KnE Social Sciences
ICTSD 2018
International Conference on Technology for Sustainable Development 2018
Volume 2019

Conference Paper

The Performance Optimization of Main Engine Injector of MV. Sinar Papua

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Abstract

This study was aimed to analyze the performance optimization of the Main Engine injector in MV (Motor Vessel) Sinar Papua. This research used SWOT analysis (Strength, Weakness, Opportunity, and Threat) to formulate the exact strategy in optimizing the injector's performance. In this study, the data were obtained through questionnaire with random data collection method. Based on the research, the optimization strategy could be done through (1) improving the skill of the engineer in maintaining the injector of the main engine, and (2) establishing sanctions to those who do not carry out injector maintenance according to the procedure of the manual book.

Keywords: optimization strategy, performance, Main Engine injector, MV Sinar Papua

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Received: 20 July 2019
Accepted: 22 August 2019
Published: 29 August 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICTSD 2018 Conference Committee.

1. Introduction

International trade grows two or three times faster than the global GDP (Gross Domestic Product) and 80% of which are transported by sea. The exports and imports of most countries in the world, especially the developing countries, depend on the maritime transportation. However, since trade is liberalized through lower tariffs and quota, this shipping costs play an important role in global supply chains. Thus, determinant of international maritime transportation costs has become the focus of international trade and development analysis (Wilmsmeier, 2014).

The sea transportation, especially vessels, must be supported by a good machine performance, especially the main engine, on board. Moreover, in order to be able to run according to its respective functions, the main engine's performance needs to be supported by each component of the engine.

How to cite this article: Agus Tjahjono, Boedojo Wiwoho, and Saifudin Afandi, (2019), "The Performance Optimization of Main Engine Injector of MV. Sinar Papua" in *International Conference on Technology for Sustainable Development 2018*, KnE Social Sciences, pages 1–9. DOI 10.18502/kss.v3i23.5132

Among the other components found in the main engine, there is one component which is able to decrease the main engine power; it is the main engine injector. This component plays an important role in supporting the process of Diesel Motors' fogging and combustion. If one of these components does not work properly, the exhaust gas temperature will be affected that it will have high temperature and the power of the main engine will also decrease. Therefore, a maintenance or replacement must be carried out on the damaged component. Based on its manual book, the injector is able to run properly for about 2000 up to 3000 hours.

If the plunger barrel does not work properly because the density between the plunger and barrel is not properly installed and it has exceeded its normal working hours (between 200-3000 hours), the fuel pressure will decrease its initial pressure from 320 bars to 290 bars. Consequently, the quality of the fuel is lower because it contains a lot of water and sludge. The condition will affect the performance of the injector. The fuel cannot be completely revoked because the fuel nozzle is clogged due to its poor quality. Thus, new spare parts are needed.

The purpose of this study was to formulate a strategy in optimizing the performance of the main engine in MV (Motor Vessel) Sinar Papua.

2. Literature Review

The injector is functioned to spray the fuel into the combustion chamber. The nozzle consists of a nozzle body and needle. The fuel sprays the nozzle from pumping injection into the cylinder with a certain pressure in order to atomize the fuel evenly. Injection pump is a type of valve which works very precisely with a tolerance of 1/1000 mm. Therefore, if the nozzle needs to be replaced, both nozzle body and needles must also be replaced. Nozzle is then lubricated with the diesel fuel. The nozzle holder is functioned to retain the nut and the distance piece. Nozzle holder consists of adjusting washer which regulates the strength of spring pressure in order to determine the pressure to open the nozzle valve (Arifin, 2011).

Prior to the injection, the injector works when the high pressure fuel flows from the injection pump through the oil channel and the nozzle holder into the oil pool at the bottom of the nozzle body. When the fuel is injected, the fuel presses and the oil pool rises. This pressure will depress the tip of the needle surface. If this pressure exceeds the spring strength, the nozzle needle will be pushed up by the fuel pressure. Thus, the nozzle needle is released from the seat nozzle body. This condition leads the nozzle to spray the fuel into the combustion chamber.

At the injection end, if the injection pump stops flowing fuel, the material pressure will drop. It causes the pressure spring to return the nozzle needle to its original position. At this point, the needle is firmly pressed into the bodley nozzle seat and closes the fuel line. Some of the fuel will be left between the nozzle needle and the nozzle body, between the pin and the nozzle holder, etc., lubricate all components and then return to the overflow pipe. As described above, the nozzle needle and nozzle body form a type of valve to regulate the beginning and the end of the fuel injection with fuel pressure.

There are two methods of fuel spray: (1) indirect spraying and (2) direct spraying. In indirect spraying, the fuel is sprayed into the pre-combustion chamber which is separated in the main combustion chamber. The space has 25% -60% of the total volume of the combustion chamber. The injector is not placed in the combustion chamber, but there is one more room in the combustion chamber called the swirl chamber–a space where the injector is placed in the cylinder head. When the piston moves TDC (Top Dead Center), most of the air entering through the suction step will enter the Swirl Chamber and the combustion occurs inside it. The result of the combustion will become a source of power in the diesel engine. Meanwhile, in direct spraying, the injector or nozzle is placed directly inside (the top) of the combustion chamber. This direct injection system usually has a cylindrical head design to increase turbulence during combustion. High pressure fuels (in low speed motors up to 1000 bar and on medium round motors that work with fuel up to 1500 bars) are sprayed into a non-high combustion chamber. In this case, three large hollowed irons were used. The spraying system is directly applied to the low-rotation motor, to the medium-round motor and to the large part of the high-speed motor (Maleev, 1991).

According to the shape of the nozzle needle tip, there are two types of nozzle that are currently used: (1) the hole type and (2) the pin type. The hole type nozzle also consists of two types: (a) single hole and (b) multiple hole. The type of nozzle used is determined by the shape of the combustion chamber. In general, multiple hole type nozzle is used for direct combustion diesel motors while the pin type is used for indirect combustion diesel motor.

Pin type nozzle that is more widely used today is the throttle type that can prevent detonation in diesel motors and can save fuel consumption due to its gradual fuel removal. Indeed, throttle type sprays some amount of fuel into the room at the beginning, and the fuel amount increases at the end of the burning process.

3. Methods

A questionnaire was used as the data collection technique of this study, in which the respondents are given a set of questions or written statements (Sugiyono in Sujarweni, 2004: 156). Sujarweni (2015: 80) states that population is defined as the total number of objects or subjects which have certain characteristics and qualities the researcher is about to examine and from which he/she will draw conclusion. Questionnaires were given to the 8^{th} semester students of machine department in Semarang Merchant Marine Polytechnic (SMMP). There were 77 students as the respondents. They were divided into 3 classes. In order to determine the sample, the Slovin method was used. The formula is as follows:

$$n = \frac{N}{1 + \left(N \times e^2\right)}$$

where n = sample size, N = population, e = margin of error.

Samples were taken by using the Slovin formula with 95% confidence level, and error rate of 5%. Based on the formula, 95% of 77 students was 69 students, so they were taken as samples.

In this research, SWOT analysis was applied with the hope that it can help to systematically identify various factors for a better life. Rangkuti (2015:1) states that threats found from the environment are used to formulate the strategy.

4. Results and Discussions

In this research, SWOT matrix was used to compose the strategic factors applied by the vessels. This matrix can clearly describe how the external opportunities and threats faced by the vessel can be adjusted to their internal strengths and weaknesses, resulting in four alternative strategies.

The SWOT matrix is an important matching tool to develop the four types of strategies: (1) S-O strategy (strength-opportunities), a strategy that uses all the power we have to seize the opportunities; (2) S-T strategy (strength-threats), a strategy that minimizes the weaknesses to seize opportunities where there are many opportunities to achieve, but there are still a lot of weaknesses found which need to be minimized; (3) W-O strategy (weakness-opportunities), a strategy which uses all powers owned to overcome the threats; (4) W-T strategy (weakness-threats), a strategy that is prepared by minimizing weaknesses to avoid threats.

Table 1: Internal factors.

	Strengths	Weights
1	Engineers skills in handling injectors	9,9
2	Spare parts availability	7,65
3	Maintenance of injector in accordance with the instruction manual book	4,95
4	Engineer experience on board was in moderate level	5,1
5	Responsibility of the Engineer	6,8
	Weaknesses	Weights
1	The addition of operational costs **for** ships to complete the needs of injector spare parts	-8,8
2	Lack of technical instructions for injector maintenance procedure	-6,2
3	Lack od Engineer skills in the maintenance of injectors	-7,5
4	The absence of spare parts for injectors on board	-3,875
5	Lack of cooperation between Engineers on board	-4,8

Table 2: External factors.

	Opportunities	Weights
1	Giving extra fund for each injector treatment	7,8
2	Coaching cooperation with the provider of injector spare parts	6,6
3	Officer supervising the maintenance of injectors from Superintendent	7,5
4	Supply of injectro spare parts on time	4,8
5	Good quality injector parts	3,4
	Threats	Weights
1	Weak supervision from the company regarding the maintenance injectors	-8,7
2	The quality of injector spare parts supply is not in accordance with standard requirements	-8
3	The supply of injector spare parts is not on time	-5,425
4	The number of injector parts not original on the market	-3,75
5	The high price of injector parts	-4,65

After each SWOT indicator was determined, the next step was to formulate a strategy by combining S with O, W with O, S with T, and W with T (Rangkuti, 2015). This strategy formulation was to determine the position and priority strategy for optimizing the injector engine performance of MV Sinar Papua. Firstly, SO strategies which can be carried out include: 1) improving the supervision of engine performance in the main engine injector maintenance by direct Superintendent, and 2) enhancing the cooperative relationship with the main engine injector spare parts provider. On the other hand, WO strategies which can be formulated were 1) supply of spare parts for main engine injectors on board, and 2) socialization to the Engineer regarding the technical instructions for main engine injector maintenance procedures.

Meanwhile, ST strategies which can be formulated were 1) improving the quality of the main engine injector maintenance, and 2) giving strict sanctions to any engineer who does not carry out manual procedures of the main engine injector maintenance. Lastly, WT strategies which can be carried out were 1) giving strict sanctions to any engineer who does not carry out the manual procedures for the main engine injector maintenance, and 2) improving the supervision of engine performance in Superintendent direct maintenance of Main Engine injectors.

Table 3: Results of internal factor analysis.

	Strengths	Score	Rating	Score x rating
1	Engineers skills in handling injectors	3.6	2.75	9.9
2	Spare parts availability	3.4	2.25	7.65
3	Maintenance of injector is in accordance with the instruction manual book	3.3	1.5	4.95
4	Engineer experience on board was in moderate level	3.4	1.5	5.1
5	Responsibility of the Engineer	3.4	2	6.8
	Sub total	17.1	10	34.4
	Weaknesses	Score	Rating	Score x rating
1	The addition of operational costs for ships to complete the needs of injector spare parts	3.2	-2.75	-8.8
2	Lack of technical instructions for injector maintenance procedure	3.1	-2	-6.2
3	Lack of Engineer skills in the maintenance of injectors	3	-2.5	-7.5
4	The absence of spare parts for injectors on board	3.1	-1.25	-3.875
5	Lack of cooperation between Engineers on board	3.2	-1.5	-4.8
	Sub total	15.6	-10	-31.175
	Total			3.225

After calculating the weights and ratings on the indicators of internal and external factors, the coordinates (X, Y) where X = total value S + W = 34 + (- 31,175) = 3,225 and Y were calculated. The following calculation of the coordinates of the SWOT matrix included total value O + T = 30.1 + (- 30,525) = -0,425 whereas the point of the coordinates were (X = 3.225; Y = -0.425).

According to Rangkuti (2015), it can be seen that the map of organizational strength is in quadrant II (strengths-threats). It is a strategy which uses all power to overcome the threat that will occur (diversification strategy). This strategy improves the quality of the Engineer’s skills in maintaining the main engine injector. The strategy also includes strict sanctions to those who do not carry out the manual procedures of the main engine injector maintenance.

TABLE 4: Results of analysis of external factors.

	Opportunity	Score	Rating	Score x rating
1	Giving extra fund for each injector treatment	2.6	3	7.8
2	Coaching cooperation with the provider of injector spare parts	3.3	2	6.6
3	Officer supervising the maintenance of injectors from Superintendent	3	2.5	7.5
4	Supply of injector spare parts on time	3.2	1.5	4.8
5	Good quality injector parts	3.4	1	3.4
	Sub total	15.5	10	30.1
	Threats	Score	Rating	Score x rating
1	Weak supervision from the company regarding the maintenance injectors	2.9	-3	-8.7
2	The quality of injector spare parts supply is not in accordance with standard requirements	3.2	-2.5	-8
3	The supply of injector spare parts is not on time	3.1	-1.75	-5.425
4	The number of counterfeit injector parts at the market	3	-1.25	-3.75
5	The high price of injector parts	3.1	-1.5	-4.65
	Sub total	15.3	-10	-30.525
	Total			-0.425

Opportunities

Quadrant IV	Quadrant I
(*Weakness*)	(*Strengths*)
Quadrant III	Quadrant II

Threats

Figure 1: SWOT diagram optimization of the main engine injector performance

The skills of the engineers greatly affect the machine performance, the main engine injector. The engineer must have a strategy and working program in performing the main engine injector maintenance to optimize the injector performance. The strategy included (a) spare parts inventory in order to find out what parts are still needed. When the injector spare parts were finished, they were required to (b) prepare a report of supply request of spare parts; (c) perform maintenance procedures once a month according to the instruction on the manual book; (d) do an opening pressure test after working for 1000 hours whether its pressure is still at normal condition (320 bar) and is not dripping on the end of the injector nozzle after fogging process. When they were done, (e) shred at the end of the needle in order to increase the fogging; (f) replace the o-ring injector that has been damaged or not feasible, (g) replace the entire injector part if the injector's working hours have exceeded the manual book rule of 2000-3000 hours, and (h) collect data in each injector maintenance machine for evaluation before carrying out further maintenance.

In order to find out whether or not maintenance was carried out in the main engine injector, the main engine performance report can be checked including its gas temperature. The normal engine exhaust gas temperature is 400^0C. If it exceeds the normal limit, it will cause problems in the main engine injector. However, the report can be manipulated by the Engineer by making up the report. For example, the main engine's exhaust gas is normally made from cylinder number 1-8, but in reality there is a flue gas temperature that exceeds the normal limit of 400^0C. Therefore, the Superintendent must conduct a direct survey and monitoring by participating in sailing to ensure that the performance report is based on real condition. If the report is made up, then the Superintendent should immediately give strict sanctions to the Engineer. The first sanction of the first mistake is that the engineer would be reminded. However, if the mistake is repeated, the Engineer would be dismissed as he is regarded as incompetent in carrying out the duties and responsibilities as an Engineer on board.

These actions and sanctions will hopefully increase the engineers' seriousness in carrying out their duties properly and correctly, especially carrying out the maintenance for the main engine based on the instruction in the manual book to keep the main engine performing properly and efficiently.

5. Conclusion

Based on the SWOT analysis, the strategy that could be done was found in quadrant II which is the ST strategy. This strategy aims to improve the quality of the Engineer's skills in main engine injector maintenance. Moreover, strict sanctions are applied to the Engineer who does not properly carry out maintenance procedures. The results of the priority factors were obtained through SWOT analysis. Thus, the Second Engineer is expected to immediately apply the results on board so that the main engine injector can perform more efficiently.

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