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Cooling System in Machine Operation at Gas Engine Power Plant at PT Multidaya Prima Elektrindo

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Abstract

In this work, it is reported that the development of technology makes the need for electrical energy in recent years has increased very rapid. PT Multidaya Prima Elektrindo is a company engaged in power generation using gas energy sources, namely the Gas Engine Power Plant. with a capacity of 2x6 MW. The energy produced by this plant will later be distributed to consumers through the State Electricity Company. Along with its use, generating machines continuously work for long periods of time. If this continues, there will be overheating of the engine which can cause a trip to the engine, to prevent a trip on the engine, monitoring the cooling system on the engine can prevent overheating which can cause a trip on the engine. By using a cooling system, the performance of the engine at the generator in generating energy is optimal. The processed data is weather data around the PLTG location and characteristic data from the gas turbine. The results of data processing are taken into consideration in choosing a cooling system. Other processing data in the form of cooling load is then used to design the components of the cooling system that will be applied. The results of the study show that reducing the outside air temperature entering the gas turbine compressor to 22 °C, can increase the output power of the PLTG gas turbine by more than 10 MW.

Keywords: *PLC, Gas Engine, Cooling System*

1. Introduction

Technological developments are growing and have provided many benefits in various aspects, one of which is the Gas Power Plant (PLTG) industry to support human survival. PLTG has a Cooling water system (CWS) for cooling gas turbines[1]. This system is one of the most important in PLTG. Before starting the gas turbine turning, the cooling system begins to cool the lube oil cooler and moves to the cooling water generator[2]. A Lube oil cooler is a cooling system in gas turbines using oil as well as a lubricant[3]. With the heat of the oil produced, it is necessary to have a lube oil cooler for gas turbines through a cold-water pipe[4]. This cooling system uses a heat exchange process system, namely a heat exchanger, where the cooled fluid is oil or air, while the cooling fluid is water[5].

Along with its use, generating machines continuously work for long periods of time[6]. If this continues, there will be overheating of the engine which can cause a trip to the engine, to prevent a trip on the engine, monitoring the cooling system on the engine to prevent overheating which can cause a trip on the engine[7]. Generators can produce electric power when the magnetic field in the generator is excited[8]. Due to the current flowing in the conductor, heat is generated[9]. Generators have many conductors and current flows through the conductors, creating a lot of heat[10]. If the heat is not "removed" it can cause the coil in the generator to be damaged (scald insulation so that a short can occur).

PLTG PT Multidaya Prima Elektrindo operates at a high average daily temperature of 33oC, this is much higher than the temperature normally applied to ISO, which is 15°C. This higher environmental temperature is one of the things that causes a significant decrease in output capacity. from gas turbines, the output capacity of the turbine is currently around 88 MW, this power is far less than the manufacturer's optimum power of 133.8 MW. Therefore, it is necessary to find a way to overcome this decrease in capacity, namely by lowering the temperature of the air entering the gas turbine compressor with the help of a cooling system. The aspects that will be discussed in this paper are weather conditions, the effect of compressor inlet air temperature on the turbine output work, and the selection of a cooling system.

2. Theoretical Review

Gas Engine Power Plant

Gas engine power plant is one type of power plant that uses gas energy as the main ingredient in generating or generating electrical energy[11]. The combustion of a gas engine in an electric energy generator will be driven by a mixture of gas and air. The gas used for

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engine combustion comes from Pertamina gas and the air comes from the compressor which will later be mixed in one gas line as fuel for the engine.

The type of generator that is usually used in its operation is using an AC generator, where there are 2 slip rings connected to each end of the coil so that the two ends of the coil do not touch each other, only connected to one slip ring continuously[12]. So, when the coil rotates it will cause an alternating current.

Figure 1. Electric Energy Generation Machine

Wartsila Engine Control System

Wartsila Engine Control System is a power generation set using a gas engine with a lean combustion four strokes, a turbocharger, and an intercooler. This engine is manufactured by the Wartsila company. WECS has the agility and flexibility that can help provide an efficient energy source[13]. The WECS engine used is the Wartsila 18V34SG type as the main driver to drive the ABB 3-phase AC generator in the power plant. The engine and generator will later be connected using a flexible coupling for 11 to ensure the generator and engine do not affect losses due to smaller deviations in temperature movement alignment or any dynamic freestyle. The Wartsila 18V34SG machine is connected to a PLC as a liaison between the Wartsila Operation Interface System (WOIS) and the Wartsila Information System Environment (WISE). WOIS that has been connected to WECS via PLC can later be monitored by the operator in regulating the operation of the power plant.

Programmable Logic Controller

Programmable Logic Controller (PLC) is an electronic system that operates a system digitally and is designed for use in industrial environments, where this system uses a programmable memory for internal storage[14]. Instructions that implement a system to control a machine or a process through digital or analog input/output modules. This PLC is assembled to replace a sequential relay circuit in a control system. In addition to being able to program a system, this tool can also be controlled and operated by operators who do not have knowledge in the field of computer operations in particular.

Components of the Engine Cooling System

In the engine cooling system, there are components needed to carry out the cooling process on the generator engine including 1. Preheater, 2. Three-way valve thermostat, 3. Radiator, 4. Charge air cooler, 5. The vessel, 6. Heat Exchanger, 7. Maintenance Water tank, and 8. Liquid Nalcool 2000.

Describe the research methods and research techniques

3. Research methods

In this study, the stages carried out by researchers were observations made at PT Multidaya Prima Elektrindo, a subsidiary of PT. Medco Power Energy is engaged in power generation using gas energy sources, namely Gas Power Plants with a capacity of 2x6 MW. The energy produced by this plant will later be distributed to consumers through the State Electricity Company (PLN). The company started commercial operations on 30 April 2008 and was placed under the management of Medco Power Indonesia on 29 July 2010 after being acquired by Medco Energi. In this gas-powered power plant, it supplies electricity to the area around the plant. During the observation, PT Multidaya Prima Elektrindo placed the writer in PLTMG SAKO, Kalidoni sub-district, Palembang. The author is placed in the control system section. One of the tasks in this section is to monitor the power generation system.

Figure 2. PT Multidaya Prima Elektrindo placed the writer in PLTMG SAKO, Kalidoni sub-district, Palembang.

Data collection was obtained from various books, journals and research on absorption chiller single effect water/lithium bromide system which has been carried out previously both domestically and abroad. From this data collection, the characteristics of each equipment in the absorption chiller single effect water/lithium

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bromide system in general are obtained. In addition, data in the form of the rate of exhaust heat from the gas turbine entering the HRSG and the discharge of ambient air through the system are also needed to determine cooling requirements. Furthermore, variations were made on the condenser temperature and flue gas temperature. This variation is done to determine the performance of the cooling system. Then in the PLTG system, a variation of the operating load scheme is carried out to determine the effect of the gas turbine system on the cooling that has been designed.

4. Results and Discussion

Generator Electrical System at PLTMG SAKO

The PT Multidaya Prima Elektrindo Gas Engine Power Plant has 2 modes, namely parallel grid and island mode. Parallel grid and island mode is a way to synchronize the generator of a power plant with the tower located at the nearest PLN to the power plant[15]. Currently, the generator has been connected to a parallel grid mode where the usage for synchron with the tower at PLN has been synchronized automatically. The energy generated from a generator with a capacity of 2x6 MW, namely, in Generator 1 the value that can actually be generated is 5925 kW of active power, the reactive power generated is 2430 kVAr, the power factor is 0.92 lag, and the maximum load when the engine is running at generator 1 of 5200 kW. Then on Generator 2, the actual value of the generator working on the active power is 5643 kW, the reactive power generated is 2736 kVAr, the power factor is 0.85 lag, and the maximum load when the engine is working on generator 2 is 5300 kW. The energy production output value written on the screen may vary based on the generator's performance[16].

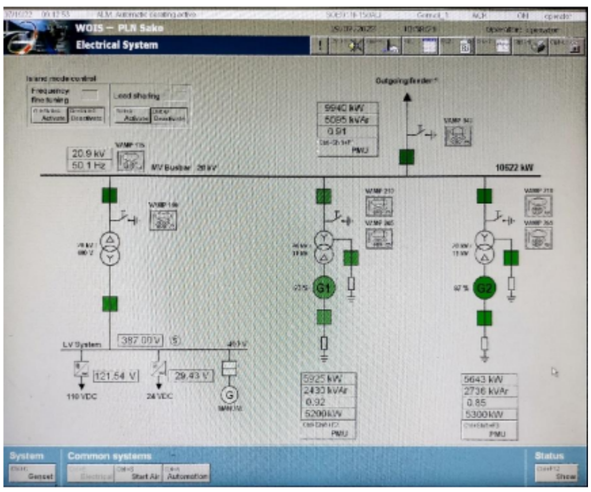

Figure 3. Generator electrical system at PLTMG SAKO

At each generator, the resulting voltage is 11 kV which will be stepped up on the transformer until the voltage reaches 20 kV. Then from the voltage that has been stepped up, it will be lowered from 20 kV to 400 V for daily use in PLTMG. From the energy that has been produced by each generator, it will be combined in the outgoing feeder to produce an actual value for the total energy of 9940 kW on active power, 5095 kVAr on reactive power, and 0.91 on power factor. The generator system contained in PLTMG SAKO can be seen more clearly in Figure 3.

Engine Cooling System at PLTMG SAKO

The cooling system is an important part of the operation of the power plant engine, where in order to produce maximum energy in the engine, a system is needed to maintain the temperature of the engine to remain optimal. In gas engine power plants, the cooling system is used to maintain the temperature of the gas or oil in the engine with the cooling medium being water[17]. The system schematic can be seen clearly in Figure 4.

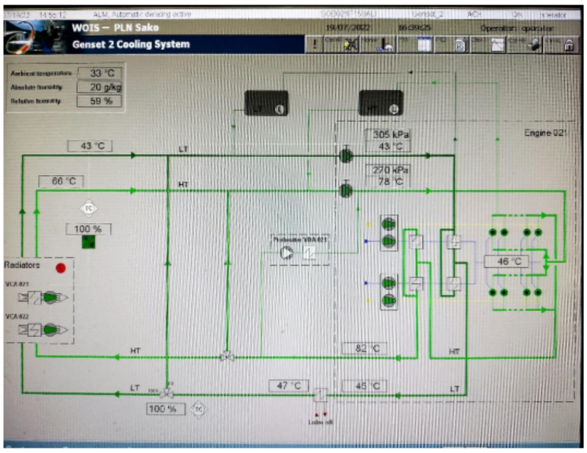

Figure 4. Schematic of the engine cooling system on PLTMG SAKO

In the cooling system scheme above, there are two main pipes in the cooling system, of which both pipes contain water as a cooling medium for engine temperature and oil contained in the engine[18]. The cooling system on the machine can be seen in the HT pipeline where the water in the pipe will be circulated so that the temperature on the machine remains stable in the temp range between 42-50 C then it will flow to the charge air cooler with an output temperature of 82 C, in this section the temperature water in the HT channel will be assisted by the LT pipe for cooling its temperature[19].

Figure 5 shows the net power increase of the gas turbine after the air cooling process. The results show the average increase in gas turbine net power at each operating load. When the compressor work is constant, the net power generated after cooling will increase. This is because the mass of air carried by the compressor increases due to the increase in air density so that the net turbine power produced is also greater. At a load of 224 MW, the net power of the gas turbine after cooling

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increases by 9.98%. The 323 MW load has a lower increase than the 224 MW load, which is 8.08%. For loads of 383 MW and 480 MW, the increase is 7.45% and 6.75% respectively.

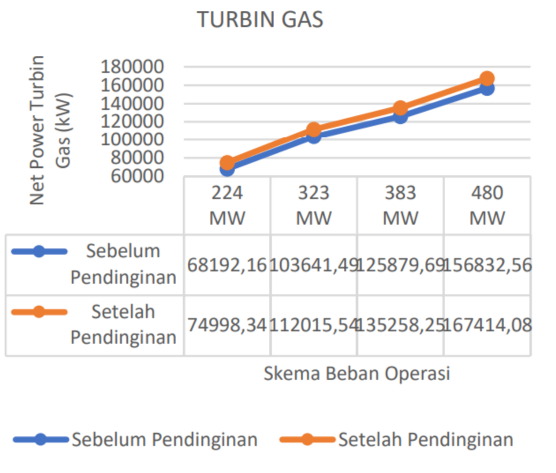

Figure 5. Estimation of additional gas turbine net power for each operating load scheme.

Figure 6 shows the increase in the mass flow rate of fuel required by the gas turbine system after the air cooling process. The results show the average addition of fuel at each operating load. This is because the combustion that occurs in the combustion chamber increases due to the increase in the mass flow rate of the air so that the need for fuel for the combustion process also increases. At a load of 224 MW, the need for fuel after cooling increases by 8.89%. The 323 MW load has a lower increase than the 224 MW load, which is 8.35%. For loads of 383 MW and 480 MW, the increase is 5.14% and 5.84% respectively.

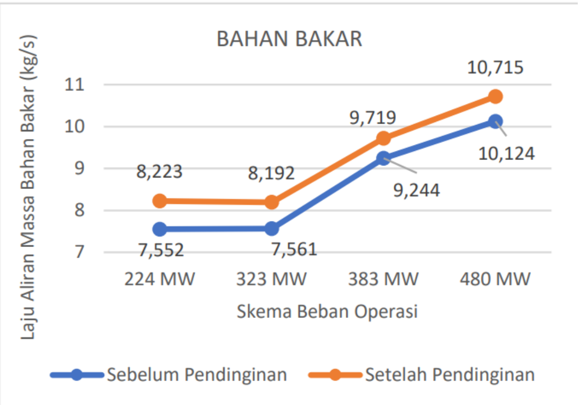

Figure 6. Estimated increase in fuel rate at each operating load scheme.

Figure 7 shows the increase in the efficiency of the gas turbine system. The results show an average increase in system efficiency at each operating load after the cooling process. At a load of 224 MW, the efficiency of the gas turbine system after cooling increases by 2.43% from before cooling. The 323 MW load has a lower increase than the 224 MW load, which is 1.11%. For loads of 383 MW and 480 MW, the increase is 1.17% and 0.99% respectively.

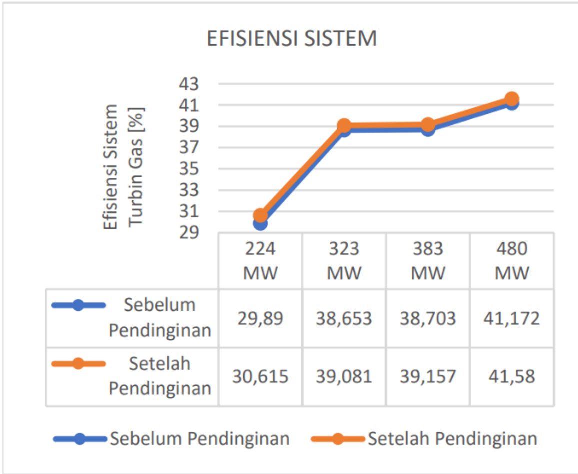

Figure 7. Estimated increase in the efficiency of the PLTG system for each operating load scheme.

The vessel contained in the cooling system scheme is used to store water for supply to the cooling line on the engine. Vessels are used to enter the water in the LT and HT pipelines when the machine is restarted after maintenance on the machine. In the engine cooling system, the LT channel is also the part used to cool the oil through the heat exchanger. The oil used in the engine also has an output temperature due to heating in the engine. In the oil section, the oil used will be filtered first on the lube oil filter before entering the engine so that the engine is protected from dirt in the oil. In the oil filter section, there are four filter tubes in the oil filtering process, where the process uses 3 main tubes as a place for oil filtration and another as a backup filter to serve as a backup filter in case of unwanted things, but these four tubes are also can be used simultaneously so that the oil will enter the engine can be filtered more cleanly. Then after the oil comes out of the engine the oil has a high temperature due to combustion in the engine. so that the oil can be reused it will be cooled in the heat exchanger.

In the engine cooling system, of course, there are several problems that will occur in the process of operating the engine[20]. Troubleshooting is carried out when there is an abnormality in the machine which can be seen on the monitor in the control room. If there are irregularities on the machine that has been connected by the PLC system, it will give an alarm signal to the problematic part. when a low-pressure alarm occurs on the pipe, the solution to make the system run normally again is by adding water to the problematic channel or by draining the problematic channel. Drain is the process of removing wind on pipes that have a low

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water pressure or exceed the normal limit of water pressure in the working cooling system.

5. Conclusion

In summary, in the cooling system for Gas Engine Power Plants (PLTMG) it can be concluded that this system is an important part of engine operation in gas engine power plants where the engine cooling process is carried out with water as a cooling medium. To keep the engine working optimally, the cooling temperature is needed in the engine, the parts that assist in the engine cooling process are heat exchangers, charge air coolers, and radiators which play an important role in the process. The higher the flue gas inlet temperature and the lower the condenser outlet temperature results in a more optimal cooling system performance. The cooling of the PLTMG intake causes the addition of fuel in each operating load scheme with an average added value of 7.05%. The net power generated by the gas turbines increased by an average increase of 8.07%. The efficiency of the gas turbine system also increased with an average increase of 1.43%.

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