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Design of Pump Installation Process for Automatic Oil Circulation in Generator to Lubricate the Engine

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Article Info	ABSTRACT
Keywords: Generator, Lubrication, Design	Genset (generator set) is a device that functions to generate electrical power. Referred to as a generator set with the understanding is a set of combined equipment from two different devices, namely the engine and generator or alternator. The engine as a rotating device while the generator or alternator as a generating device. Genset maintenance must be heated every day with a time range of 10-15 minutes for oil lubrication circulation in all parts of the engine. This is because the generator uses a battery that requires consistent battery charging. Based on the problems above, to carry out fuel efficiency in carrying out generator engine maintenance, a pump installation process design is carried out as an automatic generator oil circulation to lubricate the generator engine.
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INTRODUCTION

Genset (generator set) is a device that functions to generate electrical power. Referred to as a generator set with the understanding that it is a set of combined equipment from two different devices, namely the engine and generator or alternator. The engine as a rotating device while the generator or alternator as a generating device. For now, the generator is not used all the time and only at certain times if there is a power outage, therefore maintenance is needed so that the generator remains durable and in normal condition. Generator maintenance must be heated every day with a time range of 10-15 minutes for oil lubrication circulation in all parts of the machine. This is because the generator uses a battery that requires consistent battery charging. Generators (gensets) are widely used as backup power sources in various industries, including aviation, healthcare, and manufacturing. To ensure optimal performance and longevity, a genset requires a reliable lubrication system that continuously circulates oil to reduce friction and wear on engine components. Proper lubrication prevents overheating, minimizes mechanical damage, and enhances overall efficiency.

Conventional lubrication systems often rely on manual oil circulation, which presents several challenges. Delays in oil distribution can lead to increased friction, overheating, and accelerated wear of engine parts, ultimately reducing the genset's lifespan and increasing maintenance costs. Additionally, manual lubrication requires frequent monitoring and intervention, making it less efficient and prone to human error.

To address these issues, an automatic oil circulation system using a pump is proposed. This system is designed to ensure continuous lubrication by automatically circulating oil through the engine, eliminating the need for manual intervention. The integration of sensors to monitor oil pressure and temperature will enable real-time adjustments to optimize performance and prevent potential failures. This research aims to: Analyze the limitations of existing lubrication systems in gensets. Design an automatic pump installation for oil circulation. Evaluate the effectiveness of the proposed system in enhancing engine performance and reliability.

By implementing an automated lubrication system, genset maintenance can be streamlined, operational efficiency can be improved, and engine durability can be extended. This study will provide valuable insights into developing more efficient lubrication solutions for industrial and commercial generator applications.

Literature Review

Importance of Lubrication in Generator Engines.

Lubrication plays a crucial role in maintaining the performance and longevity of generator engines. According to Sharma et al. (2020), proper lubrication reduces friction between moving parts, minimizes wear and tear, and prevents overheating. Engine oil also helps in cooling internal components and removing contaminants that can accumulate over time (Smith & Johnson, 2018). Without an efficient lubrication system, genset engines are prone to increased mechanical failures and reduced efficiency.

Lubrication is a critical aspect of generator engine maintenance, ensuring smooth operation and preventing premature wear and tear of engine components. The primary function of lubrication is to reduce friction between moving parts, minimizing heat generation and mechanical degradation. Without proper lubrication, generator engines are susceptible to increased friction, overheating, and component failure, leading to costly repairs and reduced operational efficiency.

Generator engines consist of numerous moving parts, including pistons, crankshafts, and bearings, which constantly interact during operation. Without a sufficient layer of lubrication, metal-to-metal contact can occur, causing excessive wear and tear. Engine oil forms a protective film between these components, reducing friction and extending their lifespan (Sharma et al., 2020).

During operation, generator engines generate significant heat due to internal combustion and mechanical movement. Lubricating oil helps absorb and dissipate this heat, preventing overheating and thermal expansion of engine parts. Proper heat management ensures optimal engine performance and prevents damage caused by excessive temperatures (Smith & Johnson, 2018).

Lubricating oil also plays a vital role in cleaning the engine by removing contaminants such as dirt, debris, and combustion by-products. These impurities, if left unchecked, can accumulate and cause blockages in the oil passages, leading to inefficient lubrication and potential engine failure. Regular oil circulation helps flush out these contaminants and maintain engine cleanliness (Ahmed et al., 2021).

Engines are exposed to moisture and combustion gases that can cause corrosion of internal components. Lubricating oil contains additives that create a protective barrier, preventing oxidation and corrosion. This protection is particularly crucial for generators operating in humid or extreme environments, where corrosion risks are higher (Singh & Patel, 2022).

A well-lubricated generator engine operates more efficiently, with reduced energy losses due to friction. Proper lubrication also helps maintain engine compression, ensuring consistent power output and fuel efficiency. Studies have shown that inadequate lubrication can lead to increased fuel consumption and decreased engine performance (Li et al., 2021).

By minimizing wear, heat damage, and contamination, an effective lubrication system significantly extends the lifespan of a generator engine. Reduced mechanical failures translate to lower maintenance costs, fewer breakdowns, and increased reliability, making lubrication a cost-effective solution for long-term generator operation (Gonzalez et al., 2023). Lubrication is essential for the efficient and reliable operation of generator engines. It not only reduces friction and heat but also protects against contaminants, corrosion, and excessive wear. Implementing an automatic lubrication system can further enhance engine performance by ensuring consistent oil circulation, reducing manual maintenance requirements, and preventing unexpected failures.

Conventional Lubrication Systems in Gensets

Traditional genset lubrication systems rely on manual or semi-automatic oil circulation, where lubrication occurs based on preset intervals rather than real-time operational needs. Research by Brown (2019) highlights that conventional systems can lead to uneven lubrication, causing excessive friction in some parts while over-lubricating others, which can result in oil wastage and inefficiency. Additionally, manual lubrication requires frequent monitoring, increasing operational workload and human error risks (Ahmed et al., 2021). Conventional lubrication systems in generator sets (gensets) play a fundamental role in ensuring smooth engine operation by reducing friction, cooling engine components, and preventing wear and tear. These systems rely on a combination of oil reservoirs, pumps, filters, and distribution mechanisms to deliver lubricating oil to critical engine parts. A conventional genset lubrication system typically consists of the following key components:

a. Oil Reservoir (Oil Sump) – Stores the lubricating oil and acts as the primary source of oil supply for the engine.
b. Oil Pump – Circulates the oil throughout the engine, ensuring continuous lubrication of moving parts.
c. Oil Filters – Remove contaminants and impurities from the oil before it reaches engine components.
d. Oil Passages and Galleries – Channels within the engine that direct the flow of oil to critical areas such as the crankshaft, camshaft, and bearings.
e. Oil Cooler (Optional) – Some gensets are equipped with an oil cooler to regulate oil temperature and prevent overheating.

In a conventional genset lubrication system, oil is drawn from the reservoir by the oil pump and distributed through oil galleries to lubricate moving parts. The excess oil drains back into the sump, where it is recirculated. The process follows these steps:

1. Oil Pickup: The pump draws oil from the sump through a pickup tube.
2. Oil Filtration: The oil passes through a filter to remove dirt and contaminants.
3. Oil Distribution: The cleaned oil is sent through oil passages to lubricate the crankshaft, bearings, pistons, camshaft, and other moving parts.
4. Oil Cooling (if applicable): The oil passes through an oil cooler to dissipate heat before recirculating.
5. Oil Return: The used oil drains back into the sump, where the cycle repeats.

While conventional lubrication systems are widely used, they have several limitations:

1. Manual Monitoring and Maintenance: Regular oil checks and changes are required to maintain efficiency.
2. Inefficient Oil Circulation: Delays in oil distribution during startup can cause temporary wear due to dry friction.
3. Oil Degradation: Over time, oil loses its viscosity and lubrication properties, requiring periodic replacement.
4. Risk of Oil Starvation: If the oil level is too low or the pump fails, the engine may experience inadequate lubrication, leading to damage.

To overcome the limitations of conventional systems, modern gensets are increasingly adopting automatic lubrication systems. These systems ensure continuous and optimal oil circulation, reduce manual maintenance efforts, and enhance engine longevity. By integrating sensors, automated pumps, and real-time monitoring, automated lubrication systems offer improved reliability and efficiency compared to conventional methods. Conventional lubrication systems in gensets are essential for engine performance and longevity. However, their dependence on manual maintenance and susceptibility to inefficiencies highlight the need for advanced solutions such as automated lubrication systems. Transitioning to automated oil circulation can enhance reliability, reduce wear, and improve overall generator efficiency.

Automated Oil Circulation Systems

Recent advancements in lubrication technology have introduced automated oil circulation systems that use pumps to distribute oil continuously based on real-time monitoring. A study by Chen et al. (2020) demonstrated that automated lubrication systems improve efficiency by maintaining optimal oil pressure and reducing overheating risks. These systems utilize sensors to monitor oil levels, temperature, and viscosity, ensuring proper lubrication even in extreme conditions (Singh & Patel, 2022). Automated oil circulation systems are an advanced solution designed to enhance the lubrication process in generator sets (gensets). These systems operate without the need for manual intervention, ensuring a continuous and optimal supply of lubricating oil to engine components. By integrating sensors, automated pumps, and control mechanisms, they improve efficiency, reduce maintenance needs, and prolong engine life. An automated lubrication system typically consists of the following components:

1. Oil Pump (Automated) – A motorized pump that circulates oil continuously or at scheduled intervals.
2. Oil Reservoir – Stores the lubricating oil and ensures an adequate supply.
3. Sensors and Control Unit – Detects oil pressure, temperature, and flow rate, ensuring real-time monitoring.
4. Solenoid Valves – Automatically regulate the flow of oil based on system requirements.
5. Oil Filters – Removes contaminants from the oil before circulation.
6. Oil Coolers (if applicable) – Helps regulate the oil temperature to maintain efficiency.

Automated lubrication systems operate through a series of programmed functions that ensure continuous and controlled oil distribution. The process follows these steps:

1. Oil Level and Condition Monitoring: Sensors continuously check the oil level, viscosity, and temperature.
2. Automatic Oil Pump Activation: Based on engine operation or sensor readings, the system activates the oil pump to start lubrication.
3. Controlled Oil Distribution: Solenoid valves direct the oil to critical engine components, ensuring even distribution.
4. Real-time Adjustments: The system dynamically adjusts the oil flow rate depending on engine load and temperature.
5. Oil Filtration and Cooling: The circulated oil passes through filters and coolers to maintain optimal performance.
6. Shutdown Protection: If oil pressure drops below a safe threshold, the system triggers an alert or emergency shutdown to prevent damage.

Automated oil circulation systems offer a modern, efficient, and reliable solution for maintaining optimal lubrication in genset engines. By eliminating manual processes and integrating smart control mechanisms, these systems enhance engine performance, reduce operational risks, and improve overall reliability. Transitioning from conventional lubrication to automated systems is a step toward better genset maintenance and energy efficiency.

Implementation of Pump-Based Lubrication Systems

Pump-based lubrication systems have been widely adopted in industrial applications due to their efficiency and reliability. Research by Li et al. (2021) indicates that the use of automatic oil pumps in diesel engines significantly reduces wear and extends engine life. Similarly, Gonzalez et al. (2023) found that integrating microcontroller-based oil circulation systems can optimize lubrication processes, preventing mechanical failures and reducing maintenance costs. Despite the advantages of automated lubrication, there are challenges in designing an effective system. Factors such as oil viscosity, pump efficiency, and sensor accuracy must be considered (Rodriguez & Kim, 2021). Additionally, the cost of implementation and system maintenance may impact the feasibility of widespread adoption (Jones & Walker, 2020).

Based on the existing research, it is evident that automated lubrication systems, particularly pump-based oil circulation mechanisms, offer significant advantages in genset maintenance. These systems enhance efficiency, reduce operational costs, and prevent engine damage. However, careful design considerations must be taken into account to ensure the system's reliability and effectiveness. This study aims to develop an optimized automatic oil circulation system for gensets, leveraging existing research while addressing the identified challenges.

RESEARCH METHODS

To achieve fuel efficiency in performing generator engine maintenance, the author will raise the topic "Designing a Pump Installation Process as an Automatic Generator Oil Circulation to Lubricate Generator Engines at Halim Perdanakusuma International Airport". This design is carried out because the generator does not yet have a circulation pump so that the oil lubrication process is carried out simultaneously when warming up the generator.

Machines that are not lubricated first are likely to experience friction and wear between two surfaces that rub against each other in the machine or equipment. Because of this, the airport can suffer losses ranging from millions in cost. The research methodology for the design and implementation of an automated oil circulation system for generator lubrication consists of several key stages. These stages include system design, component selection, installation, testing, and evaluation. The following steps outline the methodology used in this study: This study employs an experimental approach by designing and implementing an automated lubrication system on a generator set (genset). The performance of the system is evaluated through observation and data analysis. The system is designed to replace conventional lubrication methods with an automated pump-driven oil circulation mechanism. The following aspects are considered:

a. System Requirements Analysis: Identification of lubrication needs based on genset specifications (oil type, pressure, flow rate).
b. Schematic Design: A flowchart and wiring diagram are created to illustrate the oil flow process, sensor placements, and control mechanisms.
c. Control Algorithm Development: A microcontroller-based control logic is developed to regulate the oil pump based on engine operation conditions.

The selection of system components is based on reliability, efficiency, and compatibility with the genset. The main components include:

a. Oil Pump: A DC-powered or AC-powered pump with adjustable flow rate.
b. Oil Reservoir: A tank to store and supply oil for circulation.
c. Sensors:
   1. Oil level sensor (to detect low oil conditions).
   2. Temperature sensor (to monitor oil temperature).
   3. Pressure sensor (to ensure adequate oil flow).
d. Control Unit: A microcontroller (e.g., Arduino or PLC) programmed to regulate oil flow.
e. Solenoid Valves: To control oil distribution to different parts of the engine.
f. Oil Filters: To remove contaminants and ensure clean lubrication.

The installation process involves the following steps:

1. Mounting the Oil Pump and Reservoir: The pump and oil tank are installed near the genset for optimal accessibility.

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2. Sensor Placement: Sensors are installed at key points to monitor oil pressure, temperature, and level.
3. Wiring and Control Unit Integration:
   a. The control unit is programmed to regulate the oil pump based on sensor feedback.
   b. Wiring connections between the microcontroller, sensors, and solenoid valves are completed.
4. Pipeline and Valve Installation: Oil circulation pipes and solenoid valves are properly arranged to ensure smooth oil flow.

After installation, the system undergoes testing under different operational conditions. The testing procedure includes:

1. Initial System Calibration: Ensuring all sensors and the control unit function correctly.
2. Lubrication Cycle Testing: Running the genset to observe how the automated system delivers oil and maintains proper lubrication.
3. Data Logging: Collecting data on oil pressure, temperature, and flow rate over multiple test cycles.
4. Failure Analysis: Simulating low oil levels or pump failures to test system response and safety mechanisms.

The effectiveness of the system is evaluated based on:

1. Lubrication Efficiency: Comparing oil distribution time and effectiveness against conventional methods.
2. Energy Consumption: Measuring power usage of the automated system.
3. System Response Time: Analyzing how quickly the system reacts to low oil levels or temperature changes.
4. Maintenance Reduction: Estimating the reduction in manual oil checks and maintenance frequency.

Based on the test results, conclusions are drawn regarding the feasibility and advantages of the automated oil circulation system. Recommendations for further improvements or adaptations to different genset models are also provided.

RESULTS AND DISCUSSION

Problem

Halim Perdana Kusuma International Airport is an airport that has a Synchronized Genset with a capacity of 1500KVA on each of its gensets. The Synchronized Gensets include the Kohler Genset as the Priority Genset and the Perkins Genset as the Back-up Genset. Based on the results of the warming up carried out every day, the genset engine is only lubricated by oil during warming up, so that when the genset is active and running to back up the airport's electricity, it is likely that the genset engine that is rarely lubricated by oil will experience friction that can accelerate engine wear and shorten engine life. The following is the current Genset warming up process.

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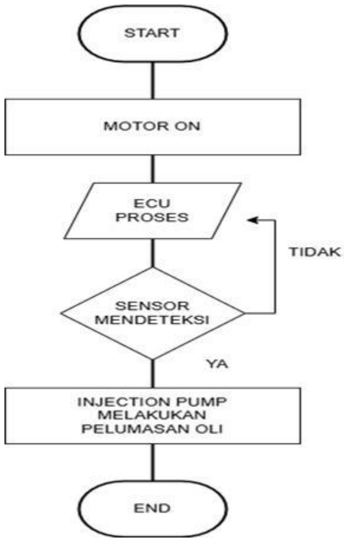

Figure 1. Current Genset Warming Up Flowchart

The current warming-up process, the engine on the Genset will only be lubricated by oil when warming up. Here is the current Genset design at Halim Perdanakusuma Airport.

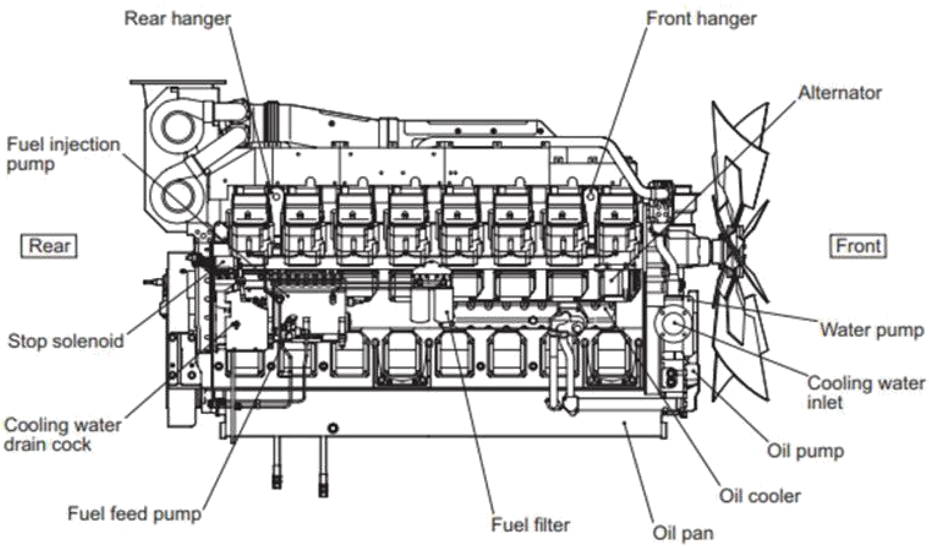

Figure 2. Current Genset Design

Problem Solving

The installation of a circulation pump as oil lubrication requires a design drawing that can facilitate the determination of the model and size of equipment needed in the pump installation process. In addition, to facilitate the lubrication process, a control panel is needed to automatically lubricate the engine twice a day. After being reviewed directly, there are parts of the Genset that will be installed:

Figure 3. Oil Pan
Source: Halim Perdanakusuma International Airport, 2024

Oil Pan is where the oil filling is done, in this oil pan there will be an addition of hydraulic hose water hose. After adding the hydraulic hose water hose, the oil pan will be connected to a hydraulic pump with the External Gear Pump type.

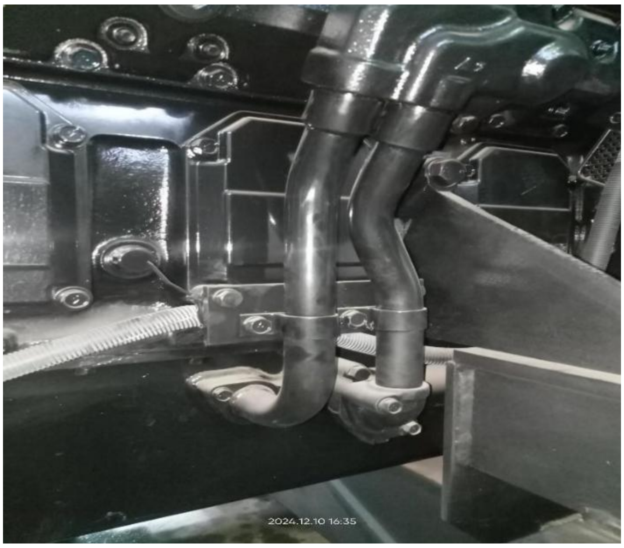

Figure 4. Oil Pump
Source: Halim Perdanakusuma International Airport, 2024

The hose on the Oil Pump is a channel that flows lubricating oil when the motor on the Genset moves during Warming Up. The Oil Pump Output hose (left) will be connected to the hydraulic hose water hose from the hydraulic pump. But before that, the hydraulic pump will be connected first by the control panel as an automation of the genset engine lubrication.

In this Oil Lubrication Circulation Pump Design, the author uses the Autocad application to draw the circulation pump and pump control panel. The pump that the author designed is a pump with one oil inlet or input and 2 outlets or outputs that will be connected to the Air Hose Hydraulic hose adjusted to the size of the part than the Oil pan of 2 inches. This Air Hose Hydraulic is capable of working with a maximum hose working pressure of 40 bar, 120 bar, or 3000 psi, this hose also functions as a fluid delivery tool. Because at the beginning of Warming Up, the generator provides oil pressure in the standard value range (0.3 MPa {3.1 kgf/cm2} [21 psi] or more) equivalent to 3 Watt 0.048 Liter and will increase to 0.39 MPa {4 kgf/cm2} [57 psi] or more equivalent to 3.9 Watt 0.124 Liter (Manual, 2018), the pump specifications that the author chose in the design are as follows:

Table 1. Pump Specifications

Output Power	375 Watt
Input Power	750 Watts / 5.5 A
Max Capacity	43 Liters/minute
Fan	Cooper (Impeller), Shaft (Brass)
Voltage	220V
Suction Height	8 m
Max Total Height	18 m
Pipe Size	1" x 1"

Furthermore, the control panel will be connected to the pump as a form of pump automation and manual access will also be provided as support for the bypass on the circulation pump to make it easier for technicians to operate it.

Oil Circulation Pump Design

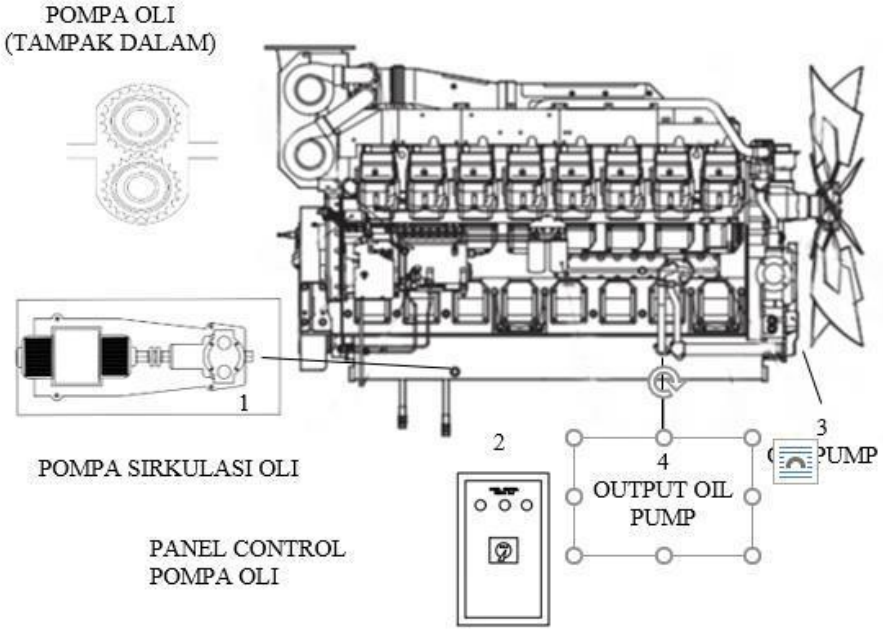

Figure 5. Circulation Pump Design

The Control Panel that has been assembled as in figure 5 will be connected to the circulation pump as a pump control during automatic and manual, using the Air Hose Hydraulic hose, the use of this hose functions to dampen or reduce vibrations when oil is flowed into the generator engine. For the automation process, the author connects the control panel with wiring as in the picture For the process of turning on the panel there are

2 ways, namely Auto and Manual. How to turn it on through the control panel that has been connected to the pump. Then, an indicator light, timer, and selector switch are provided which will later turn on the indicator light will light up on each component in the panel working as in figure 7 and figure 8.

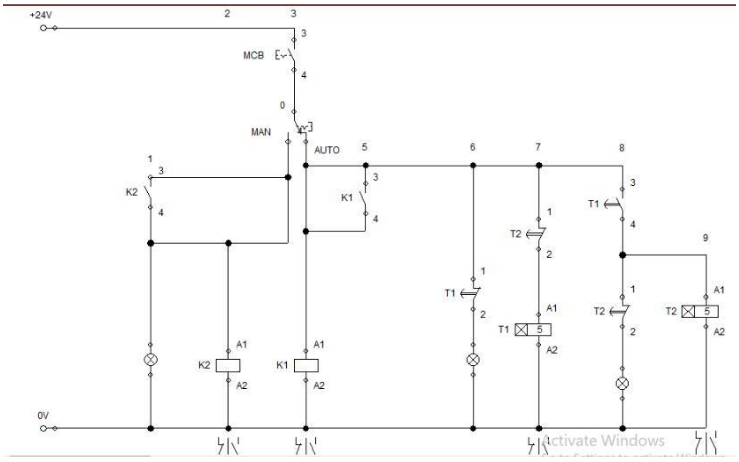

Figure 6. Wiring Panel

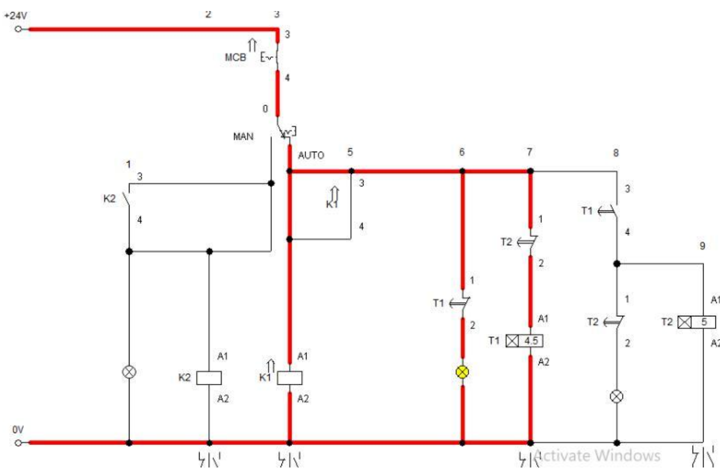

Figure 7. Auto Mode Panel when working

In auto mode, the pump will work as indicated by the timer (T1) turning on until the specified time. In auto mode, the pump that has stopped working to lubricate is indicated by a timer (T2) that lights up until the specified time.

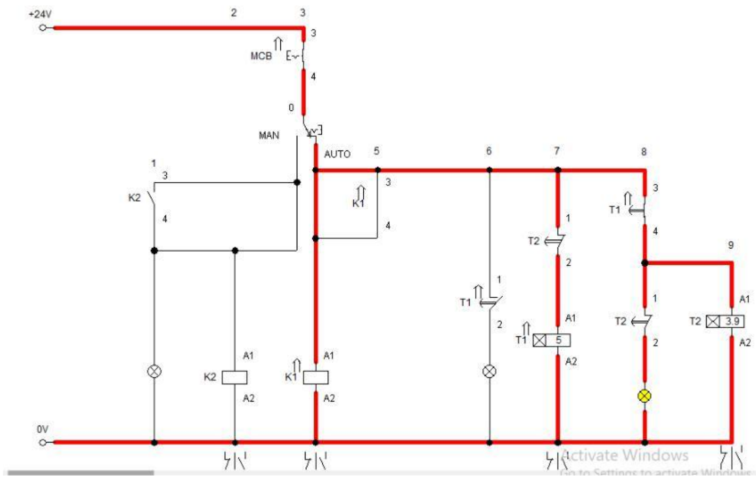

Figure 8.Auto Mode Panel when Stopped

Auto mode can indeed make it easier for technicians to lubricate the generator automatically. However, when suddenly damage occurs in auto mode, the lubrication process can be done manually by changing the selector switch to manual form as in Figure 9 below.

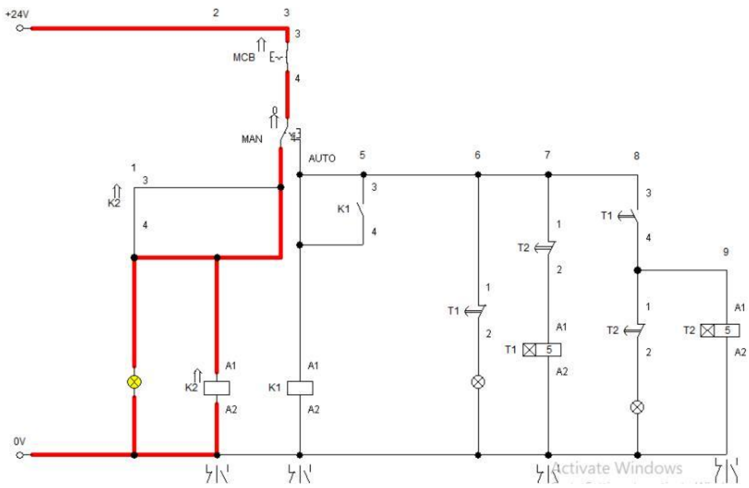

Figure 9.Manual Mode Panel

From the results of this design, efficiency in lubricating the generator engine will run well and reduce fuel usage [3].

CONCLUSION

The design of a pump installation process for automatic oil circulation in a generator has been successfully developed to enhance engine lubrication efficiency. This system ensures continuous and controlled lubrication, reducing wear and tear on engine components while improving overall generator performance. The key conclusions from this research are: Improved Lubrication Efficiency – The automated system ensures a consistent oil flow to critical engine parts, preventing friction-related damage and reducing the risk of

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overheating. Increased Generator Reliability – By maintaining proper lubrication at all times, the system minimizes mechanical failures, extending the operational lifespan of the generator. Reduced Maintenance Costs – Automation eliminates the need for frequent manual lubrication checks, reducing maintenance time and costs associated with engine repairs. Energy and Operational Efficiency – The pump system operates with minimal energy consumption and ensures optimal lubrication under varying load conditions. Enhanced Safety and System Responsiveness – The integration of sensors and control mechanisms allows real-time monitoring of oil levels, pressure, and temperature, preventing critical failures and ensuring safe operation.

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