The Efficiency of Generator Toward Changes Electric Loading in Fishing Vessels

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ABSTRACT

The research aims to identify the electrical load on fishing vessels and determine the efficiency of the generator power used to electrical source fishing vessels. Researchers carried out several stages, i.e., identifying the electric power distribution system, identifying the generator capacity and electrical load received, calculating the electrical load on different operational conditions. The study was carried out for four different operational conditions, i.e. sail to the loading port, fish loading, sail to unloading port, and frozen fish unloading. KM. Okishin 07 uses a radial electrical distribution system, using two electric generator units with identical specifications. Each has a capacity of 225 kVA. The generator operates efficiently in all operational conditions, with 79.70% to 83.08%. The highest efficiency occurs in fish loading operations meanwhile the lowest efficiency occurs in frozen fish unloading operations. Refrigeration machine operation is an of the biggest electric load increasing factors.

Keywords: electric load, electric generator, generator efficiency, fishing vessel

INTRODUCTION

Fishing vessels in their operation play an essential role in supporting the use of marine resources. For the optimum operation of catching and storing fish, facilities and infrastructure are needed to support the operation of fishing vessels. The type of engine used onboard is the main and auxiliary engines. The main engine functions to move the vessel by rotating the propellers, while the auxiliary engine functions to supply electrical energy and hydraulic power onboard (Capasso et al., 2019).

Generators are electric machines that can convert mechanical energy into electrical power (Alamsyah, 2017; Andreas et al., 2020). Propulsion or mechanical power from combustion motors or steam turbines can be used. the electrical generator driven by a combustion engine is currently the most suitable choice for vessels (Mendonça et al., 2017), that need a larger supply of electricity. The energy produced as a source of electricity will be distributed to electrical equipment as a source of electricity.

To connect electrical energy from the generator to the load, a good distribution system is needed. Several electrical distribution systems are used, such as a radial system (Cahyono et al., 2017), where the voltage source point and the load point have only one line. There are no other alternative paths. This spindle distribution system consists of several radial systems whose ends are combined at the feeder. The system is two radial networks connected by a circuit breaker that can be served from two directions (Pramono et al., 2018). The loop system has the direction of current flowing from various directions so that it requires coordination of Directional Over Current Relay (DOCR) protection (Rahmatullah & Dewantara, 2019).

The use of electric power for fishing vessels, in general, uses electrical energy that is large enough to support fishing work. Electricity is used to drive equipment to support all activities and operations on fishing vessels both on the deck and in the engine room (Ayom et al., 2020). Electrical loads on the deck such as anchor winch, navigation equipment, lighting. The electrical loads on accommodation rooms such as television, radio, tape, and rice cooker. while in the engine room, electric energy is used to drive electric motors as propulsion of auxiliary machines such as sewer water pumps, fuel pumps, lubricating oil pumps, electric motors for air compressors, and refrigeration compressors (Ridwan & Zakiah, 2020). The electrical system contained in the vessel consists of power generation equipment, distribution systems, and various kinds of electrical equipment (Demeianto et al., 2020). Electric power drives motors for many auxiliary engines and various deck equipment, lighting, and air conditioning equipment.

The supply of sustainable electricity is needed for the safe operation of fishing vessels equipment. Therefore the availability of adequate generator power capacity is crucial. This is mainly related to the condition of the vessels when sailing, so the vessels must be equipped with an emergency power generation system to deal with emergency conditions on the vessels (Faturachman & Febrian, 2020; Mahmuddin et al., 2019).

The generator functions as the primary power supply, which is very important to meet all the electricity needs on fishing vessels (Darma et al., 2019). However, in most cases that occur onboard, the most significant needs are as much as possible supported by the generators on board. This causes a build-up of power in the electrical installation onboard. The build-up of power usually occurs at certain times when some equipment onboard is being used. Therefore, operating the electrical generator load that exceeds the maximum generator operational limit must be avoided, and excessive loading will have a fatal impact (Mardiyono, 2020). This paper aims to identify the electrical load on fishing vessels and determine the efficiency of the generator power used to electrical source fishing vessels.

RESEARCH METHODS

The research was conducted on the fishing vessel KM. Okishin 07. The vessel is a modified ship that was previously a fishing vessel with longline fishing gear, which was later converted into a fish carrier vessel. Besides functioning as a fish carrier vessel, the vessel is also used for fish processing catches from plasma vessels in collaboration with PT. Okishin Flores. Objects of the research are electric generators as a source of electrical energy onboard shown in Figure 1. Electric generator using diesel engine drive. Voltmeter and Amperemeter are used to measure output electric power from the generator.

Several stages are carried out systematically to get the electrical load data onboard. The first stage is observing and identifying the electricity distribution system on board from the generator to the load. The second stage is to identify and calculate electrical power is available as a power source to operate electrical equipment and machinery. The third stage is to calculate the electrical load used.

Four types of ship operational conditions are based on used electrical loads. Each condition has a different job and is carried out using different electrical machinery and equipment. The operational conditions are 1) sail to the loading port; 2) fish loading; 3) sail to unloading port; and 4) frozen fish unloading.

Figure 1. Engine Generator set owned by KM. Okishin 07

The specifications for the generator as the power plant onboard are shown in Table 1. The specification diesel engine is shown in Table 2. To obtain the distribution of electricity on the ship, identification of the path of the electrical load starting from the generator to the load on the electrical connection panel. The identification process is also done for all of the devices that use electricity from the generator. The data that has been obtained is then made in a block diagram to describe the distribution system.

Table 1. Specifications of KM Generator Drive Motor. Okishin 07

Spesification	
Merk	: Niigata
Type	: 6 HL – HS
Driver	: Diesel 4-tak
Cylinder	: 6 buah
Power	: 405,43 HP
Rotation	: 1500 RPM
Weight	: 1580 kg
Fuel	: HSD (Solar)
Lubriction	: SAE 40
Year	: 1986
Factory	: Niigata Engineering Co. Ltd, Jepang

The maximum power of the generator engine on board is influenced by the magnitude of the generator output in kVA units and the power factor owned by the engine. By knowing output power (S) and power factor ($\cos\varphi$) using Equation (1), it can be seen the amount of electric power available.

$$P = \mathrm{S}.\cos\varphi \quad (1)$$

Table 2. Specifications of KM Electric Generator. Okishin 07

Spesification	
Merk	: Niigata
Type	: SB-HW-64-SG. 34
Unit	: 2 unit
Frequency	: 50 Hz
Voltage	: 380/220 Volt
Outout power	: 225 kVA
Power factor	: 0.8
Phase	: 3 fasa
Rotation	: 1500 Rpm

The efficiency of the use of electrical energy produced by the generator is used to determine how much use of electrical energy has been generated by the generator to support vessel operations. To determine the efficiency of using electrical energy generated by the generator, it is necessary to know how much electrical energy is used (P_o) and how much electrical energy is generated by the generator (P_i). To determine the efficiency of the generator is calculated using Equation (2).

$$\eta = \frac{Po}{Pi} \times 100\% \quad (2)$$

Po = Power used
Pi = Available power

RESULTS AND DISCUSSION

Electric Distribution System

The electrical power distribution system from the generator to the users onboard uses a radial distribution system. The connecting panels for electricity receive electric current from the main panel, connected directly to generators one and two, as shown in Figure 2. To connect the two generators, the main panel equipped with synchroscope equipment. This distribution system was chosen because it is simple, and the cost is relatively lower than other distribution systems. This is following what was written by George (2018) in his article that this radial system is widely used because of its simplicity and low investment costs.

The electric current distribution system starts from the first and second generators as electrical energy generators. The electrical energy is distributed to the main circuit board. Electrical energy is distributed from the main circuit board to some of the distribution panels equipped with safety devices like circuit breakers, magnetic contactors, over current relay, marine transformer, and safety fuse. The distribution panels distribute electric energy to the devices such as lighting installations, electrical and navigation equipment, and auxiliary machines (most uses drive electric motor).

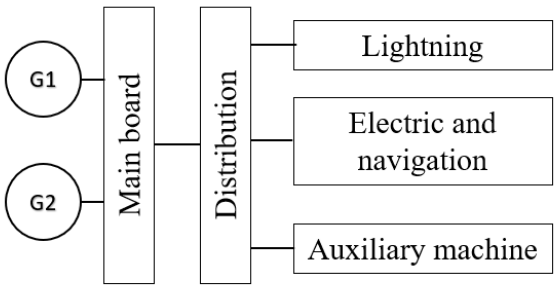

Figure 2. Block diagram of the electrical distribution system

Available Electricity

The amount of electrical power available on the ship can be calculated by multiplying the engine power factor with the power generated by the generator (Equation 1) and then multiplying the number of generators on board. Based on the data obtained and observations on board, the overall electrical power consumption can be met by the power of one generator unit and only one generator unit operated. Thus, the available electrical power from one generator unit is :

$$P = 225\ kVA\ \times 0.8$$
$$P = 180\ kW$$

KM. Okishin 07 uses a lot of electrical energy in operational conditions. The electrical energy is used for lighting accommodation from the engine room to the navigation room. Electrical distribution for navigation equipment is used for ship navigation purposes, while the load from the electric motor is used to operate auxiliary aircraft to assist work activities on board. The use of the electrical load is obtained by observing and recording data on the use of the electrical load used. From Table 3, the total amount of electricity used from several electrical loads is 168,495 W. Then the efficiency of the overall electric power consumption of one generator unit is calculated using Equation (2).

$$\eta = \frac{168.495\ W}{180.000\ W} \times 100\%$$
$$\eta = 93.6\%$$

From the results calculated, the overall electricity consumption efficiency is 93.6% and is declared inefficient because it exceeds the generator load factor by around 60% - 86% (Ricesno & Nandika, 2020).

Table 3. Electic Load on KM. Okishin 07

No	Load	Power (W)	Number	Total power (W)
LAMP				
1.	Officer room	40	1	40
2.	Engineer room	40	1	40
3.	Cadet room	40	3	120
4.	Pray room	20	1	20
5.	Warehouse	60	1	60
6.	Dining room	40	2	80
7.	Aisle	20	3	60
8.	Bathroom	20	1	20
9.	Kitchen	40	1	40
10.	Engine room	60	6	360
11.	Navigation	20	3	60
12.	Hold room	60	4	240
13.	Navigation L and R	500	2	1000
14.	Top lamp	40	5	200
15.	Deck	500	3	1500
16.	Processing room	40	5	200
ACCOMODATION EQUIPMENT				
17.	DVD Player	80	1	80
18.	Televisi	100	1	100
19.	Sound system	600	1	600
20.	Rice Cooker	500	1	500
21.	Heater	1.000	1	1.000
NAVIGATION INSTRUMENT				
22.	Bateray charger	2.000	1	2.000
23.	Radar	250	1	250
24.	Radio SSB	100	1	100
25.	Gyro Compas	80	1	80

No	Load	Power (W)	Number	Total power (W)
26.	Echo Sounder	100	1	100
27.	GPS	65	1	65
AUXILIARY MACHINE				
28.	Welding	8.000	1	8.000
29	AC	30.000	3	90.000
30.	Grinding	250	1	250
31.	General Service Pump	11.000	1	11.000
32	Air compressor	5.000	1	5.000
33.	Hidraulic	7.030	1	7.030
34.	Bilge pump	1.800	1	1.800
35.	Fresh water pump	1.500	1	1.500
36.	Steering Gear	1.500	1	1.500
37.	Condenser	3.700	1	3.700
38.	Sea water pump	2.700	1	2.700
39.	Fuel transfer pump	5.000	1	5.000
40.	Lubrication	3.700	1	3.700
41.	Blower engine room	2.200	2	4.400
42.	Blower Frezeer room	5.500	1	5.500
43.	Anchor Winch	5.700	1	5.700
44.	Winch Test	2.800	1	2.800
Total load				168.495

Condition of Sail To The Loading Port

The voyage to the loading port area takes three days. Vessel activities only sail from the Banyuwangi Port to the loading port in Larantuka. The condition uses one electric generator power. The electric power used during the voyage to the loading port is shown in Table 4. The result of total power is 145,005 W.

Table 4. Electric Power Used When Sail to The Loading Port

No.	Distribution	Power (W)
1	Lighting installation	2.300
2	Electrical and navigation equipment	4.875
3	Auxiliary machine	137.830
total		145.005

From the total power of electricity, the Efficiency value result is 80.56% which is declared efficient because it is at the generator load factor value of around 60% - 86%.

$$\eta = \frac{145.005\ W}{180.000\ W} \times 100\%$$

$$\eta = 0.8056 \times 100\%$$

$$\eta = 80.56\%$$

Condition of Fish Loading

Table 5. Electric Power Used When Fish Loading

No.	Distribution	Power (W)
1	Lighting installation	4.040
2	Electrical and navigation equipment	4.875
3	Auxiliary machine	140.630
Total		149.545

When carrying out fish loading, electrical power changes due to the increase in the electrical power required for lighting installations and electric motors (mainly refrigeration process). Loading operations from plasma vessels are carried out every day. The electricity power consumption during fish loading is shown in Table 5.

From Table 5, Electrical power consumption during the fish loading operation, it is known that the total electricity consumption is 149,545 W. The efficiency value using equation (2) is:

$$\eta = \frac{149.545\ W}{180.000\ W} \times 100\%$$

$$\eta = 0{,}8308 \times 100\%$$

$$\eta = 83{,}08\%$$

The efficiency of electric power consumption is 83.08%. This condition is declared efficient because of around 60% - 86% of the generator load factor value.

Condition of Sail To The Unloading Port

Time duration sail from Larantuka port to unloading port in Banyuwangi takes three days. The electricity power consumption used is shown in Table 6

Table 6. Electric Power Used When Sailing to The Unloading Port

No.	Distribution	Power (W)
1	Lighting installation	1.540
2	Electrical and navigation equipment	4.875
3	Auxiliary machine	137.830
Total		145.005

Thus, it can be seen the efficiency of electricity consumption from Equation (2) as follows:

$$\eta = \frac{144.245\ W}{180.000\ W} \times 100\%$$

$$\eta = 0{,}8013 \times 100\%$$

$$\eta = 80{,}13\%$$

From the above calculation results, the efficiency of electric power consumption of 80.13% is declared efficient because it is by the generator load factor value of around 60% - 86%.

Unloading Fish Condition

Unloading frozen fish from the cold room to the container truck for one day. The process of transferring frozen fish is assisted by a winch. The electricity power consumption used is shown in Table 7.

Table 7. Electric Power Used When Fish Unloading

No.	Distribution	Power (W)
1	Lighting installation	1.060
2	Electrical and navigation equipment	2.280
3	Auxiliary machine	140.130
Total		143.470

The efficiency of electric power consumption from the following equation (2)

$$\eta = \frac{143.470\ W}{180.000\ W} \times 100\%$$

$$\eta = 0{,}7970 \times 100\%$$

$$\eta = 79{,}70\%$$

From the above calculation results, the efficiency is 79.70%, declared efficient because it is by the generator load factor value of around 60% - 86%.

Efficiency Overall power consumption

The overall power consumption can be met by the power of one generator so that the work of the generator on the ship can be carried out alternately. The overall efficiency of electric power used for various operational conditions is shown in Figure 3. The electric load on the generator fluctuates, the highest efficiency of using the generator occurs in loading the fish to the cold room. The fish loading from the plasma vessel to onboard is a complex job. The activity needs refrigeration machinery that has bigger power consumption. Meanwhile, the lowest efficiency occurs when unloading frozen fish. The activity does not use much work equipment in the engine room and accommodation, most of the electrical loads are only for the winch.

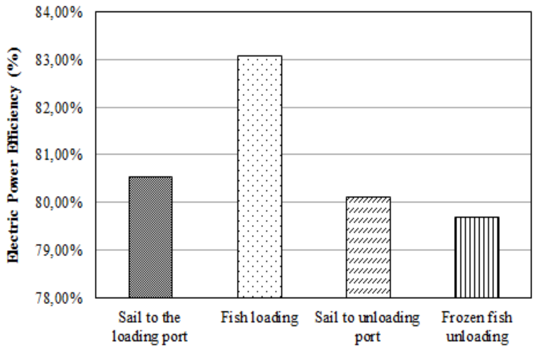

Figure 3. The overall efficiency of electric power used for various operational conditions

CONCLUSION

Electricity distribution system in KM. Okishin 07 uses a radial distribution system. The electricity generated by the generator is distributed to the main panel, continued to the distribution panel, and distributed to electrical equipment. The electric power generated by one generator unit available on the ship is 180 kW. Based on four operating conditions different of vessel i.e. sail to loading port, fish loading, sail to unloading port, and frozen fish unloading, all condition have good efficiency power consumption that value between 60% - 86%. The highest of efficiency occurs at fish loading condition that need most power from refrigeration machinery. The value of efficiency is 83.08%.

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