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APPLICATION OF BYPASS HEATER SYSTEM FOR PREVENTION OF OVERCOOLING IN DIESEL ENGINES

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Abstrak:
The purpose of this study isto obtain solutions based on symptoms and causes in each component of the main machine support system. Industrial and agency activities are currently strongly influenced by the electricity supply from PLN. When the PLN electricity goes out, the generator will immediately turn on and all loads previously electrified by PLN power will move to the generator. This displacement occurs quickly and not gradually. Diesel engines (engines) will receive high loads when conditions are still not hot. Diesel engines take longer to heat compared to gasoline engines. This condition is referred to as overcooling. This study uses a bypass heater system to accelerate the healing process and prevent overcooling. Experiments that have been conducted show that the use of a heater as 3000 W for generators with a size of 400 kVa can reduce the heating period by 17 minutes (54%). In addition, it can reduce fuel consumption by an average of 0.5 lt/h during the heating period.

Keywords: Genset; Over Cooling; Diesel Engine Heater.

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INTRODUCTION

Electricity blackouts are a very frequent problem in Indonesia. Moreover, outside the Java-Bali area which is already integrated with the electricity network. Figure 1 shows the number and area of electrical disturbances. South and Central Kalimantan provinces are the areas with the highest frequency of power outages in Indonesia (Wandaliya, 2017). With the high frequency of power outages, many industries must provide backup power in the form of generator sets to keep activities running when there is a power outage (Asfara Mahendra, 2019). For large power, generators use diesel engines as power plants. Because it is an emergency, the generator generation system is designed to start immediately when electricity from PLN goes out. With this system, industrial activities will not be disrupted. The move from PLN supply to generator sets occurs quickly and not gradually. Diesel engines (engines) will receive high loads when conditions are still not hot even though diesel engines require a longer time to heat compared to gasoline engines. This condition is referred to as overcooling. Overcooling is the opposite condition to overheating. Overcooling events occur when the engine temperature is running below the temperature it should be.

Some of the consequences that occur due to the influence of overcooling conditions include faster wear (Deng et al., 2018);(Xin, 2013);(Lodi et al., 2020). This is because lubrication is not complete when the temperature is still cold and has high emissions (Deng et al., 2018). Engines that run at temperatures lower than working temperatures will produce CO, NOx, and HC pollutants that are more fuel-wasteful (Xin, 2013).

According to Mitchell (2009) Factory standard cooling systems usually present two problems. First, the disadvantages associated with the operation of mechanical components at high rotational speeds are caused due to their mechanical linkage. This not only reduces overall engine power but increases fuel consumption. Second, overcooling can occur because the speed of the water pump is directly proportional to the speed of the engine. In cold conditions, the pump speed should be reduced to heat faster.

Several studies have been conducted to overcome overcooling and accelerate engine warm-up processes. Modifications are carried out both mechanically, electrically, and chemically. Mechanical modifications are made by Ibrahim (2017) By utilizing the wasted heat of the exhaust around the turbocharger to accelerate the heating of the coolant. Chalgren (2004) and Mitchell (2009) Modify the valve on the thermostat to speed up the warm-up time. While other studies state that using a thermostat with a variable opening system can reduce engine warm-up periods and significantly reduce CO2, CO, HC, and smoke exhaust emissions (Mohamed, 2016). Research using heat storage can also accelerate heating in winter (Vasiliev et al., 1999). Some use fans with variable speeds to speed up the heating period (Nunney, 2007). The use of nanofluids (Al2O3) is also able to speed up the warm-up process. Ghasemi Zavaragh (2017) conducted research using air injection and managed to accelerate the heating time by 33.3%.

This study discusses the use of engine heaters to prevent overcooling in industries that use diesel engines as power plants during emergencies with a high frequency of power outages.

The purpose of this study isto obtain solutions based on symptoms and causes in each component of the main machine support system. The benefits of this research are to increase work productivity, namely increasing work efficiency to overcome diesel engine problems and the results of work solutions Time saving in solving complex problems.

METHOD

Overcooling can damage the engine just as much as overheating. Overcooling occurs when the engine operates below its normal operating temperature (Kamal & Khan, 2021). This condition can be exacerbated if using high-sulfur fuels. High sulfur fuels increase wear if the temperature is not more than 80 °C [13]. So far, many people are more concerned about overheating and pay less attention to the possibility of overcooling. Overcooling causes the same impact as overheating (Anwar & Oktofan, 2020). Engines that operate below normal temperatures produce poor combustion, fuel waste, excessive heat dissipation, high wear on piston rings and liners, and high friction and noise (Xin, 2013). In addition, the condition of the overcooling cylinder causes the addition of corrosive and destructive acids (Sabde et al., 2021).

When the engine is started, in the first few cycles, the air pressure in the inlet manifold (Inlet Manifold Air Pressure, IMAP) is equal to atmospheric pressure, and the cylinders are filled. IMAP drops rapidly because the throttle valve is closed. In low-temperature conditions, sprayed fuel does not evaporate well (Luan & Henein, 1998). Diesel engines are the most efficient internal combustion engines in terms of fuel. However, diesel engine performance is less than optimal when the engine is cold (Lodi et al., 2020). Warm-up time is the transition time between engine start and engine operation that has reached its normal operation (Gao et al., 2019). This timeframe is a very important time for the engine. Failure in warm-up time can have an impact on damage to the engine.

In this transition period, fuel consumption and exhaust emissions are different from normal conditions. In addition, oil temperature, air temperature, and fuel that is still cold also have a bad impact on the engine. Combustion, while the engine is still cold, is inefficient because the engine walls are not yet hot (Chen et al., 2014). When the engine is still cold, the high viscosity of the lubricating oil results in higher friction losses. Friction losses in the engine during the initial stage of heating (about 20 ^{0}C ambient) can be up to 2.5 times higher than when the lubricant is already in operating conditions. In addition, the first few minutes of operation also result in higher exhaust emissions. Since the fuel in a diesel engine burns fuel with excess air, gases with a high content of NOx appear as a result of higher cylinder temperatures and pressures (Lodi et al., 2020). In addition, fine particles or soot in the form of HC that does not burn in diesel exhaust will also appear when conditions are cold.

Engine performance inefficiencies and higher emissions during cold engine conditions were studied in several studies. Research shows increased fuel consumption when the engine oil temperature is below 90 °C (Andrews et al., 2007). Other studies have shown that piston and connecting rod friction is higher when the oil temperature is below the working temperature (Daniels & Braun, 2006).

A detailed schematic layout of the test setup and technical specifications of the engine are presented in Figure 1 and Table 1, respectively. The experimental setup consists of a diesel engine, PTC (Positive Temperature Coefficient) electric heater, thermocouple, dynamometer, and measurement instruments integrated with the engine monitoring system on ET (Electronic Technician).

Table 1
Engine set-up specifications

1	*Engine type*	C13 ATAAC, I-6 4-*stroke water-cooled diesel*
2	*Genset type*	PRIME 280 ekW 350 kVA 50 Hz 1500 rpm 400 Volts
3	*Bore*	130.00 mm (5.12 in)
4	*Stroke*	157.00 mm (6.18 in)
5	*Displacement*	12.50 L (762.80 in3)
6	*Compression ratio*	16.3:1
7	*Aspiration*	*Air-to-air aftercooled*
8	*Fuel system*	MAUI
9	Governor type Cooling System	ADEM A4 control system
10	*Air Flow Restriction*	0.12 kPa
11	*Air Flow (max @ rated speed for radiator arrangement)*	398 m^3/min
12	*Engine Coolant Capacity*	14.2 L
13	*Radiator Capacity*	31 L
14	*Engine Coolant Capacity w/ Rad*	45.2 L
15	*Heat rejection to coolant*	113 kW

In this experimental study, fuel measurements were taken to measure fuel consumption during the heating process. A thermal camera is used to indicate the surface temperature of the engine.

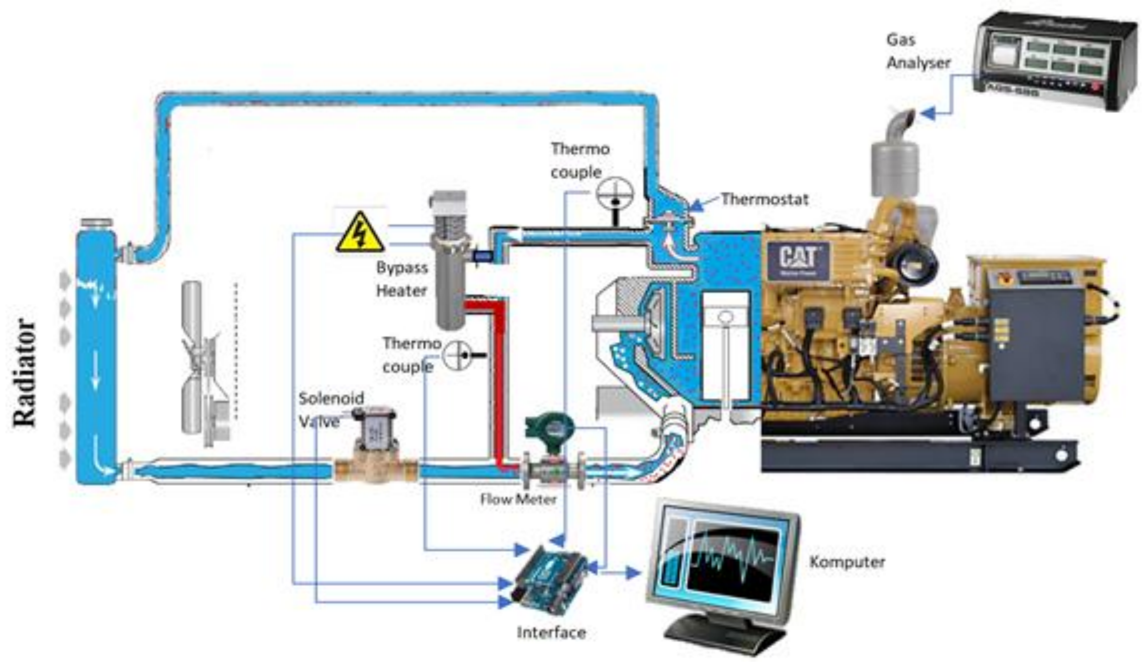

Figure 1: Experiment design

Engine speed is also measured by the ET system, as well as engine oil and oil pressure settings. All measurable data described above is collected and recorded on a computer. Things that will be analyzed in this study are as follows: (1) Warm-up time. Warm-up time becomes one of the significant parameters of engine characteristics. A shorter duration of heating time can reduce fuel waste and exhaust emissions. (2) Engine oil pressure. (3) Fuel consumption. To compare the effect of adding a bypass heater on fuel consumption.

RESULTS AND DISCUSSION

The effect of using a heater on achieving normal engine temperature (figure 2) shows that an engine *running* without using a heater requires normal engine achievement time at a temperature of 81 ^{0} C (C13 engine normal temperature specifications are 81-84 OC) with a time of 35 minutes while when using a heater time is needed to reach normal engine temperature i.e. 17 minutes.

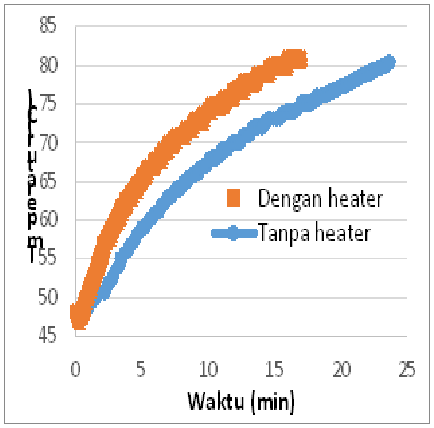

Figure 2: How the heater affects engine warm-up time

In Figure 2 it can be seen that when the engine starts at a temperature of 46 C then done with the engine running at 1450 RPM by comparing without the use of a heater to using a heater at an electric capacity of 3000 Watts. There is an acceleration in achieving engine thermature with an effective time of 18 minutes and this greatly helps the engine work according to its engine rate to reduce the occurrence of overcooling that occurs in the engine cooling system.

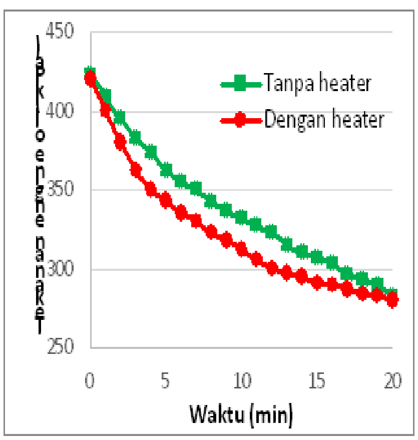

Figure 3: Decrease in engine oil pressure due to heater

Figure 3. The above shows the effect of using a heater on engine oil pressure. From the picture, it appears that the engine oil pressure in engines that use haters drops faster than without haters. Engine oil pressure is inversely proportional to engine heat. This is because it is related to the viscosity of the oil. The hotter the oil, the more viscosity decreases. So when the engine temperature rises, it will cause the engine viscosity to decrease. A decrease in viscosity causes the oil to flow more easily and has an impact on decreasing flow resistance caused by oil viscosity. With a decrease in flow resistance, the oil pressure in the engine will decrease as the

temperature increases. The use of a heater on the engine will accelerate engine warm-up so that oil pressure will also decrease faster.

Accelerating engine heating will be based on preventing overcooling of the engine. Overcooling the engine will occur if the engine temperature does not reach 77 OC. At the time of starting, it engin Prada in an overcooling condition. This condition causes the oil to have a high viscosity, and friction between engine components is also high. With the acceleration of heating through this heater system, engine conditions working at low temperatures will be passed faster. Thus reducing the risk of damage caused by overcooling conditions.

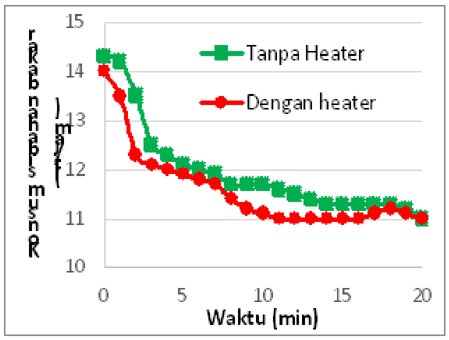

Figure 4: Fuel consumption overheating time.

Figure 4 shows the effect of heater use on fuel consumption. From the picture, it appears that the use of a heater will reduce fuel consumption. Fuel consumption will decrease with increasing warm-up time. Engine fuel consumption is related to engine efficiency. The more efficient the engine, the less fuel consumption. One of the factors that affect engine efficiency is losses in the engine. The biggest losses in the engine are frictional losses.

To reduce losses due to friction, engine oil is used. And the engine oil itself is affected by the settings. The higher the temperature, the lower the viscosity of the oil. The lower the viscosity, the easier it is for oil to flow into the engine lines. This is what causes a decrease in fuel consumption. With the installation of a heater, fuel consumption will decrease due to thinner oil in the engine. So that engine losses due to friction will be reduced.

CONCLUSION

Based on the analysis and discussion in the previous chapter, the following conclusions can be drawn: (1) Installation of heaters can accelerate the heating process from 37 minutes to 17 minutes (54%). (2) The heater system can reduce engine fuel consumption during the heating process. (3) The heater system reduces engine oil pressure faster. (4) The heater system can reduce the occurrence of adverse effects caused by engine overcooling.

The presence of an engine heater can reduce the effects of overcooling and reduce fuel consumption. However, on the other hand, it requires installation costs and electrical energy costs in the heater system itself. In this study, there has not been an economic calculation and analysis of the comparison of installation costs and costs incurred without heating installation. So this condition requires further research on the economic impact of using heaters from the engine.

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