RSF Conference Proceeding Series: Engineering and Technology, Vol. 3 No. 1 (2023)
https://doi.org/10.31098/cset.v3i1.733

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Research Paper

Enhancing Burner Efficiency on Marine Vessels: A SWOT Analysis Approach

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Received: Sept 1, 2023	Revised: Sept 19, 2023	Accepted: Sept 30, 2023	Online: Oct 5, 2023

Abstract

As the main heat source on board, the Thermal oil heater has a burner that is responsible for the combustion process. The burner has an important role in the operation of the Thermal oil heater. However, several problems were found in its operation, such as decreased performance and inefficient maintenance on the burner, which caused obstruction of ship operations and had an impact on company losses. This study aims to find a performance strategy for the burner to operate optimally. Based on the burner manual book found on the ship and the theory put forward by experts, This research is a qualitative study, using the SWOT method to analyze internal and external factors. To find out the cause of the decline in burner performance and also to find out the right maintenance management to prevent degradation of the burner. This research used observation, interviews, literature reviews, and documentation for data collection. Based on the author's observations using findings, manual books, and several related journals as data sources, he also interviewed several crew members as validators as well as for comparisons. This research concludes that by maximizing maintenance time and the accuracy of maintenance time according to the running hours in the manual book, The importance of maintenance has a significant influence on the optimization of the burner, but coordination with the maintenance team is also important.

Keywords *burner, manual book, thermal oil heater*

INTRODUCTION

Maritime transportation is a key element for global trade within the scope of cheaper, safer, and more environmentally friendly solutions. The capacity of commercial ships makes it possible to carry large amounts of cargo at lower transportation costs (Atak et al., 2023). The growth of the global merchant fleet over the past decades has increased rapidly, not only in the number of ships but also in tonnage, affecting maritime traffic, especially in nearby coastal areas, straits, and channels, causing traffic congestion and complexity (Moreno et al., 2022). Global transportation and economic savings However, in its application, there are often delays or disruptions that hamper the operational process of the ship, ranging from weather constraints to human factors to problems with machinery. It is also not uncommon for pollution to be one of the main obstacles to ship operations. Currently, in addition to petroleum and coal, one of the main energy sources is natural gas. Its abundance in nature, ease of transfer, good heating value, and low pollution attract worldwide attention (Mostafavi & Shirazi, 2020).

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Auxiliary machinery must be supported using fuel of good quality to improve the performance of diesel engines so they can run optimally and act as a support for the main engine. Such as diesel generators that produce electricity and boilers or thermal units as heat producers on board. Heat generators on board ships generally use thermal oil, which is useful in many applications and industries where high temperatures are required. As a heat generator on a thermal ship has a working system that is almost the same as a boiler, the difference is that a thermal ship does not produce steam. Thermal works by heating the oil in the vessel to produce heat, which will be used to heat the fuel on the ship.

Crude oil, as an important energy source, has been regarded as an important input in the process of economic growth. As a derived demand for international trade, the crude oil ocean shipping market serves international trade and reflects the development and trends of the international economic environment (Chen et al. 2019). Thermal oil heaters have several parts, including an expansion tank that functions for oil storage, a blower to provide air supply to the combustion chamber, a booster pump as a fuel supplier to the nozzle, and a burner to atomize the fuel and provide a spark that will burn the fuel.

The burner itself uses MDO fuel; there are several types, one of which is palm biodiesel. Palm biodiesel is free of sulfates and easy to use with existing equipment. Palm biodiesel has a higher flash point compared to diesel, for example. The burner itself is a crucial thermal component that must be considered for maintenance. One result of the lack of maintenance on the burner is the occurrence of a burner that fails to ignite, that is, the burner is unable to emit a fire so the thermal cannot operate.

Such things should be prevented by shipping companies with the need for regular maintenance and planned repairs to all machinery and equipment on board. Maintenance is a series of activities to ensure that facilities and machinery are always in prime condition to carry out production effectively according to a predetermined schedule. As a strategy to counteract damage to all buildings and infrastructure. Preventive maintenance procedures consist of simple actions that are continuous over time and are characterized by low costs that allow the profitable use of resources on a large number of assets (Salzano et al., 2023).

This study aims to determine the cause of the decline in burner performance on the thermal oil heater and the appropriate maintenance management to prevent degradation of the thermal oil heater burner, as well as the strategy for optimizing burner performance on the thermal oil heater.

LITERATURE REVIEW

A thermal oil heater is one of the auxiliary machines that has a high-temperature and high-pressure oil heating function. The process of heating oil to high pressure and temperature can occur by heating the oil using fuel inside the thermal oil heater. By utilizing hot gas from fuel combustion oil. Combustion is carried out continuously in the combustion chamber by flowing fuel and air from outside.

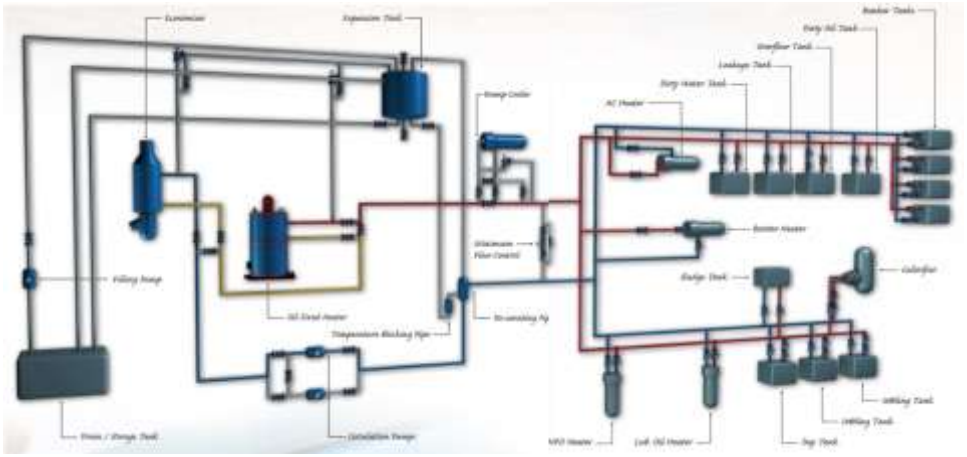

Figure 1. System thermal oil heater
(Source: Manual Book Aalborg Industries, 2008)

The burner used in an oil-fired boiler generally consists of an oil gun, an air register, and some auxiliary equipment, such as ignition equipment, etc. Oil is injected through the oil gun. It is atomized into droplets and then burned in the fireplace.

Figure 2. Thermal Oil Heater
(Source: Manual Book Aalborg Industries, 2008)

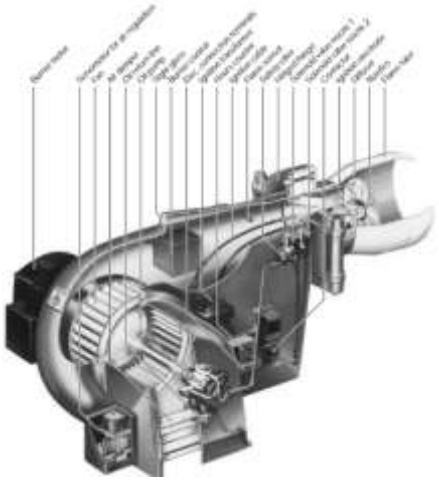

Figure 3 Burner
(Source: Manual Book Aalborg Industries, 2008)

The tip of the oil gun is its main component and is known as the atomizer. The atomizer plays a decisive role in the quality of atomization. Combustion air is injected through the air register in such a way that it provides the best combustion conditions for the atomized oil spray. The main determining factors for good combustion in an oil-fired boiler are both. atomization quality and free air supply. In this section, the principles of the operation, construction, and calculation of oil atomizers are discussed. Air is supplied through the air register, continued by the oil enters the furnace through the atomizer and breaks into droplets. Good atomization quality is a basic requirement of good combustion. The finer the atomized oil droplets, the faster they burn.

The burner has several important components, namely the blower, fuel supply pump, nozzle, electrode, flame sensor, combustion chamber, and safety devices. The blower is a component used to provide the required airflow for combustion. Sufficient air must be mixed with the fuel for efficient combustion to occur. The fuel supply pump is the part that carries the fuel to the burner. The nozzle is the part where fuel and air are mixed in the right proportions before burning, nozzle design is important to ensure good and efficient combustion. An electrode is a component that produces an electric spark or a small fire to burn a mixture of fuel and air that comes out of the nozzle at first. It's important to start the combustion process. Flame sensor is used to detect the presence and stability of fire, if the fire dies or becomes unstable, this sensor will give feedback to the control system to take necessary action. The combustion chamber is the area where the fuel and air mixture burns. The design quality of this chamber will affect combustion efficiency and heat yield. Safety device burners on Thermal are usually equipped with various safety systems such as automatic shutdown if problems are detected on combustion, excessive pressure, or very high temperatures.

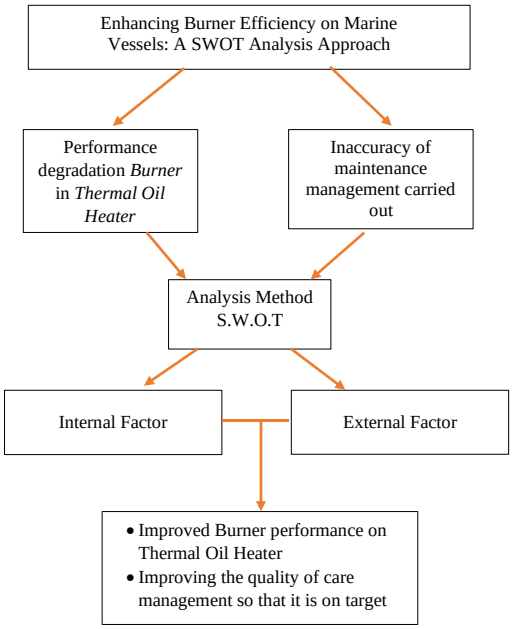

Figure 4. Research framework

METHODOLOGY

Research Method

In this research, the author used a descriptive-qualitative method. This research aims to provide a systematic, accurate, and actual description by sample data from the population obtained correctly. Researchers conducted this research process for approximately 12 months on the ship, from August 10th, 2021, to August 13, 2022. The researcher conducted interviews with the crew related to the topic of this research and literature studies in the VII and VIII semesters conducted at the Semarang

Merchant Marine Polytechnic.

The research instruments used by the author include interviews, observation, and documentation. Observation instruments are research conducted by researchers when practicing sea work on board ships. This research was carried out for approximately 12 months by researching and observing the object of research to find out the work system's maintenance. documentation instrument, which includes documents or even photos or videos as evidence that the data provided is valid, such as photos of machinery repairs on board and work completion documents. And the last is Interview, The Chief Engineer and the 1st Engineer were both considered worthy because they had been in the field long enough to be called experts, as well as active practitioners who were active in this field of research. The Chief Engineer himself has sailed for more than 20 years on the ship. He has taken the highest marine education, so he gets the title of a master marine engineer. The 1st Engineer has also sailed for more than 10 years on board and has sufficient experience with burners. By describing the document so that it can be understood. Researchers use ski-native data analysis techniques with a problem approach method or SWOT (Strength, Weakness, Opportunity, Threats) tool. According to Rangkuti (2008: 18), SWOT analysis is the systematic identification of various factors to formulate a company strategy. SWOT analysis consists of elements of S (strength), W (weakness), O (opportunity), and T (threats).

FINDINGS AND DISCUSSION

Table 1. Crew interview results

Problem	• Rare electrode spare parts • Hectic ship operations make maintenance difficult on machinery	• low fuel pressure, not up to what is required. • carbon accumulated at the electrode tip makes ignition failure
Solving	• contacted the shore base for spare parts on the ship to be completed immediately • perform maximum maintenance when the ship is at anchor	• check the strainer filter and clean it regularly • perform routine maintenance and checking of each part of the electrode

Source: Author Analysis

On December 5, 2021, the ship arrived at the Tanjung Wangi anchorage area after maneuvering. The main engine was offline, and the exhaust gas from the economizer couldn't be used for heating. Attempting to operate the thermal oil heater, the IV Engineer encountered a "miss fire" alarm indicating a failure to ignite the combustion chamber. Despite several reset attempts, the issue persisted. Subsequent investigation revealed that the electrode gap of the burner wasn't as per the manual. After readjusting and reinstalling it, the problem persisted. Further inspection revealed carbon residue hindering the electrode's ignition process. Cleaning the electrode's tip restored the burner to normal operation. This incident underscores the significance of regular maintenance and equipment checks onboard ships.

On Thursday, December 23, 2021, while the ship was in Tuban, it proceeded directly to the Single Buoy Mooring (SBM) area at TPPI Tuban for cargo loading after completing maneuvering upon arrival from Banyuwangi. However, upon restarting the Thermal Oil Heater (TOH) and deactivating the economizer, an issue arose with the burner. The expected fuel pressure of 2.5 bar and atomizing pressure of 27 bar couldn't be achieved; the atomizing pressure only reached around 15–18 bar. Engineer IV promptly conducted maintenance on the fuel filter, discovering a blockage in it. After cleaning the fuel filter, the burner was restarted. The pressure rose back to 27 bar, enabling ignition and the resumption of burner operation.

Figure 5. Cleaning and adjusting space between electrode

Figure 6. Cleaning strainer filter burner

Following the interview result and several related findings and articles, the author separates several factors according to the SWOT indicator.

Table 1. SWOT indicator

No	**Strength**
1	Work well before expiration
2	Burner understanding
3	Maintenance according to working hours
4	Other auxiliary machinery in good performance
No	**Weakness**
1	Flame eye gets dirty easily
2	Blockage of the stainer
3	Rare electrode spare parts
4	Distance between electrodes that are easy to move
No	***Opportunity***
1	Inspectors routinely check MSL availability
2	Short voyage facilitates spare part delivery
3	Good quality of spare parts
4	DPA who is easy to contact
No	***Threats***
1	Lack of spare parts on board
2	Short voyage complicates maintenance time
3	The spare part request process takes time
4	Low fuel quality

Based on observations made by researchers on the ship, it can be formulated for internal factors as follows: a) Dirty flame eye sensor, resulting in the burner sounding the flame failure alarm. The flame eye sensor very easy to get dirty, although problem solving is relatively fast. Of course, this can interfere with the ship's operational activities. Time that should be used to perform

maintenance on other machinery will be consumed to simply clean the sensor on the flame eye. b) Blockage of the strainer: the fuel filter on the burner has a function to filter the fuel before entering the atomizer. The clogging of this filter results in a decrease in fuel pressure so that the combustion fire does not appear, results in combustion failure in the combustion chamber, and triggers a missed fire alarm. c) Distance between electrodes that easily move, vibration, or vibration caused by the operation of each piece of machinery on board has a negative impact on some machinery, especially burners. Excessive vibration makes the bolt bonds that bind the electrodes decrease in strength. Make the electrode loose and change the ideal position of the electrode. d) Rare electrode spare parts: the scarcity of spare parts on board is always a problem. The absence of spare parts finally forces the ship to use makeshift spare parts, even though it can decrease the performance of the machinery.

Meanwhile, when examined with factors outside the ship, researchers formulated several factors causing the decline in burner performance as follows: a) lack of spare parts on board; lack of attention from the shore base resulted in limited stock of spare parts, thus disrupting the engine replacement process. The disruption of the running hours of a spare part will greatly affect the performance of the engine. b) A short voyage complicates maintenance time, which is what the crew feels on MT. Pagerungan is the speed of the ship's operation. Continuous ship operations take up time for machinery maintenance. The impact is that many problems are found in the engine, especially the burner, which should have been anticipated with routine maintenance. c) The spare part request process takes time. If there is sudden damage to an engine, the availability of spare parts is a top priority, but often the spare part request process takes a long time, sometimes months. While the condition of the engine is deteriorating, it will get worse over time due to the long waiting time for spare part requests. d) Low fuel quality: cleaning the fuel filter is part of engine maintenance; the result of not carrying out this activity is a clogged filter, which results in a decrease in pressure in the engine.

In this case, if the burner filter experiences repeated blockages, the quality of the fuel used is certainly low. Fuel quality in general can be seen from the sulfur content and specific gravity. If the fuel has a high sulfur content, then in the combustion process it will leave a lot of residual combustion emissions that can cause dirt to crust in the combustion chamber and other machinery. The specific gravity of fuel can affect the quality of fuel because it can affect engine performance. Fuels with a lower specific gravity tend to be lighter, while fuels with a higher specific gravity tend to be heavier.

Burner fuels can provide better engine performance because they are easier to atomize and leave less debris in the fuel filter. Conversely, heavier fuels tend to be more difficult to atomize and burn more slowly, which can affect engine performance and also leave residual impurities in the filter that result in clogging or blockage of the burner. If the above things are still ignored due to a situation, it is feared that degradation of the burner will occur, resulting in something undesirable. Burners that experience a decrease in performance can affect the performance of the thermal oil heater. The heat generated will require more fuel to reach the desired temperature. The fuel used to maintain a stable combustion temperature will be more wasteful and have an impact on fuel inefficiency. Poor-quality fuel also has serious effects, such as fire instability, which can result in fire.

Proper maintenance management is needed to prevent the degradation of the thermal oil heater burner. Proper maintenance management can help prevent the degradation of the thermal oil heater burner. Based on observations made by researchers on the ship, the machinists gave a technical description of the maintenance on the burner. There are several ways to perform proper maintenance on the thermal oil heater burner, as follows: a) Performing regular burner maintenance: the burner must be cleaned regularly to avoid the accumulation of dust and dirt that can interfere with the combustion process. Cleaning the burner can also help prevent corrosion of the metallic parts on the burner. Maintenance should be carried out by the manual book guidelines on board.

Sometimes maintenance that is too frequent will hurt the machinery itself. So the manual book should be used as a reference for maintenance guidelines. b) Replacing parts that have passed their running hours: some parts on the burner can experience wear over time to the running hours written in the manual book. Regular replacement of worn parts, such as nozzles and electrodes, can help prevent degradation of the burner. c) Checking fuel quality: poor fuel quality can affect burner performance and accelerate degradation. Checking the fuel quality regularly and ensuring that the fuel used is in line with the manufacturer's recommended specifications can help prevent burner degradation. A step that can be taken to check fuel quality is to routinely send fuel samples to the shore base, where they will be tested in a trusted laboratory. d) Perform regular preventive maintenance: Performing preventive maintenance on the burner regularly can help prevent burner degradation. Preventive maintenance can include checks and repairs carried out at certain times, such as fuel filter replacement. The main purpose of preventive maintenance is to take precautions to extend the life of the engine.

Based on previous research conducted by Relly in 2018 with the titles Analysis of the Effect of Circulating Pump and Buner on Thermal Oil Heater Performance (with SPSS method) and Thermal Oil Heater Performance Optimization Strategy (with SWOT method) on the MT. Sei Pakning Ship, different results were obtained in determining the strategy, where the strategy determined by this previous researcher was the SO strategy. Although more focused on the thermal oil heater, the SO strategy taken is related to the burner. The strategic result of this research is to carry out targeted maintenance in an efficient and planned manner. Maintenance is differentiated according to maintenance time: daily, weekly, quarterly, and annual maintenance. Some maintenance strategies have similarities, such as adjusting the electrode distance, cleaning the burner from dust and dirt, and cleaning the filter in the burner. Previous research has found several similarities in determining strategies, especially in maintenance, while other strategies are more directed toward optimizing the thermal oil heater. The conclusion that can be drawn from the similarities between the two studies is to strengthen the efficiency of the strategy in terms of maintenance. Differences in existing strategies can be caused by differences in research focus.

CONCLUSION AND FURTHER RESEARCH

Causes of decreased burner performance on thermal oil heaters. Decreased burner performance in thermal oil heaters can be caused by internal and external factors. Internal factors include dirty flame eye sensors, blockages in strainers, the distance between electrodes that easily move, and the scarcity of electrode spare parts. While external factors include a lack of spare parts on board, a short voyage, which complicates maintenance time, a spare part request process that takes time, and low fuel quality, All these factors are interrelated and can create a complex correlation, which in turn can disrupt ship operations and affect the performance of machinery.

Proper maintenance management is needed to prevent the degradation of the thermal oil heater burner. Proper maintenance management of the thermal oil heater burner can prevent degradation and extend its service life. Some of the proper maintenance methods include periodic cleaning, replacement of worn parts, checking fuel quality, and regular preventive maintenance. Manual book guidelines must be used as a reference for maintenance guidelines, but maintenance that is too frequent can have a negative impact on machinery. Performing proper maintenance regularly can prevent the degradation of the thermal oil heater burner.

Burner performance optimization strategy on thermal oil heaters Researchers conducted a performance optimization strategy on the thermal oil heater using the SWOT method, namely by distributing questionnaires to respondents. Respondents fill in each indicator value that gives weight to the assessment according to what they experience on their respective ships. The recapitulation results lead to quadrant III coordinates for the W-T strategy. The W-T strategy is to optimize maintenance time on ships with short shipping routes, and every maintenance carried out

must be made sure to be right on target according to running hours.

Some limitations were found during the research-space limitations; the ship had limited space to accommodate research tools and equipment, which can limit the types of research that can be conducted. limit the type of research that can be conducted. Researchers can only access certain locations, so the research location can be limited and cannot cover a wider area. There is a lack of research time on the ship due to tight schedules or limited operating time at sea, so research must be done with limited time constraints. conducted with limited time constraints

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