

Cooling Water Motor Pump Protection System Analysis at PLTMG Maxpower Panaran Indonesia

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ABSTRACT

Gas Engine Power Plant (PLTMG) is a power plant that uses a gas engine as a generator drive. Maxpower Panaran MHP produces 2x25 MW of electrical power which is distributed through the 20 KV Batam and 150 KV Batam-Bintan distribution networks with the island mode of operation. Maxpower Panaran MHP is a power plant with 18 gas engines. There is 1 engine with 20 cylinders and 1 generator in each engine. This plant uses Compressed Natural Gas (CNG) fuel with cogeneration mode of operation. This research was conducted for a case study focusing on the cooling water motor pump protection system to evaluate the performance of the protection on the motor pump so that the cooling system at Maxpower Panaran can work optimally. One of the main protections of this system is the fuse and the Thermal Overload Relay (TOR). The research was conducted in December after a short circuit occurred in the fuse motor pump jacket water. This research was conducted by performing calculations and analysis based on the standardization of induction motor protection systems. The research was carried out based on calculations, the TOR rating was at a rating of 28.5A with the installed TOR rating at a rating of 34 A, from the results of the analysis carried out, the TOR rating was already above the threshold value that should be. Based on NEMA standardization, the calculated fuse rating is 57A with the installed fuse rating in the range of 25A - 35A. Therefore, a 50A fuse is required to maintain the reliability of the machine so that it does not blow or re-burn the fuse.

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1. INTRODUCTION

Electrical energy is one of the most basic needs to support human life in the 5.0 era. The growth of electrical energy demand has increased every year. Gas Engine Power Plant (PLTMG) is a power plant that uses a gas engine as a generator drive. PLTMG is functioned to overcome the need for electrical energy during the peak load because the operation of providing power is faster by producing large power but only requires a small space for the placement of the engine[1].

Maxpower Indonesia's Gas Power Plant (PLTMG) located in Panaran is one of the power plant that fulfill reliable electricity sply in Batam with 18 gas engines. Each engine consists of 20 cylinder and 1 genrator which produces 2x25 MW of electricity distributed through the 20 kV and 150 kV Batam-Bintan distribution networks with the mode operation is island mode. This plant uses single-fuel engine technology for power generation with the following fuels Compressed Natural Gas (CNG). The gas engine functions to convert thermal energy into mechanical energy which is converted back into electricity by the generator. Jenbacher engines use LEANOX method, which is a development og Lean-Mix. Engines with this method are supplied with a mixture of gas with surplus air to reduce emissions at the combustion stage to a minimum. The engine is

the Jenbacher JMS-620 NS F-L gas engine. Jenbacher has several types of engine types, for type Jenbacher JMS is a type with a co-generation plant mode of operation. This type of engine not only generates electricity but also reused heat. The heat that is utilized is the heat form exhaust gas, lubrication system, and cooling system[2].

In the process of converting potential energy into mechanical energy before electricity is generated, the motor produces heat energy that continues to increase as the motor runs. In the process of converting potential energy into mechanical energy before electricity is generated, the engine produces heat energy that continues to increase as the engine runs. Requiring a cooling tower to maintain engine stability before overheating occurs. In principle the cooling tower works by using an electric motor to drive a fan and circulate cooling water. Therefore, to maintain the effectiveness of the engine during the starting and running process, it is essential to ensure that there is no trip in the electrical system that supplies power to the cooling tower area. This requires a protection system to keep the engine optimal and reliable, preventing any disturbances on the engine[2]. If disturbances in the power system are not prevented and handled properly, it can damage the machine in operation. However, the electric power system has main protection, including the fuse and Thermal Overload Relay (TOR). The protection system used in the electrical system of the cooling system panaran is comprised of a fuse, Thermal Overload Relay (TOR), and soft starter. The cooling system is powered by a 3-phase electric motor that drives the fan and pumps water for the cooling circulation process in the production plant.

This research focuses on the cooling water pump protection system to evaluate its performance of protection on the motor pumo so that the cooling system at Maxpower Panaran can work optimally. In the field conditions encountered, the cooling system process at the PLTMG Maxpower Panaran has the potential to experience interference caused by continuous motor work with the start-stop engine process within 24 hours. These conditions cause various possible disturbances[3]. Therefore, this research also aims to research will then provide an overview of the three-phase induction motor used by the Jenbacher machine and analyze the protection system that works on the cooling water system. Finally, the research wil evaluate the protection system of the cooling water motor pump used by the Jenbacher at the PLTMG Maxpower Panaran.

2. METHOD

The research conducted is a type of quantitative research that is then carried out, with calculations and analysis based on the standardization of induction motor protection systems. The standard used refers to the NEMA and NEC standards. The data analyzed is the amount of current and voltage that passes through the fuse. This is then compared with the capable power capacity of the fuse used. The steps taken to analyze a Cooling Water Motor Pump Protection System at PLTMG Maxpower Panaran Batam are shown in the flowchart in Figure 1.

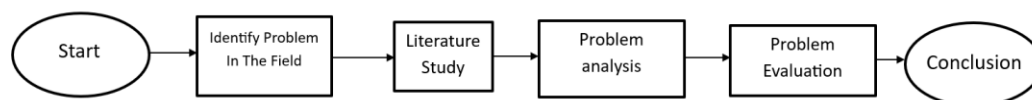


Figure 1. Flowchart

The data parameters utilized in this calculation are derived from calculations based on the standarization of the protection system, as outlined below:

Table 1. Data Parameters

Parameters	Unit	Symbol
Current flowing on the motor	Amp	I
Voltage flowing on the motor	Volt	V
Power factor	-	$\cos\theta$
Motor Power	Watt	P

The calculation parameters to be processed include the following:

Table 2. Calculation Parameters

Parameters	Symbol
Nominal current	In
Fuse rating	A
TOR rating	A

3. RESULTS AND DISCUSSION

3.1. 3-Phase Pump Motor

The pump motor utilized in the PLTMG Maxpower Panaran Indonesia is a squirrel cage pump motor. The specifications of the PLTMG Maxpower Panaran Indonesia 3-phase pump motor can be identified in Figure 2.

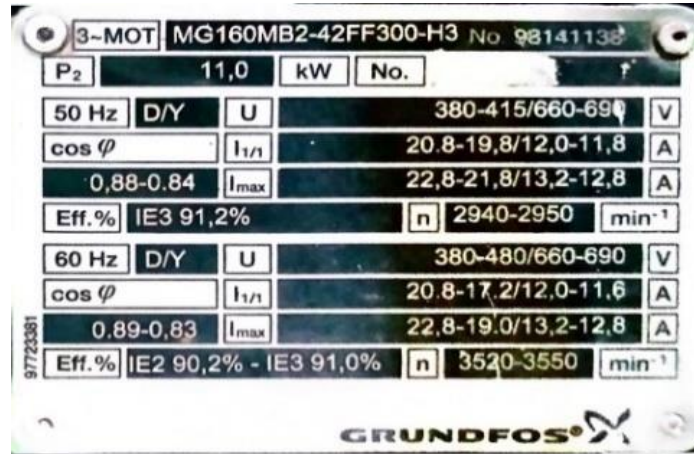


Figure 2. 3-Phase Pump Motor Nameplate

A review of the nameplate reveals that the motor, with a power rating of 11 kW, has two distinct specification ratings. A voltage analysis indicated that the motor is rated for a voltage range of 380-415V at PLTMG Maxpower Panaran Indonesia[8]. The specifications of the 3-phase pump motor can be identified in Table 3.

Table 3. 3-Phase Pump Motor Specifications

Certification	IEC60034 and IEC 60072-1/EN50347
Frequency	50 Hz
Voltage	380-415 V
Nominal current (In)	21,8-22,8 A
Power	11kW
Type of Motor	3 Phase
Efficiency	91,2%

3.2. Analysis of Calculation

The selection of fuse capacity and TOR used is a function of the type of motor being protected. The following is a summary of the results of the calculations performed to determine the appropriate fuse capacity and TOR values used in the PLTMG Maxpower Panaran Indonesia.

3.2.1. Analysis of Thermal Overload Relay (TOR) Calculation

The Thermal Overload Relay is one component of the protection system that is used as protection against overload due to the current flowing in the Thermal Overload Relay (TOR). This component serves to safeguard the 3-phase motor from a sudden surge in current flow. Once the nominal current of the motor has been determined, the appropriate fuse rating can be calculated using the following formula:

$$\text{TOR Rating} = 125\% \times I_n \dots \dots \dots (A)$$

In accordance with the provisions of the National Electrical Code (NEC), It is necessary to consider the type of motor being protected when selecting the capacity of the Thermal Overload Relay (TOR). The formula indicates that the fuse capacity or rating should be 125% of the nominal current (In). The highest nominal current flow is obtained at 22,8 A, as indicated on the motor’s nameplate. Therefore, the TOR rating that must be used is:

$$\begin{aligned} \text{TOR Rating} &= 125\% \times I_n \\ &= 125\% \times 22,8 \text{ A} \\ &= 28,5 \text{ A} \end{aligned}$$

A field observation revealed that the type of TOR utilized is Type 3RV2021-4FA10, with the following specifications:

- Protected motor power : 11 kW
- Range rating : 34 A – 40 A
- Install : 34 A

The data indicates that the TOR rating, with a value of 34 A, is utilized at a current passing through it of 28.5 A. The installed rating exceeds the threshold value, as evidenced by the results of the field analysis.

Table 4. Analysis of TOR Rating Calculation

Protection Type	Type	TOR Rating (A)		
		Analysis	Installed	Recommend
Thermal Overload Relay (TOR)	3RV2021-4FA10	28.5 A	34 A	34 A

3.2.2. Analysis of Fuse

The fuse is designed to perform protection functions in the shortest possible time. In the event that installation of the fuse is not appropriate or that the current passing through the circuit exceeds the capacity of the fuse, an overload will occur. Consequently, the fuse functions to interrupt the flow of electric current by melting the element and breaking the circuit into an open circuit. Following the determination of the nominal current of the motor, the fuse rating can be calculated using the following formula:

$$\text{Fuse Rating} = 250\% \times I_n \dots\dots\dots(A)$$

Following the provisions of NEMA, it is of the utmost importance to consider the type of motor being protected when selecting the capacity of the fuse. The formula indicates that the fuse capacity/rating should be 250% of the nominal current (I_n). According to the nameplate of the motor utilized in the Maxpower Panaran Indonesia MHP, the maximum nominal current flow is 22.8A. Consequently, the fuse rating that must be utilized is as follows:

$$\begin{aligned} \text{Fuse Rating} &= 250\% \times I_n \\ &= 250\% \times 22,8A \\ &= 57A \end{aligned}$$

The results of the analysis in Table 5 indicate that the fuse rating is 57A. The data presented above indicates that the use of a fuse with a current rating of 25-35 A is below the threshold value based on the analysis results. In the context of fuse usage, the rating applied is contingent upon the available fuse rating. The analysis results indicate a value of 57A, which is close to the value of a fuse rating of 50A. It is therefore recommended that a fuse rating be selected that is as close as possible to the threshold value to prevent the fuse from breaking under the effects of a very high current surge.

Table 5. Analysis of Fuse Rating Calculation

Protection Type	Type	Fuse Rating (A)		
		Analysis	Installed	Recommend
Fuse	CLF	57A	25-35A	50A

4. CONCLUSION

1. The squirrel cage motor utilized at PT Maxpower Panaran Indonesia is a three-phase induction motor. The induction motor is responsible for pumping water, which is then directed to the water jacket, which serves as a low-temperature (LT) cooler.
2. The three-phase induction motor is protected by several systems, including fuses and thermal overload relays (TOR). The function of the protection system is to prevent damage to components that have been affected by the fault current and to components that have not been affected by the fault current. This is achieved by isolating the affected components as small a distance as possible from the source of the fault current and by preventing the spread of the disturbance. This protection system is designed to protect against surges caused by:
 - a. Excessive wind passing through the pump motor causing the pump RPM to spike.
 - b. Start-Up Current.
 - c. Under Voltage.

- d. Electrical disturbances, such as sudden voltage drops, and failures in voltage control systems can create current surges.
 - e. Mechanical disturbances, cylinder head leaks, or cracks in the jacket water system that cool the engine temperature can increase the mechanical load on the motor.
3. The protection system utilized in the 380V 3-phase induction motor exhibits a calculated TOR rating of 28.5A, while the installed TOR rating is 34A. The results of the analysis indicate that the TOR rating is already above the threshold value that should be. The fuse protection system installed has a rating of 25 amperes. The field conditions indicate that the rating is incapable of withstanding the current surge that occurs. This resulted in the burning of some fuses, necessitating a change in rating to a fuse with a 35A rating. In light of the prevailing field conditions, it is evident that the 35A rating is similarly incapable of withstanding the current surge that occurs. Some of these field conditions serve as the basis for calculations in accordance with NEMA standardization, resulting in a calculated fuse rating of 57A. In accordance with the standard, the closest fuse rating to 57A is a fuse with a rating of 50A. Consequently, a fuse with a rating of 50A is necessary to ensure the continued reliability of the machine, preventing any potential trips or fuse burning.

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REFERENCES

- [1] A. Candra and S. Nurmutia, Laporan Teknik Tenaga Listrik, no. 1. 2020.
- [2] Muammar, Fauzan, and Zamzami, "Studi Proses Cooling Sistem Pada Pembangkit Listrik Tenaga Mesin Gas Di Pt. Pjb Ubjom Pltmg Arun," J. Elektro, vol. 06, no. 02, pp. 2–7, 2022.
- [3] D. Darmawansyah, M. K. A. Rosa, and I. N. Anggraini, "Sistem Proteksi Motor Induksi 3 Fasa Terhadap Berbagai Gangguan Menggunakan Mikrokontroler," J. Amplif. J. Ilm. Bid. Tek. Elektro Dan Komput., vol. 10, no. 1, pp. 9–17, 2020, doi: 10.33369/jamplifier.v10i1.15168.
- [4] Safaruddin, "Jurnal Kotamo," J. Kotamo, vol. 2, no. 3, pp. 1–9, 2022, [Online]. Available: https://www.researchgate.net/publication/359123883_STANDARDISASI
- [5] U. Teori, "STUDI TENTANG SISTEM PROTEKSI MOTOR INDUKSI 3 PHASA DI PT. PLN NUSANTARA POWER UPDK BELAWAN," pp. 416–427, 2023.
- [6] T. Puspita and I. Akbar Darmawan, "Thermal Overload Relay (TOR) Sebagai Sistem Proteksi Motor Induksi 3 Fasa Pada Mesin Molding Biofuel Pelletizer Di PT. Sejin Lestari Furniture," Jtmei, vol. 2, no. 2, pp. 168–181, 2023, [Online]. Available: <https://doi.org/>
- [7] P. Protection, "Control and Automation For industrial applications Thermal overload Relay s".
- [8] R. Instalasi, S. Kontrol, M. Pompa, P. Air, B. Sistem, and P. Sekunder, "INSTALLATION DESIGN OF PUMP MOTOR CONTROL SYSTEMS FOR SUPPLIED," pp. 401–408, 2013.
- [9] S. I. Abood and J. Fuller, Power System Protection and Relaying. 2023. doi: 10.1201/9781003394389.
- [10] Darmala and M. A. Kesatria, "Analisa Perhitungan Proteksi Motor Induksi 3 Fasa (200Kw, 132Kw, 75Kw) Dengan Thermal Overload Relay Pt. Tanjungenim Lestari," pp. 5–25, 2019.
- [11] D. Pt and M. Power, "Analisis Kinerja Motor Induksi Tiga Fasa 2 , 2 kW," vol. 7, no. 2, pp. 16–24, 2023, doi: 10.31849/sainetin.v7i2.9639.
- [12] W. Utama and B. Syairudin, "Perencanaan dan Pengendalian Proyek Konstruksi dengan Metode Critical Chain Project Management dan Root Cause Analysis," J. Tek. ITS, vol. 9, no. 2, 2021, doi: 10.12962/j23373539.v9i2.54339.
- [13] R. Wiryatama, D. A. Asfani, and D. Fahmi, "Analisis Karakteristik Busur Api Listrik Tegangan Rendah Pada Hubung Singkat Langsung Melalui Sinkronisasi Penginderaan Termal Bunga Api Dan Arus Hubung Singkat," J. Tek. ITS, vol. 6, no. 1, 2017, doi: 10.12962/j23373539.v6i1.21148.
- [14] F. Abidin, M. Pujiantara, and D. F. U. Putra, "Optimasi Total Operating Time Rele Arus Lebih dengan Pertimbangan Konfigurasi Mesh, Open-mesh, dan Radial Menggunakan Firefly Algorithm," J. Tek. ITS, vol. 9, no. 2, 2021, doi: 10.12962/j23373539.v9i2.53424.
- [15] D. Immanuel, Y. Ambabunga, and M. Lumembang, "Analisis Fuse Cut Out Sebagai Pengaman Transformator Distribusi Tegangan 20 Kv Menggunakan Software Etap," J. Dyn. Saint, vol. 7, no. 2, pp. 15–20, 2023, doi: 10.47178/dynamicsaint.v7i2.1880.
- [16] A. K. Tama, L. Anggraini, and B. Tutuko, "Analisis Kinerja Manajemen Konstruksi Pada Proyek Gedung Digitasi Universitas Negeri Semarang," J. Tek. Sipil, pp. 1–15, 2020.
- [17] L. Belakang, "SOFT STARTING PADA MOTOR INDUKSI 3 FASA".
- [18] I. N. Sunaya and I. G. S. Widharma, "Analisis Koordinasi Over Current Relay Dan Ground Fault Relay Terhadap Keandalan Sistem," J. Ilm. Vastuwidya, vol. 3, no. 1, pp. 30–40, 2020, doi: 10.47532/jiv.v3i1.98.
- [19] H. Pradika and M. Moediyono, "Thermal Overload Relay Sebagai Pengaman Overload Pada Miniatur Gardu Induk Berbasis Programmable Logic Controller (Plc) Cp1E-E40Dr-a," Gema Teknol., vol. 17, no. 2, pp. 80–85, 2015, doi: 10.14710/gt.v17i2.8922.
- [20] F. Arvianto and M. Rameli, "Pengaturan Kecepatan Motor Induksi Tiga Fasa Menggunakan Metode Flux Vector Control Berbasis Self-Tuning PI," J. Tek. ITS, vol. 6, no. 2, 2017, doi: 10.12962/j23373539.v6i2.25079.

- [21] M. D. Mulyawan, I. N. S. Kumara, I. B. A. Swamardika, and K. O. Saputra, "Kualitas Sistem Informasi Berdasarkan ISO/IEC 25010: Literature Review," *Maj. Ilm. Teknol. Elektro*, vol. 20, no. 1, p. 15, 2021, doi: 10.24843/mite.2021.v20i01.p02.
- [22] B. Suhendro, L. M. Antoro, and S. Suroso, "Sistem Kendali Penggerak Motor Stepper Pada Orbital Welding Menggunakan Perangkat Lunak LabVIEW," *Pros. SNFA (Seminar Nas. Fis. dan Apl.*, vol. 5, pp. 47–56, 2020, doi: 10.20961/prosidingsnfa.v5i0.46593.

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