosing the best maintenance scheme is to minimize the cost spent by the company. A study proposed about the project that can enhance the safety of ship by doing condition monitoring (Lazakis et al., 2016). This paper brought a new inspection method both for the ship structure and its machineries and integrating it with decision-making tools for onboard and offshore assistance. Disadvantages that are going to be tackled by this research is that the conventional condition based maintenance cannot be processed

onboard, for example, for lubrication oil analysis the oil must be collected and then tested in a laboratory.

## APPLICATION OF CONDITION BASED MAINTENANCE ON DUAL FUEL ENGINE

The dual fuel diesel engine (DFDE) has been on the market for past few years to answer the need of a low-emission engine. An engine can be categorized as a dual fuel engine when it used both gas and liquid fuel to be burned in the combustion chamber. Natural gas is known as the gas fuel that can be the substitution for the oil fuel. The liquid fuel, can be medium diesel oil (MDO) or high-speed diesel (HSD) oil, usually is used as the pilot fuel and the gas fuel will be used at the rest of its operation. Many engine manufacturers have produced this type of engine, such as MAN B&W, Wartsila, MaK etc.

As outlined in product guides of several dual fuel engine manufacturers, a dual fuel engine has similar engine components compared to the conventional diesel engine (Wartsila, 2016). As for the conventional diesel engine, the transducers that installed to capture the telemetry data, can be placed to measure the propeller shaft torque and power, temperature on vibration dampers, piston temperature and pressure, valve temperature. Moreover, transducers are installed to test the timing of the gear drive, the turbocharger, and to monitor the diesel fuel pump. Also, a device to monitor wears from the engine needs to be installed, to analyze the engine wear.

## DISCUSSION

There is no research taken to arrange the condition based maintenance scheme. Telemetry data is collected from the dual fuel diesel engine, in fact, without considering two operating conditions. Discussions made from the above literature review are:

1. Many researches have been addressed the importance of condition based monitoring to reduce the cost of operation and to minimize the work done by the crews.
2. Condition monitoring that usually conducted on the rotating machine, particularly diesel engine, are oil wear analysis and vibration monitoring. These methods are commonly used due to its easiness and the reliable data gathered by this analysis. The faulty vibration is detected by the transducer and directly monitored by the crews, so an action can be taken immediately to check the engine. Meanwhile, the oil analysis detects the engine wear. Some contaminants found in the lubricating oil of the engine can indicate an early failure due to wearing.
3. Many developments have been made to make those two analyses to be more efficient, because up to now, the condition monitoring is rarely used due to the expensive cost of to build this system, although it can reduce the cost of break down maintenance and the unnecessary maintenance actions. Furthermore, this maintenance scheme can also save the time to do the spare part procurement. As we know that a DFDE is still rarely used in Indonesia. So, if an early fault has been detected and replacing a component is found to be the solution, then the spare part can be ordered and arrived in place before the main engine reaches its downtime condition.

## CONCLUSION AND FURTHER RESEARCH

The conclusion and further researches that can be carried based on these review article are:

1. The two operating conditions need to be considered as one of the basis parameter for the maintenance plan, as the components inside the engine are used in both operating conditions.
2. An online monitoring system can be set up based on this telemetry system. Those that are not in the ship can also monitor the main engine condition, such as the ship owner and the ship operator. Moreover, they can also give an addition opinion about the maintenance action that can be taken regarding the faulty main engine.

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