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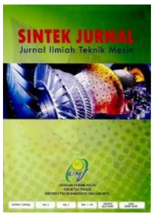

ENERGY SAVING ANALYSIS USING BURNER /THERMAL TANK AND HEATER ELECTRIC IN THE MARINE FUEL OIL (MFO) TREATMENT PROCESS

S.A. Kartika[1,*], N.H. Abdullah[1], P. Saksono[1]
[1]Mechanical Engienering Study Program, Faculty of Industrial Technology, Universitas Balikpapan,
Jln. Pupuk Raya, Gn. Bahagia, Balikpapan Selatan, Kota Balikpapan, Kalimantan Timur, 76114

*E-mail: siska.ayukartika@uniba-bpn.ac.id

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ABSTRACT

Energy savings in Diesel Power Plants (PLTD) have been carried out by comparing the Marine Fuel Oil (MFO) processing process when using a burner/thermal tank and an electric heater. Energy savings are analyzed in this study by calculating the comparison of operational costs, cost efficiency and processing time. The place of research was carried out in one of the Diesel Power Plants in Indonesia, with the object of research being an electric heater and a burner/thermal tank. The research method used quantitative methods in the form of literature study, observation, and field testing. The research was conducted by collecting data on temperature, humidity, and fuel consumption when testing the MFO treatment every 1 hour until the specified temperature was reached 94-96°C. Based on the research results, the processing of MFO using a burner/thermal tank is more efficient in terms of time at the beginning of processing, with a savings of 17.2% and in terms of operational costs more efficient 11.67%. However, after the process continued for 7 days, MFO processing using an electric heater was more efficient in terms of operating costs by 31.87%.

Keywords: heater electric; burner/thermal tank; efficiency; energy saving

1. INTRODUCTION

Electrical energy is one of the supporting factors that are very important for the overall development of an area. The need for electrical energy is inevitable in modern human life and it will even continue to increase due to the increasing population of the world and the emergence of new industries. This poses a challenge to electricity producers to be more competitive and efficient in producing electrical energy. Diesel Power Plant is one of the generating units that contribute electricity supply to the Kalimantan area. As a research place, this Diesel Power Plant (PLTD) with a capacity of 5x3 MW (SWD 9 TM 410RR) which operates using 2 types of fuel, namely High-Speed Diesel (HSD) / Light Fuel Oil, Marine Fuel Oil (MFO) / Heavy Fuel Oil.

Marine Fuel Oil (MFO) is a fuel oil that is not a product of distillation, but the result of a residue type which is black. This type of oil has a high viscosity level compared to diesel oil. So that the use of MFO as a fuel cannot be applied directly but must go through a treatment process that aims to reduce viscosity and uniformity of fuel particle size (to avoid blockages in the injector nozzle) [1].

The MFO treatment process to heat the current tank service can be done in 2 ways, by using an electric heater and burner/thermal tank. Electric heaters use electricity as the primary energy to operate and run circulation pumps. Burner uses electricity to run pumps and High-Speed Diesel (HSD) as the main fuel fueled in the burner / thermal tank to heat thermal oil.

Based on the background above, it is necessary to do the research to analyze in terms of operational cost, and processing time between using an electric heater and a thermal tank burner. The problem of this research was which one saving more between operational cost and processing time using an electric heater and a burner / thermal tank in MFO treatment. So that the research purposes were 1) to calculate and determine the amount of comparison of operational costs and processing time using an electric heater and a burner / thermal tank on MFO treatment process; 2) to determine whether heater electric or burner/thermal tank which is the most efficient.

There were some limitations of the problem in this research and also as the scope of this research, as follows: data collection was taken from the MFO temperature in the initial tank service 27-30 °C until the MFO temperature reaches 94-96 °C. Data collection using electric heater and burner / thermal tank was done every 1 hour until the MFO temperature in the tank service reached 94-96 °C. The processing of research data was carried out with an operating scheme of up to 7 days for each tool tested. For comparison using the data of the optimization cost and the time needed until the temperature was reached.

Some of previous relevant research, stated that energy is a basic human need, which continues to increase in line with his life rate. Fuel oil / fossil energy is one of the most renewable energy sources (Non-Renewable *Energy Sources)* which has been mainstay to meet energy needs throughout the activity sector. The wealth of energy sources in Indonesia, namely *hydropower*, geothermal, natural gas, coal, peat, biomass, biogas, wind, marine energy, solar and others can be used as alternative energy, replacing the dependence on fuel oil, which is increasingly limited both in number and reserve. Fuel oil holds a very dominant position in the fulfillment of energy needs in the country. The energy crisis that hit the world has an impact, the high price of world crude oil, directly affects economic activity. The wealth of energy resources, especially the new and renewable energy sources that we have, needs to be considered as alternative energy replacing and reducing the role of fuel oil in energy consumption in Indonesia [2].

As stated by Sunardi et.al., the research was a study entitled Comparison of Energy Prices from Renewable and Fossil Energy Sources. Comparison of energy prices from new, renewable, and fossil energy sources. Low-cost transportation for people and goods is essential to the economic health of the nation. Until now if the price of oil rises, the cost of automatic transportation will follow, and some people suffer from soaring prices of food and other goods. Almost 100 percent of Indonesia's transportation energy needs are supported by oil. While costs in the energy sector are primarily electricity, in developed countries that also play a significant role in supporting transportation, it is much more stable and predictable. Energy needs are so high in the transportation sector tend to force humans to strive for energy sources and means in other forms such as electricity or hydrogen that can match or exceed the performance of fuel oil. The paper aims to analyze economic comparisons of energy prices from renewable energy and fossil sources to see the extent to which economic opportunities of some types of energy can play a significant role in the transportation sector and the subsequent impact in energy systems. The methodology used is a library search and calculations directly on related materials or energies. From the results of the analysis obtained that it will increasingly be needed the role of nuclear energy and certain other energies as a source of electrical energy weighing the economic aspects are relatively better [3].

Heat transfer can be defined as the transfer of energy from one region to another as a result of the difference in temperature between those areas from higher fluid temperatures to other fluids that have lower temperatures [4].

Heat transfer is generally divided into three different ways of heat transfer: *conduction*, convection, and radiation. Conduction heat transfer is the process of heat transfer in which heat flows from a high-temperature area to a low-temperature area in a medium (solid, liquid or gas) or between different mediums that intersect directly so that there is an exchange of momentum energy. In conduction heat flow, the transfer of energy occurs due to direct molecular connections in the absence of a large enough molecular exposure. Conduction is the only mechanism heat can flow in a solid that is not translucent. Conduction is very important in fluids, but in non-solid mediums it is usually combined with convection, and in some ways also with radiation.

Convection heat transfer is an energy *transport* process with the combined work of heat conduction, storage, and mixing motion. Convection is very important as a mechanism of energy transfer between the surface of solid objects and liquids or gases.

Convection heat transfer can be clarified into two types according to the way it flows, namely *free convection* and forced *convection.* Free convection is heat transfer caused by different temperatures and tight differences only and there is no outside energy to push it. Free convection can occur because there is a flowing current due to buoyancy, while buoyancy forces occur because there is a difference in fluid density without being affected by forces from outside the system. The difference in fluid density occurs due to the gradient temperature in the fluid. Examples of free convection include the flow of fluids that cross hot radiators.

Forced convection is the heat transfer of gas or liquid flow caused by the presence of energy from the outside. Forced convection can also occur because the fluid current that occurs is driven by a mechanical equipment (example: pumps and mixers), so fluid current does not only depend on the difference in density. Examples of heat transfer by forced convection there is a hot plate blown air with a fan / blower.

Radiation heat transfer is the process of flowing heat from high-temperature objects to low temperatures where each object is in the same space, even if there is a vacuum between them.

Heat transfer radiation can be emitted by both solid, liquid, and gaseous materials. This mechanism of heat transfer by radiation is associated with changes in the electron configuration of atoms or molecules of the material that is connected. Furthermore, this radiation energy field is emitted as electromagnetic waves. So radiation heat transfer does not require media such as conduction heat transfer and convection.

Heater functions to heat liquid or steam using steam or other heating media. Electric heaters are widely used in everyday life, both in households and industrial equipment and machines. The shapes and types of electric heaters vary depending on the function of the place of installation and the media to be heated. The heat generated from this electric heater comes from a wire or tape with high electrical resistance (Resistant Wire). Usually the material used is nickel which is electrified at both ends and covered by an electrical insulator that is able to transmit heat properly so that it is safe to use. There are 2 main types of electric heating elements, namely: [5]

1. Basic Forms of Electric Heating Elements, namely heating elements where the resistant wire is only coated by an electric insulator, the various types of heating elements of this form are:

a. Coil Heater, its open shape is not covered by an insulator or a sleeve pipe. Suitable for heating air, the heat generated is directly transferred to the surrounding air. The installation of this heater uses a support (handle holder) with good electrical insulating material and high heat resistance.
b. Infra, this type of heater is used as a radiation source, where the ceramic coating surface functions as a reflector. This type of heater is widely used to heat objects that result in a shiny surface such as drying the results of painting or coloring, making foam, drying screen printing results etc.
c. Quartz, this type of heater has a heating element rolled over a ceramic rod, so that the two terminals are on one side, then this coil is inserted into a tube made of quartz

(silica) with a milky white color and the tube is covered with a layer of perforated PVC pipe which functions as a quartz protection from collisions with other objects when immersed in the liquid to be heated.

2. Advanced Form Electric Heating Element, is a heating element of the basic shape which is covered by a pipe or sheet metal plate as an adjustment to the use of the heating element. Metal materials commonly used are: mild steel, stainless steel, copper and brass. This shape heating element is:

a. Tubular, this heater has the most forms, but can be classified according to its use, namely: standard straight tubular heaters, U form, W form, multiform or over the side heaters which are used to heat air or liquids.
b. Cartridge, in the form of a tube that can be inserted into the hole. The cartridge consists of a resistance coil wound around a ceramic core which is surrounded by a dielectric and encased in a metal sheath.

Meanwhile, a thermal oil heater is an auxiliary aircraft for generating heat power by using a synthetic oil fluid (thermal oil fluid) as a heat-conducting medium where the oil is heated and then circulated to the system. The construction of the thermal oil heater itself is a burner, coil pipes, economizer, and a thermal oil heater circulation pump. The working principle is that the burner burns fuel in the furnace, from the fuel combustion process it produces heat which is then absorbed by the thermal oil fluid which is in the coil pipes capable of heating the thermal oil fluid around 300 °C, then circulated by a circulation pump to heat up. [6]

Efficiency is a measure of comparing input usage plans with realized use or other words of actual use. Efficiency assumes that the right goals have been determined and strives to find the best ways to achieve those goals. Efficiency can only be evaluated by relative assessments, comparing inputs and outputs received. The best comparison between an activity and its results. So it takes 2 (two) elements, namely the activities and the results of these activities. So that success can be assessed in terms of the amount of resources / costs to achieve the results of the activities carried out. To calculate efficiency can be determined by the following equation [7]:

$$\eta = \frac{X_1 - X_2}{X_1} \text{ x } 100\ \% \qquad (1)$$

Where: η = Efficiency
X_1 = Total time or cost (testing 1)
X_2 = Total time or cost (testing 2)

Efficiency has several types The following are 3 Types of efficiency : 1) Optimal Efficiency is the best comparison between the sacrifices made and the results obtained in accordance with what is expected, 2) Benchmark efficiency is a comparison between the minimum results that have been predetermined and the real results achieved, 3) Efficiency with break-even is a type of efficiency that is often used in various fields of business, where *breakeven point* is the boundary point between efficient and inefficient business.

Marine Fuel Oil (MFO) is a petroleum refining product where it is produced after residue and before asphalt, MFO is not a distillation product but the result of a type of residue that is pitch black. This type of oil has a high viscosity level compared to diesel or other types of oil. The use of MFO is generally for direct combustion in large industries and is used as a fuel steam power *station*, a factory for *boiler* engine fuel and shipping. In terms of the function of the difference between MFO and other oils lies in the shape and manufacturing process, with such a dense shape, for its use MFO must be heated first in order to be pumped and injected. While in terms of economy the use of MFO is cheaper than solar [8].

Some of the properties of MFO that must be fulfilled include:

a. Nature of stability
Testing is conducted by *testing density* at 15°C based on ASTMD 1298. This test is done to avoid the occurrence of clumping that can result in disruption of combustion stability and cause a decrease in the efficiency of this fuel consumption.
b. Viscosity
The test was conducted with *kinematic viscosity* at 50°C based on ASTM D 445. This viscosity is related to the ease or

absence of fuel flowed through the pipe when used as diesel engine fuel.

c. Corrosiveness
Corrosive occurs during the use of fuel in the combustion engine, which is caused by a change in sulfur content that turns into oxides that then mix with water and condense into acids. Testing of this corrosive nature is done with *sulfur content* testing based on ASTM D 2662.

d. Nature of Cleanliness
Cleanliness is very important in the manufacturing process, contamination in the MFO manufacturing process can affect the quality and quality of fuel. For example, charcoal and sediment contamination can cause crust formation in *the noozle injector* and interfere with the combustion process. While contamination by water causes no maximum combustion process when used.

The magnitude of electrical energy depends on the difference in potential value (voltage), resistance, and electric current. The length of time the use of electrical energy will also affect the amount of electrical energy. To find total electricity usage can be determined by the following equation [9]:

$$W = P \cdot t \qquad (2)$$

Where:
W = electrical energy (kWh)
P = electric power (Watt)
t = time (second)

One of operational cost is the cost of fuel consumption, electricity usage, *thermal* oil use used in *the MFO treatment* process can be determined by the following equation [10]:

Electricity Consumption Cost = kWh x Electricity Unit Tariff (3)

HSD Operating Expenses = FC x HSD Price per liter (4)

Thermal Oil Operating Expense = LC x Thermal Oil Price per liter (5)

Figure 1. Heater Electric

2. METHODS

The research object is focused on analyzing the comparative use of electric heaters and burners / thermal tanks in marine fuel oil (MFO) treatment systems. Design of heater electric as shown in figure 1, and design of burner/thermal tank system as shown in figure 2.

Table 1. Name Plate Heater Electric [10]

MFO Heater	
Capacity	30 KW
Volt/PH/Hz	380/3/50
No. Of Heating Elements	9
No. Of Bundles	1
Maximum Temperature	200°C
Maximum Flow	
Alpha Omega *Heat Transfer Engineering*	

Figure 2. *Burner / Thermal Tank*

Table 2. Name Plate Burner/Thermal Tank[6]

TALAND THERMAL

Type	*Oil Heaher*
Type	600 VDC
Energy Out Put	600.000 k.Cal/h
Vol Flow Min	13000 Ltr/H
ΔP Min @1_CST	10 mCL
Δ T Max	65°C
Elektrical	380V/50 Hz *With Neural*
No. Machine	19510061 AI
Year	2007
Made in	Indonesia

The implementation of this research and observation took place at the Diesel Power Plant (PLTD) in Balikpapan with a unit capacity of 5x3 MW. The time of the research was carried out in January - April 2021. The research object was focused on a comparative analysis of the use of electric heaters and burner/thermal tanks in marine fuel oil (MFO) processing systems.

The tools and materials used in data collection consist of:

1. Controller, which functions to utilize the help of various kinds of sensors as input, such as a temperature sensor which will then be processed by the control unit to give commands to the system. In this study temperature control was used to monitor temperature parameters and to set maximum and minimum temperature limits in electric heaters with burner/thermal tanks.
2. Flowmeter, a tool used to detect the presence of a material flow (liquid, gas, powder) in a flow path, with all aspects of the flow itself, which includes flow velocity or flow rate and the total mass or volume of material flowing over a period certain time.
3. Log Sheet, a collection of records or information summarized in a table which is done by recording all the treatment of equipment when working.
4. Digital Hygrometer Thermometer, a device for measuring humidity and temperature levels in a place or environment.

The research procedure in this study begins with operating the electric heater (heater electric) as seen in figure 1 and the burner/thermal tank as seen in figure 2. Then record the data retrieval of operating time, electricity consumption, fuel, and thermal oil. Next, enter the data needed to calculate the efficiency of the electric heater and burner/thermal tank, such as data collection on operating time, amount of electricity usage, amount of HSD usage, and amount of thermal oil usage.

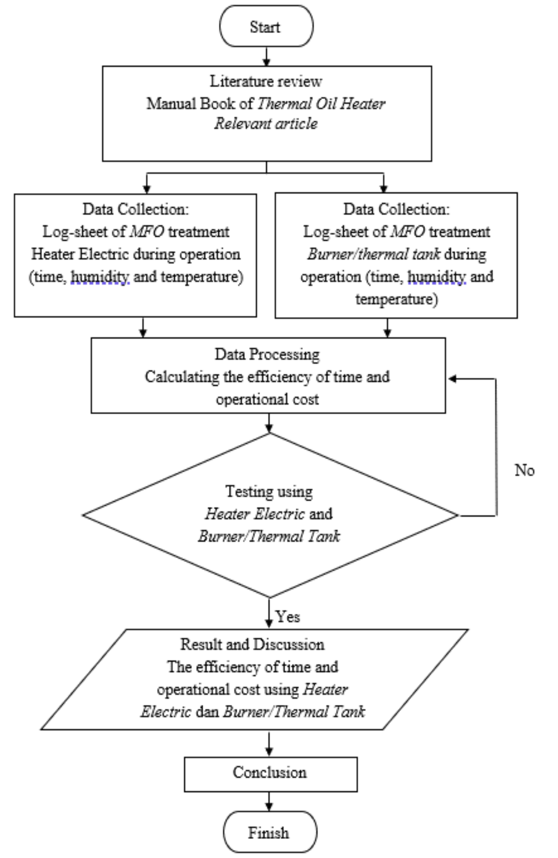

Figure 3. Research Flow Chart

The methodology of research considers for energy calculation and economic evaluation. The research variables used include independent variables/causative variables, which are variables that affect changes in other variables. In this study, the independent variable was comparing the operation and observation time of the Marine Fuel Oil (MFO) processing system using an electric heater and a burner/thermal tank. While the dependent variable/dependent variable is a variable that is influenced by the independent variables that have been determined, so in this study the dependent variable is energy saving, cost efficiency and processing time of Marine Fuel Oil (MFO) using an Electric Heater with a Thermal Tank Burner. Control variable, is a variable that is kept constant so that the dependent variable appears not because of other variables. The control variables in this study were the test temperature reaching 94-96°C, the temperature of the test room and the MFO tank service environment ± 24-34°C, and the humidity of ± 60-96%. Research flow chart as seen in Figure 3.

3. RESULT AND DISCUSSION

Based on the results of testing the electric heater in test 1, it was obtained from the results during the test with an initial temperature of 28.5°C until it reached a temperature of 94.9°C in the service tank at the 20 ton level, by recording the log sheet once every 1 hour (as seen in table 1) and in test 2 it was found from the results during the test with an initial temperature of 27.2°C until it reaches a temperature of 94.3°C in the service tank at the level of 20 tons, recording the log sheet once every 1 hour (as seen in table 2). So from tests 1 and 2, it is known that the heater was working automatically, where when the heater temperature reaches 100°C heater tubes 2 and 3 will stop and tube 1 operates. Then when the heater temperature drops to 97°C, heater tubes 2 and 3 will return to operation, so that the results are obtained as shown in tables 3 and 4.

Table 1. Test 1 - Heater Electric Operation from 28,5°C-94,9°C

No	Hour	Temperature(°C)				Humidity (%)	
		Heater	*Service Tank*	*Heater Room*	*Service Tank Area*	*Heater Room*	*Service Tank Area*
1	8:00	28,0	28,5	27,5	27, 1	84	84
2	9:00	58,3	38,9	28,3	28,0	84	84
3	10:00	59,6	50,2	29,1	29,0	81	82
4	11:00	61,0	54,3	29,3	29,3	81	81
5	12:00	63,4	56,9	31,0	31,0	78	78
6	13:00	64,7	58,3	31,9	32,0	73	74
7	14:00	66,1	60,7	32,7	32,9	69	70
8	15:00	68,9	62,5	33,4	33,1	60	59
9	16:00	71,5	64,1	32,0	32,0	64	65
10	17:00	73,3	66,5	30,1	30,0	68	68
11	18:00	75,9	68,1	29,7	29,1	71	70
12	19:00	77,4	70,0	28,3	28,0	76	77
13	20:00	78,5	71,9	27,9	27,6	81	82
14	21:00	80,3	73,8	27,8	26,4	84	88
15	22:00	81,7	75,0	26,5	26,4	86	88
16	23:00	82,4	76,2	27,2	27,0	88	91
17	0:00	83,8	77,7	26,1	25,7	90	88
18	1:00	84,2	79,2	25,9	25,5	88	88
19	2:00	85,7	80,4	26,1	25,0	86	90
20	3:00	86,1	81,9	26,0	25,9	88	91
21	4:00	86,9	83,7	25,8	25,6	88	92
22	5:00	88,8	85,1	25,2	24,6	89	95
23	6:00	90,0	86,8	26,5	26,0	87	91
24	7:00	91,7	88,7	26,0	26,1	84	86
25	8:00	92,5	89,6	27,1	26,8	84	84
26	9:00	94,1	91,0	28,3	27,5	80	82
27	10:00	95,9	92,2	29,1	28,8	78	80
28	11:00	98,5	93,3	30,3	29,0	78	79
29	12:00	100	94,0	30,1	29,8	78	78
30	13:00	99,6	94,9	30,3	30,0	76	78
Average				30,74	28,87	80,07	81,43

Table 2. Test 2 - Heater Electric Operation from 27,2°C-94,3°C

No	Hour	Temperature (°C)				Humidity (%)	
		Heater	*Service Tank*	*Heater Room*	*Service Tank Area*	*Heater Room*	*Service Tank Area*
1	8:00	27,1	27,2	28,3	27,8	84	84
2	9:00	57,5	38,8	28,1	27,9	81	84
3	10:00	59,0	40,1	28,9	28,4	80	82
4	11:00	60,6	41,7	29,0	28,1	80	80
5	12:00	61,2	43,3	29,5	29,2	78	80
6	13:00	63,7	45,8	30,0	29,5	75	76
7	14:00	64,3	48,2	30,0	29,9	69	74
8	15:00	68,1	51,0	31,2	30,2	69	70
9	16:00	70,5	52,8	29,0	29,2	76	74
10	17:00	72,3	55,2	29,3	29,8	76	76
11	18:00	73,9	56,8	29,1	29,0	80	80
12	19:00	74,8	58,7	28,6	28,1	78	84
13	20:00	75,4	61,0	28,6	27,9	79	81
14	21:00	76,8	62,9	28,5	27,6	84	83
15	22:00	78,1	65,9	27,6	27,3	80	85
16	23:00	80,9	68,2	28,4	28,4	85	90
17	0:00	82,1	69,6	25,6	24,2	89	95
18	1:00	84,1	72,0	27,0	26,8	83	87
19	2:00	85,9	74,2	27,0	26,8	83	85
20	3:00	87,3	75,4	26,8	26,6	83	83
21	4:00	89,3	76,6	25,8	25,3	85	88
22	5:00	90,0	77,4	26,0	25,8	85	88
23	6:00	92,0	79,1	26,5	26,1	84	87
24	7:00	93,7	83,2	27,2	26,8	80	84
25	8:00	94,5	85,6	27,4	27,0	80	84
26	9:00	95,1	88,0	28,0	27,8	80	81
27	10:00	96,9	89,9	28,9	28,5	78	80
28	11:00	97,8	91,7	29,5	29,1	76	79
29	12:00	99,8	93,6	30,0	29,8	76	76
30	13:00	98,6	94,3	30,4	30,1	74	74
Average				28,56	28,39	79,67	81,80

Table 3. Test 1 & 2 - Heater Electric Operation

Test	Testing Time (Hour)	Temperature (°C)		Temperature Average (°C)		Humidity Average (%)	
		Heater	*Service Tank*	*Heater Room*	*Service Tank Area*	*Heater Room*	*Service Tank Area*
Test 1	29	100	94,9	30,4	27,1	80,0	81,0
Test 2	29	100	94,3	28,0	27,5	79,6	81,8
Average				**29,2**	**27,1**	**80,0**	**81,0**

Table 4. Automatic Heater Electric Operation

Heater Electric	Automatis *Heater*		Time (minute)	Total Time (minute)
	Stop	*Start*		
Test 1	12.00	12.05	5	14
	12.23	12.27	4	
	12.46	12.51	5	
Test 2	12.06	12.12	6	16
	12.31	12.36	5	
	12.51	12.56	5	
	Average			15

Based on operational data was obtained from the results during testing with an initial temperature of 29°C until it reaches a temperature of 95.6°C on a service tank at the 20ton level, recording a log-sheet once every 1 hour. The test was carried out using a Burner/Thermal Tank, so that the following operating data as seen in table 5.

Table 5. Test 1 - *Burner/Thermal Tank* from 29°C-95,6°C

No	Hour	Temperature (°C)					Humidity (%)	
		Oil Thermal In	*Oil Thermal Out*	*Service Tank*	*Burner Room*	*Service Tank Area*	*Room Burner*	*Service Tank Area*
1	8:00	27,0	33,8	29,0	27,7	27, 5	84	84
2	9:00	36,7	42,0	40,6	28,0	28,0	81	81
3	10:00	40,0	46,1	42,0	29,5	29,2	76	77
4	11:00	44,1	50,0	46,7	30,0	29,5	71	71
5	12:00	49,3	54,1	50,6	31,6	31,0	68	68
6	13:00	53,0	57,4	53,2	32,8	32,2	63	66
7	14:00	56,5	60,0	54,3	32,7	32,1	69	70
8	15:00	60,9	66,6	58,9	32,7	32,0	66	69
9	16:00	65,1	70,7	63,1	29,3	29,8	64	66
10	17:00	71,0	75,9	68,7	29,1	29,0	68	68
11	18:00	77,2	82,9	71,0	28,6	28,1	71	70
12	19:00	80,0	84,2	74,4	28,6	27,9	76	77
13	20:00	84,3	86,5	76,5	27,9	27,6	81	82
14	21:00	86,1	88,1	78,0	27,8	26,4	84	88
15	22:00	87,6	89,8	79,2	26,5	26,4	86	88
16	23:00	89,1	91,2	80,9	27,2	27,0	88	91
17	0:00	90,8	93,3	82,0	24,7	24,6	93	94
18	1:00	91,7	95,9	83,1	25,9	25,5	88	88
19	2:00	92,9	97,6	85,6	26,1	25,0	86	90
20	3:00	94,3	99,8	86,2	26,0	25,9	88	91
21	4:00	96,0	102,1	89,2	25,8	25,6	88	95
22	5:00	98,1	104,5	90,9	25,2	24,6	89	90
23	6:00	100,1	106,1	92,1	26,5	26,0	87	89
24	7:00	102,4	109,3	93,7	27,4	27,0	84	84
25	8:00	104,4	111,2	95,6	28,0	27,8	84	85

Operational data was obtained from the results during testing with an initial temperature of 27.3°C until it reaches a temperature of 95.1°C on a tank service at the 20 ton level, recording a log-sheet once every 1 hour. The test was carried out using a Burner/Thermal Tank, so that the following operating data as seen in table 6.

Table 6. Test 2 - *Burner/Thermal Tank* from 27,3°C-95,1°C

No	Hour	Temperature (°C)					Humidty (%)	
		Oil Thermal In	*Oil Thermal Out*	*Service Tank*	*Burner Room*	*Service Tank Area*	*Burner Room*	*Service Tank Area*
1	8:00	25,0	25,7	27,3	27,9	27,2	81	83
2	9:00	30,0	39,0	37,6	28,2	27,9	79	81
3	10:00	35,6	44,1	40,0	29,8	28,4	76	79
4	11:00	40,2	49,6	43,7	30,8	30,6	73	75
5	12:00	43,5	53,1	46,9	31,5	31,0	70	72
6	13:00	46,9	56,6	50,0	32,2	31,9	68	70
7	14:00	50,8	61,9	52,3	32,8	32,4	65	67
8	15:00	54,6	66,6	55,1	32,0	31,6	67	70
9	16:00	60,1	72,5	58,9	31,3	30,9	70	72
10	17:00	67,6	78,9	61,1	30,8	30,2	74	74
11	18:00	71,3	81,9	64,3	30,0	29,3	78	78
12	19:00	74,6	83,6	67,8	28,9	28,7	81	82
13	20:00	77,0	84,5	70,0	28,7	28,4	82	83
14	21:00	80,2	86,9	72,4	28,2	28,1	83	83
15	22:00	83,4	89,1	74,2	28,2	27,9	83	83
16	23:00	87,4	91,2	76,9	27,5	27,1	86	86
17	0:00	89,6	93,1	79,8	27,0	26,4	88	85
18	1:00	91,7	95,3	81,1	26,4	25,6	91	83
19	2:00	93,0	97,1	83,3	27,0	26,2	83	83
20	3:00	96,1	99,0	82,2	27,1	26,8	83	85
21	4:00	98,0	100,1	84,6	27,6	27,2	81	83
22	5:00	99,2	102,9	86,9	26,9	26,2	78	82
23	6:00	100,1	105,0	90,1	27,2	26,9	80	81
24	7:00	101,8	106,3	93,1	27,9	27,2	81	81
25	8:00	103,4	107,9	95,1	28,3	28,0	82	84
	Average				29	28,1	78,52	79,4

Table 7. Test 1 & 2 - Burner/Thermal Tank Operation

Test	Testing Time (Hour)	Temperature (°C)		Temperature Average (°C)		Humidity Average (%)		*Flowmeter (L)*
		Oil Thermal	*Service Tank*	*Burner Room*	*Service Tank Area*	*Burner Room*	*Service Tank Area*	
Test 1	24	111,2	95,6	30,0	27,1	79,8	80,4	204
Test 2	24	107,9	95,1	29,6	29,5	78,5	79,4	200
Average				**29,8**	**28,3**	**79,1**	**79,9**	**202**

Table 8. Electric Tool Power Usage

No	*Treatment*	Type	Power kW
1	Heater Electric	*Heater*	3 x 30
		Circulation Pump Motor	2,20
2	Burner/Thermal Tank	Circulation Pump Motor	15,0
		Fuel Pump Motor	0,37
		Burner Motor	6,25

Electric tool power usage for heater electric and burner thermal tank can be shown in figure 8 above. It can be used to compare energy consumption between heater electric and burner/thermal tank system. After obtaining all the necessary data to carry out the calculations that will be discussed in this study includes calculating the value of time efficiency and initial operating costs for marine fuel oil (MFO) treatment from an initial temperature of 27-30°C until the temperature reaches 94-96°C and the entire time efficiency and operating costs of treating marine fuel oil (MFO) for 24 hours / 7 days between using an electric heater and a burner/thermal tank.

Based on the results of the calculations above, it can be discussed in the form of a time comparison chart at temperatures reaching 94-96°C, a cost chart at temperatures reaching 94-96°C, a graph of MFO treatment costs for 24/7 days, between using an electric heater and a burner/thermal tank can be seen at Figure 4.

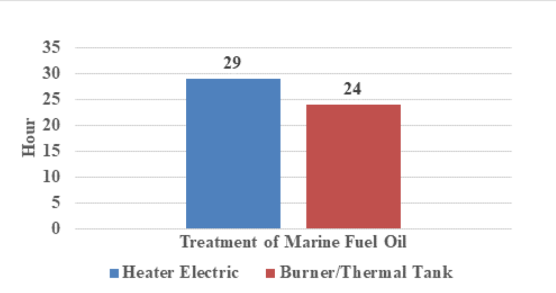

Figure 4. Graph of the comparison MFO treatment type and operation time

Based on test data 1 and 2, preheat operation treatment of marine fuel oil (MFO) between using an electric heater and burners/thermal. The service tank temperatures are 94.9°C and 94.3°C, the average is heater room temperature and service tank area 29.2°C and 27.1°C, the humidity heater room and service tank area 80% and 81% in the test with heater electric, and the service tank temperature is 95.6°C and 95.1°C, the average is the temperature of the burner room/thermal tank, and the service area of the tank is 30.02°C and 27.14°C humidity of burner/thermal tank and service tank area of 79.1% and 79.9% in the test with a burner/thermal tank. So from these data obtained, the average test time using an electric heater for 29 hours is higher than the test using burner/thermal tank for 24 hours, or it can be concluded that advantages of using a burner/thermal tank at the beginning of treatment is 17.2% more efficient.

This is due to the difference between the fast and slow rise in the heating temperature for MFO treatment, as well as during treatment with a burner/thermal tank, heating is carried out in the service tank by circulating thermal oil to the tubing pipe, which is in the tank while heating with a heater.

Electricity is carried out outside the service tank by pumping the MFO into the electric heater and recirculates it to the service tank.

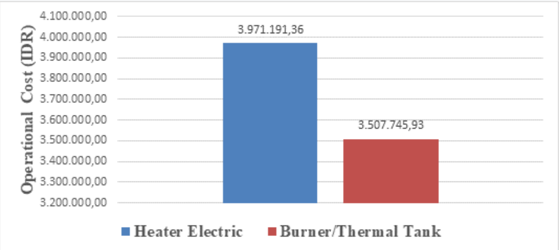

Figure 5. Graph of the comparison MFO treatment type and operational cost in temperature 94-96 °C

Based on test data 1 and 2, preheat operation treatment of marine fuel oil (MFO) between utilizing an electric heater and burner/thermal until the temperature reaches 94-96°C. Get the service temperature tanks 94.9°C and 94.3°C, the average temperature of the heater room and the service area of the tank 29.2°C and 27.1°C, humidity of heater room and service tank area 80% and 81% in testing with an electric heater, and obtained the service tank temperature 95.6°C and 95.1°C, the average temperature of the burner/thermal tank and area service tank 30.02°C and 27.14°C burner/thermal tank humidity and area service tank 79.1% and 79.9% in the test with a burner/thermal tank. As well as, the average time of testing using an electric heater is 29 hours tank and for 24 hours of testing using a burner/thermal. With refers to the price of industrial oil from PT. Pertamina (Persero) to PT. PLN (Persero), where the price of HSD fuel is IDR 7,860 per liter and Oil Thermal 32 is IDR 29,260 per litre and refers to the basic electricity tariff of IDR. 1,444.70 per kWh, the operational costs of marine fuel oil (MFO) treatment until the temperature reaches 94-96°C using an electric heater for IDR. 3,974,369.7 and by using a burner/thermal tank of IDR 3,507,745.93, as shown in figure 5. So that advantages of using burner/thermal tank is efficiency in terms of operational costs by using a burner/thermal tank at the beginning of treatment is more efficient at 11.67%.

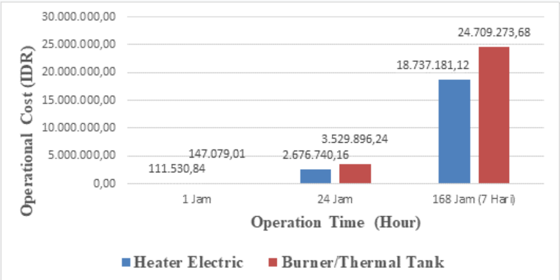

Figure 6. Graph of Operational Cost and Operation Time

Based on the graph of advanced operational costs up to 7 days of treatment marine fuel oil (MFO) operation between using an electric heater and using an electric heater burner/thermal tank in some time, obtained from the calculation of the total P value, FC and LC are multiplied by the basic electricity tariff and the price of oil per liter. With reference to the price of industrial oil from PT. Pertamina (Persero) to PT. PLN (Persero), where the price of HSD fuel is IDR 7,860,- per liter and Oil Thermal is 32 IDR 29,260,- per liter and refers to the basic electricity tariff of IDR 1,444.70 per liter kWh, the economic evaluation can be seen in the operational cost of marine fuel oil (MFO) treatment is between using an electric heater within 1 hour of IDR 111,530.84, within 24 hours IDR 2,676,740.16,-, and within 168 hours

(7 days) amounting to IDR. 18,737,181.12, - while using a burner/thermal tank within 1 hour of IDR. 147/079,01, within 24 hours of IDR 3,529.896,24 and within a period of 168 hours (7 days) IDR 24.709.273,68, as shown in figure 6 above. So that efficiency in terms of operational costs with using an electric heater is 31.87% more efficient, amounting to Rp 48,036.33, - in 1 hour IDR 1.152,871.98,- within 24 hours, IDR 8,070,103,90,- within 168 hours (7 days).

4. CONCLUSIONS

Based on the discussion, testing and calculating marine fuel treatment oil (MFO) between using an electric heater and a burner/thermal tank, it can be concluded as follows: 1) Large comparison of costs and time on marine fuel oil (MFO) treatment between using an electric heater with a burner/thermal tank obtained a comparison of the time value of 24 hours using a burner/thermal tank and 29 hours using an electric heater at a temperature of 94-96 °C. Cost value comparison using an electric heater within 168 hours of IDR 18.737.181.12,-. By using burner/thermal tank within 168 hours of IDR 24,709,273.68,-. 2) The most efficient way of treating marine fuel oil (MFO) in terms of time by 17.2% which is 5 hours faster by using a burner/thermal tank at preheating. Value of operational cost efficiency continued for 7 days by 31.87% more efficient IDR 5,972,092.56 by using a heater.

REFERENCES

[1] Hasna, H. S. 2019. The Process of Treatment Marine Fuel Oil (MFO) As Fuel In Diesel Engines. Journal of Chemical Engineering State University Semarang. Thesis is not published. Semarang.

[2] Imam, K. 2015. Utilization of Alternative Energy as Energy Renewed To Support Fuel Substitution. University Engineering Journal Wijaya Putra. Thesis is not published. Surabaya.

[3] L. Edward, Sunardi. 2014. Comparison of Energy Prices from Energy Sources New Renewable And Fossil. Center for the Study of Nuclear Energy Systems. Report unpublished research. Jakarta.

[4] Holman, Jack P. 2010. Heat Transfer: Tenth Edition. New York: Mac Graw Hill.

[5] Cengel, Yunus A., 2003. "Heat Transfer: A Practical Approach Second Edition," McGraw-Hill. New York.

[6] Manual book Thermal Oil Heater. PT Mubarok Pratama.

[7] Mulyamah. 1987. Change management. Jakarta: Yudhisthira.

[8] Specification for MFO Type of Fuel Oil (Directorate General of Oil and Gas, 2008).

[9] Complete Basic Physics Formulas (Wikibooks).

[10] Concession Data of PT PLN (Persero) PLTD Gunung Malang.

[11] Anandh N. and P. Kumar. 2021. "A Case Analysis on Energy Savings and Efficiency Improvement of a Chiller Plant in a Luxury Hotel Building", International Energy Journal 21: 447 – 456.

[12] Shaari M.S., Mariadas P.A, Hussain N.E.,Murthy U. 2021. "The Effect of Energy Consumption in the Agricultural Sector on CO2 Emission in Malaysia". International Energy Journal 21: 427 – 436.

[13] Upakool J., Thanarak P. 2021. "Monitoring and Assessment of Energy Efficiency and CO2 Emission from Cogeneration Power Plants". International Energy Journal 21: 323 – 338.

[14] Win T., Harayanto T., Sari D.W. 2021. "Analysis of Energy Efficiency of Indonesia's Sugar Industry". ". International Energy Journal 21: 245 – 256.