

APPLICATION OF DIESEL ENGINE USING POWER PLANT

Abstract

A diesel power station, also known as a diesel power plant, employs a diesel engine as the primary driving force for electricity generation. Within such a station, the diesel engine serves as the prime mover. The diesel fuel undergoes combustion within the engine, and the resultant combustion products function as the working fluid, generating mechanical energy. This mechanical energy, in turn, drives an alternator that transforms it into electrical energy. Due to the relatively high cost of diesel fuel, diesel power stations are typically utilized for the production of smaller quantities of power. While steam power stations and hydroelectric plants are commonly employed for generating larger quantities of power at more economical rates, diesel power stations have gained popularity in areas with lower power demands, inadequate supplies of coal and water, and limited transportation options. The majority of the world's energy needs are met by a select group of conventional energy sources, collectively known as fossil fuels. Fossil fuels are naturally occurring energy resources formed through processes such as the gradual decomposition of organic matter buried deep beneath the Earth's surface. Over millions of years, this buried matter is subjected to heat and pressure in the Earth's crust, resulting in the formation of fossil fuels. These fuels primarily consist of carbon-rich substances such as coal, petroleum, and natural gas. Additionally, these diesel power stations also serve as standby generators to ensure a continuous power supply to critical facilities such as hospitals, radio stations, movie theaters, and telephone exchanges.

Keywords: Diesel Power, diesel engine, diesel fuel.

Authors

Benjamin Franklin Selvanayagam

Associate Professor
Department of Mechanical Engineering
Sri Ramakrishna Institute of Technology
Tamil Nadu, India.
benjaminfranklin.me@srit.org

Priyan K

UG Scholars
Department of Mechanical Engineering
Sri Ramakrishna Institute of Technology
Tamil Nadu, India.

Ragul Prasad N

UG Scholars
Department of Mechanical Engineering
Sri Ramakrishna Institute of Technology
Tamil Nadu, India.

Koushik S

UG Scholars
Department of Mechanical Engineering
Sri Ramakrishna Institute of Technology
Tamil Nadu, India.

Gokul G

UG Scholars
Department of Mechanical Engineering
Sri Ramakrishna Institute of Technology
Tamil Nadu, India.

Dr. S. Benjamin Franklin

Associate Professor
Department of Mechanical Engineering
Sri Ramakrishna Institute of Technology
Coimbatore, Tamil Nadu, India.

I. INTRODUCTION

While humanity has been harnessing solar, wind, and water energy for millennia, technological advancements have transformed these ancient energy sources into cutting-edge power generation methods. Power plants are categorized as follows: 1. Diesel power plants, 2. Coal-fired thermal power plants, 3. Gas thermal power plants, 4. Geothermal power plants, 5. Biomass thermal power plants, and 6. Nuclear thermal power plants. In a diesel power plant, the design and layout are relatively straightforward, occupying minimal space due to the small number and size of auxiliaries. These plants can be located virtually anywhere, start up quickly, and rapidly accommodate varying loads, all while minimizing standby losses. They demand a reduced quantity of water for cooling and offer a cost advantage over steam power stations of equivalent capacity. Furthermore, their thermal efficiency surpasses that of steam power stations, and they require fewer operating personnel. Coal-fired thermal power plants rely on coal as their primary energy source. In India, electricity production encompasses both conventional sources such as thermal, nuclear, and hydroelectric, as well as renewable sources like wind, solar, and biomass. Despite this diversified mix, a significant portion—75% of the total—is generated by coal-fired thermal power plants. Gas thermal power plants utilize gases or oils as their fuel source. A gas-fired power station, also known as a natural gas power plant, burns natural gas to generate electricity. Geothermal power plants harness underground fluids to produce heat and generate electricity. Biomass thermal power plants generate power using materials such as biases, rice husk, straw, cotton stalks, coconut shells, and more. Nuclear power plants employ nuclear fission to produce heat for electricity generation. The operational phase of a nuclear power plant typically endures the longest within its entire lifecycle.

II. ESSENTIAL ELEMENTS OF DIESEL POWER PLANT

- Air intake system
- Fuel supply system
- Cooling system
- Exhaust system
- Engine starting system
- Lubricating system

III. AIR INTAKE SYSTEM

This system is responsible for delivering the essential air required for fuel combustion in the engine. It comprises a network of pipes designed to supply fresh air to the engine manifold. Filters are incorporated into the system to eliminate dust particles from the air, which could potentially act as abrasives within the engine cylinder. Given the precise tolerances necessary to achieve the compression ratio in a diesel engine and the prevalence of turbocharged or supercharged diesel engines, it is imperative that the air entering the engine is clean, devoid of debris, and maintained at a low temperature. Furthermore, for enhanced efficiency in a turbocharged or supercharged engine, the compressed air must undergo cooling after compression. The air intake system is specifically engineered to perform these crucial functions. Air intake systems typically fall into one of two categories: wet or dry. In a wet filter intake system, as illustrated in Figure 1, the air is drawn or passed through a housing containing an oil bath that effectively removes dirt particles from the air.

Subsequently, the air flows through a screen-type material to ensure any residual oil is separated from the air. Conversely, in a dry filter system, materials such as paper, cloth, or metal screen are employed to capture and retain dirt particles before they enter the engine. Additionally to air purification, the intake system is typically designed to draw fresh air from a location as distant from the engine as feasible, usually situated just outside the engine's housing or enclosure. This ensures that the engine receives a supply of air that has not been heated by the engine's waste heat. The rationale behind maintaining the engine's air supply as cool as possible is that cool air possesses greater density than hot air. This translates to a higher oxygen content per unit volume in cool air compared to less dense, warmer air. Consequently, cooler air facilitates a more efficient fuel combustion process, resulting in increased power output. Following filtration, the air is directed by the intake system into the engine's intake manifold or air box. The manifold or air box plays the crucial role of directing the fresh air to each of the engine's intake valves or ports. In the case of a turbocharged or supercharged engine, the fresh air may undergo compression with a blower and potentially be cooled before entering the intake manifold or air box. Additionally, the intake system serves to minimize air flow noise.

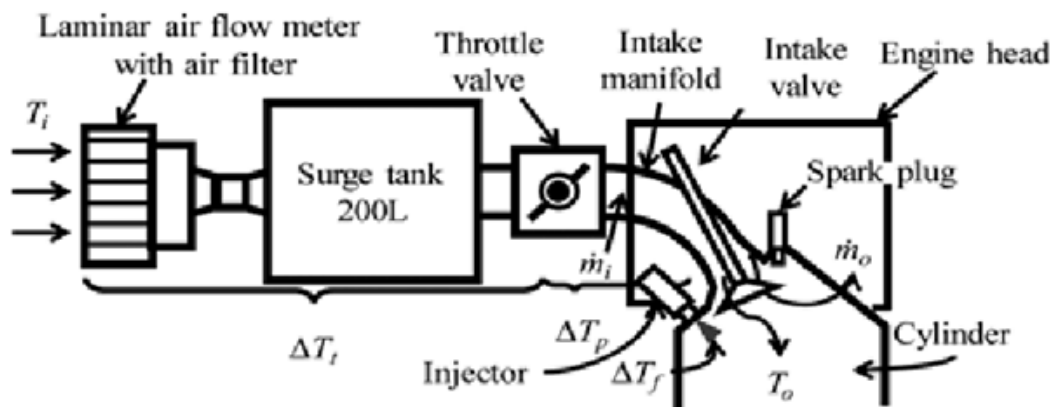


Figure 1: Air Intake System

IV. FUEL SUPPLY SYSTEM

The system comprises a storage tank, strainers, a fuel transfer pump, and an all-day fuel tank. Fuel oil is delivered to the plant site via rail or road and stored in the storage tank. Subsequently, the oil is pumped from the storage tank to a smaller all-day tank at daily or regular intervals. From this secondary tank, the fuel oil is then passed through strainers to effectively eliminate any suspended impurities. The purified oil is subsequently introduced into the engine via a fuel injection pump. A fuel supply system in a diesel engine provides measures, injects and atomizes the fuel. Thus, it is also referred to as the "heart" of an engine. Apart from it, the types of injectors directly affect how well an engine performs. Additionally, fuel injection systems are more expensive since they are produced with remarkable accuracy. Fuel will flow either due to gravity or through a fuel feed pump, which is available to give energy to an injection pump through a filter. Then, it supplies the cylinder heads' built-in injectors with fuel.

1. Types of Fuel Injection System

- **Air Injection System:** In this method, a compressor is used to compress the air to a very high pressure initially. Subsequently, fuel is pumped and metered to a nozzle, which is coupled to a high-pressure air source. The gasoline is then blasted into the engine by the air when this nozzle is opened, producing a finely atomized spray. Unfortunately, this approach is no longer in use due to the complexity and cost of the system.
- **Solid Injection System:** People mostly replace the injection method with this one. This is a direct injection of the atomised, under-pressure fuel into the combustion chamber. Above all, it requires a pump to supply the gasoline at high pressure (as high as 300 bar abs). Also, it can be further divided into the three following widely employed systems.
- **Common Rail System:** In this instance, filters allow fuel to pass from the storage tank to a low-pressure pump. The low-pressure pump moves fuel from the high-pressure pump to the common rail. As a result, high-pressure fuel is gathered in the common rail, and the necessary amount of fuel is then sent to the injectors and cylinders via metering devices. This method is typically used with multi-cylinder and Cummins engines.
- **Individual Pump System:** In this case, fuel passes through filters, low-pressure pumps, and the storage tank. This low-pressure pump distributes the fuel to 4 different metering and pressure pumps. The fuel will be pumped to individual injectors that are available in the cylinder heads using these independent metering and pressure pumps. Also, these are employed in big, slow-moving engines.
- **Distributor System**
In distributor systems, fuel will move from a storage tank through filters to the low-pressure pump, then to the metering and pressure pumps. This fuel distributor device distributes and sends the necessary amount of fuel to each injector and cylinder using the fuel metering and pressure pump. Later, it is made use of in small and medium-sized engines.
- **Multipoint Fuel Injection System:** At all engine speeds and loads, a multipoint fuel injection system is utilized to provide an air-fuel mixture of the right strength. It helps in providing the necessary quantity to each cylinder of a multi-cylinder engine.

2. Types of Nozzles: In diesel engines, there are 3 types of nozzles those are:

- **Single Hole:** These are nozzles with 0.2 mm diameter and are primarily used in combustion chambers. Good mixing of air is challenging in this case. Also, it has the tendency to dribble.
- **Multiple Holes:** The usual size of multiple hole-type nozzles is 0.35 to 1.5 mm and generally has 4 to 18 holes.

- **Pintle:** In this case, the spindle is equipped with a projection called a pintle. It prevents weak injection and dribbling, which peeks out from the nozzle's mouth. Moreover, you can also find a conical or cylindrical form of the nozzle to avoid dribbling.

3. Types of Injectors: Primarily, there are three types of injectors:

- **Air Blast Injectors:** These are utilized in systems that inject air. However, methods for injecting air are no longer used since they call for multistage compressors. Therefore, these injectors are no longer in use.
- **Mechanically Operated Injectors:** The same mechanism that was once used to run IC engine valves now operates them.
- **Automatic Fuel Injector:** All automotive CI engines use these Automatic Fuel Injectors. They consist of a needle valve that raises the fuel pressure. Apart from it, the gasoline pump is what generates this fuel pressure.
- **Electronic Fuel Injection System**

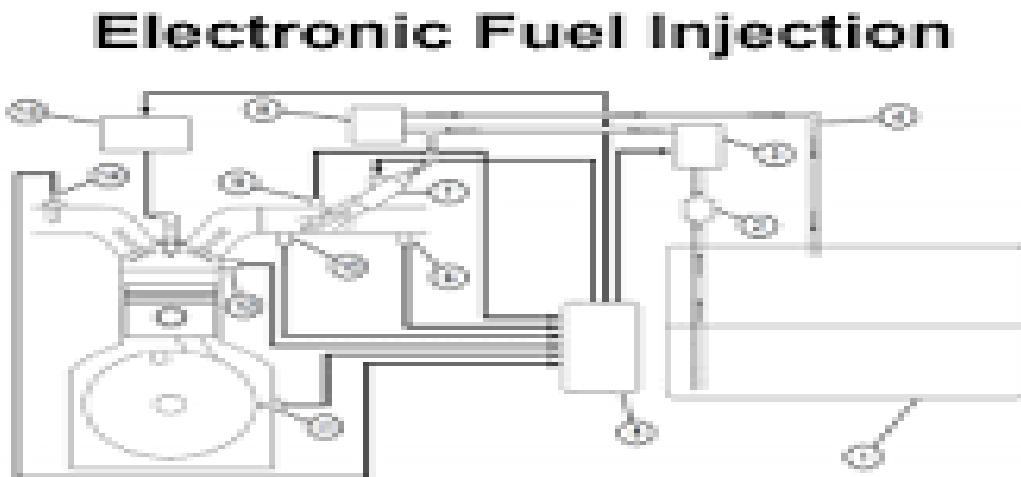


Figure 2: Electronic Injections System

Electronics were first introduced in 1965, and now electronic components account for about 30–40% of the cost of automobiles. In this regard, electronics and computers are used in cars to get maximum power and optimum economy. Electronic fuel injection systems use a variety of sensors to measure characteristics like temperature, gas pressure, throttle position, air flow rate, etc. Then the Electronic Control Unit (ECU), essentially a computer, receives this data via sensors. Later, this ECU processes the data and controls injectors or other devices to have optimum power, the best economy, and minimal emissions the goal of a diesel fuel system is constant regardless of the kind of fuel supply system used in a diesel engine. It involves injecting pressurized, atomized fuel into each engine cylinder precisely and on schedule. Combustion occurs in a diesel engine when hot compressed air and fuel surge come together.

V. COOLING SYSTEM

The engine cooling system comprises coolant pumps, water cooling towers or a spray pond, a water treatment or filtration plant, and connecting pipe works. During internal combustion, heat is generated, which powers the engine, but certain portions of this heat can elevate the temperatures of various engine components. Elevated temperatures can potentially cause permanent damage to the machinery. Therefore, it is imperative to regulate the overall temperature of the engine within acceptable limits. The cooling system in a diesel power station is designed precisely for this purpose. Its role is to transfer heat away from the diesel engine, maintaining its temperature within safe parameters. In this cooling system, a water pump circulates water through the cylinders of the diesel engine to dissipate the heat generated. To enable water reuse, a cooling tower is employed for this purpose. The cooling system necessitates access to a water source, a water pump, and cooling towers. The pump continuously circulates water through the engine's cylinders and head jacket, extracting heat from the engine, causing the water to become hot. Subsequently, the hot water is cooled by the cooling towers and returned for the cooling process in a continuous cycle.

1. Types of Cooling System

- **Open Cooling System:** A plant next to a river may use the water from the river to cool itself and then release the heated water back into the river. The term "open cooling system" refers to this kind of cooling system.
- **Closed Cooling System:** The Chilling Only water lost from leaks, evaporation, etc. is replaced by adding make-up water from the supply source after the water is repeatedly cycled.

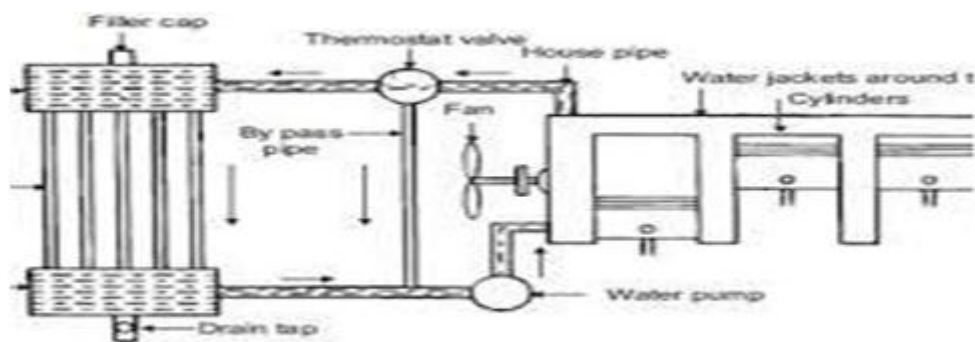


Figure 3: Engine Water Cooling System

VI. LUBRICATION SYSTEM

The engine lubrication system comprises components such as the lubricating oil pump, oil tanks, filters, coolers, purifiers, and connecting pipes. Its primary function is to supply lubricating oil to the moving parts of the engine in order to reduce friction between them and mitigate wear and tear on the engine components. This system effectively minimizes the friction between the engine's rubbing surfaces. In this system, lubricating oil is

initially stored in the main lubricating oil tank. From this reservoir, the oil is drawn using an oil pump and subsequently passed through an oil filter to remove any impurities present. Following the filtration process, the purified lubricating oil is distributed to various points within the machinery where lubrication is required. To maintain the temperature of the lubricating oil at an optimal level, an oil cooler is integrated into the system. The oil is cooled through a heat exchanger using cold water before being delivered to the engine.

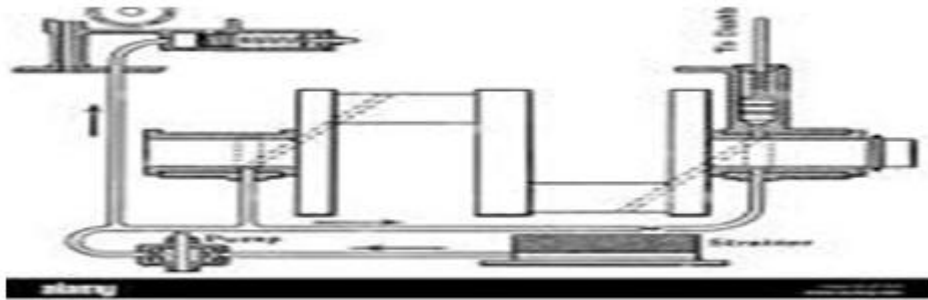


Figure 4: Engine Lubrication system

The exhaust system serves several essential functions, including the collection of exhaust gases from the engine cylinders, the removal of harmful substances, noise reduction, and the discharge of purified exhaust gases at a location within the vehicle that is away from passengers. Depending on the engine type, the exhaust system may comprise either one or two channels. It is crucial to carefully select the flow resistance to minimize any adverse impact on engine performance caused by exhaust backpressure. To ensure the optimal functioning of the exhaust system, it must be viewed as an integrated whole and designed accordingly. This entails the coordination of its components by design engineers to align with the specific vehicle and engine requirements. Every internal combustion engine naturally produces "exhaust noise" due to the rhythmic expulsion of gases from the cylinders. The mitigation of this noise is achieved through the reduction of sound energy in the exhaust gas flow, typically employing two fundamental approaches: sound absorption and sound reflection within the silencer. Often, both principles are combined within a single silencer. Additional sound-absorbing and sound-modifying elements, such as exhaust chambers, exhaust flaps, and even catalytic converters, can be employed to eliminate particularly undesirable frequencies from the exhaust noise.

VII. EXHAUST SYSTEM

The exhaust system itself represents a subsystem susceptible to vibrations, generating noise through inherent natural frequencies and vibrations that transmit to the vehicle's body. Therefore, meticulous coordination of the entire system is imperative. This encompasses the design and placement of individual exhaust system components and their flexible mountings. In addition to the multifaceted functions the exhaust system must perform, it is subjected to substantial stresses. Inside the cylinders, the fuel-air mixture undergoes rapid heating, reaching temperatures of up to 2,400 °C. Consequently, it expands significantly before being discharged into the exhaust system at supersonic velocities. This results in noise levels resembling the sharp crack of an explosion, necessitating a reduction of approximately 50 dB(A) as the noise travels from the engine exhaust valve to the exhaust system's terminus. In

In addition to enduring temperature and pressure stresses, the exhaust system must effectively handle vibrations emanating from the engine and the vehicle's body, as well as vibrations and impacts from the road surface. Furthermore, the exhaust system must resist corrosion from internal sources, including hot gases and acidic substances, as well as external factors such as moisture, splashed water, and saltwater. There is also the potential risk of catalyst poisoning due to the presence of sulfur or lead in the fuel.

The basic exhausts utilized in the past have virtually little in common with today's exhaust systems. In contemporary automobiles, they mostly comprise a front segment with

- the exhaust manifold,
- the purification system and
- The connecting pipes, together with a rear section with the silencer system and pipes.

The entire system is affixed to the floor pan using flexible mounting components. The quantity of catalytic converters and silencers is contingent upon factors such as the engine type, engine performance, and mandated emission standards. Were the exhaust system comprised solely of inflexible pipes, the rear silencer would experience pronounced vibrations, potentially leading to subsequent damage. Consequently, contemporary exhaust systems incorporate mass dampers and decoupling elements. These components serve to prevent significant deflections in the exhaust system and also mitigate the transfer of minor vibrations from the engine to the exhaust system, thereby averting the transmission of acoustic pulses into the interior. Mass dampers and decoupling elements play a dual role in enhancing ride comfort and prolonging the service life of the exhaust system.

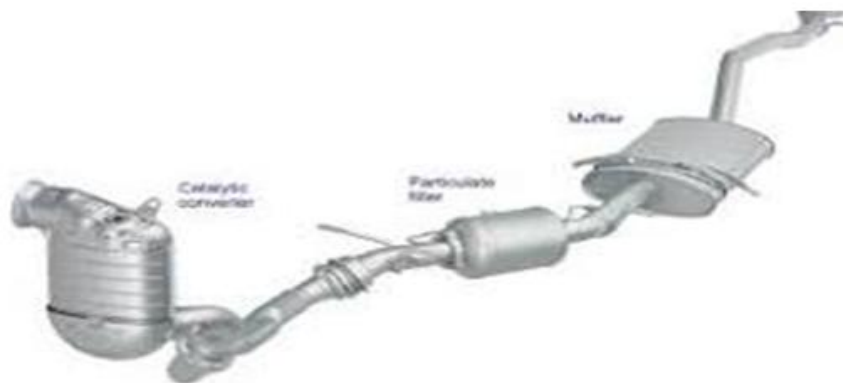


Figure 5: Engine Exhaust System

VIII. STARTING SYSTEM

The Significance of Starting Systems A functional machine relies on a running engine, and if the engine fails to turn over, it won't initiate. Therefore, a properly functioning and dependable starting system is indispensable for maintaining the productivity of a machine. Historically, electric motors have been the primary choice for cranking diesel engines to initiate the combustion process. In certain applications, an air or hydraulic motor can generate the necessary torque to rotate the engine. In the past, diesel engines were occasionally jump-started using a smaller gasoline engine referred to as a "pup engine." Another method involved initiating the diesel engine on gasoline and then transitioning it to

operate on diesel fuel. This presented a complex solution to a straightforward task since it required the engine to adjust its compression ratio, employ a spark ignition system, and utilize a carburetor. With the proliferation of 12V electrical systems and advancements in electric motor design, electric starters emerged as an effective solution. In many cases, larger diesel engines employ a 24V starting system to ensure even greater cranking power. A diesel engine necessitates rotation within the range of 150 to 250 rpm to initiate. The primary objective of the starting system is to supply the required torque to attain the minimum cranking speed. As the starter motor commences rotation of the flywheel, the crankshaft is set in motion, initiating piston movement. For a small four-cylinder engine, generating substantial starter torque is unnecessary. However, as engines expand in both cylinder count and piston size, a considerable torque output becomes essential to achieve the requisite cranking speed. In certain heavy-duty applications, 24V starters can produce torque exceeding 200 ft-lb, with this torque being further magnified by the gear reduction factor between the starter motor pinion gear and the ring gear on the engine's flywheel, typically around 20:1. In scenarios involving larger engines, multiple starters may be required. Some starters designed for sizable diesel engines can generate over 15 kW or 20 hp of power. When the starter motor sets the engine in motion, the pistons initiate upward travel within the cylinders during the compression stroke. A crucial requirement is to generate pressure ranging from 350 to 600 psi atop the piston. This pressure constitutes the principal resistance that the starter must overcome. It is this pressure that facilitates the creation of the necessary heat within the cylinder, ensuring that when fuel is injected, it can ignite. Should the starting system fail to crank the engine at a sufficient speed, the compression pressure and heat levels may not reach the required thresholds for fuel ignition. Insufficient piston speed can lead to compression leakage past the piston rings, and the rings may not be pressed against the cylinder properly, allowing compression pressure to escape into the crankcase. Under such circumstances, the engine either fails to start or starts with incomplete combustion, resulting in elevated emissions.

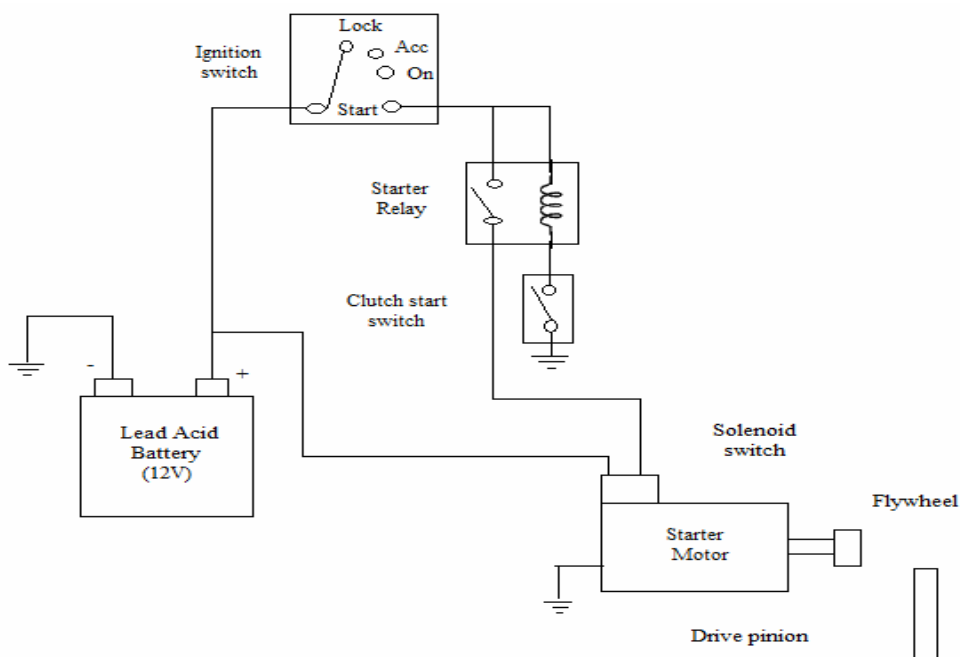


Figure 6: Engine Starting System

This underscores the importance of maintaining a properly functioning starting system. The speed at which a starter can crank a diesel engine directly affects its starting time and the efficiency of its combustion. This cranking task becomes notably more challenging in colder temperatures, particularly when the engine is responsible for directly driving other machine components like hydraulic pumps, a torque converter, or a PTO (power take-off) drive shaft. In colder conditions, cold engine oil imposes an additional load on the starter, which can be three to four times higher than what it would be in warmer weather. The incorrect viscosity of engine oil (too thick) for the temperature exacerbates the engine's rolling resistance. Furthermore, the battery's efficiency diminishes in cold weather. Consequently, when engineers design a cranking system, they must account for cold weather cranking challenges, often incorporating a cold weather starting option. This may involve the utilization of larger or multiple batteries, a higher output starter, thicker battery cables, battery blankets, oil heaters, diesel-fired coolant heaters, electric immersion coolant heaters (block heaters), and one or more starting aids like an ether injection system or an inlet heater. An additional challenge in modern starting systems arises from electronic controls integrated into certain engines. Some ECMs (Electronic Control Modules) require a minimum number of engine revolutions at a specific speed before they activate the fuel system. This translates to prolonged cranking times and greater strain on the cranking system. In some electronic engines, even when the engine is warm, they may crank for five seconds or more before the ECM initiates fuel injection and the engine starts. It is essential to ensure the proper operation of a machine's starting system, and understanding how its key components function is crucial.

IX. MAINTENANCE OF DIESEL ELECTRIC POWER PLANT

When it comes to diesel engines or diesel electric power plants, the following factors are taken into account throughout the maintenance phase.

- Maintaining the diesel engine's working condition every 30 minutes.
- To keep an accurate log sheet record of the instrument reading.
- To keep track of the temperature, pressure, electrical load, flow, and other parameters of the instrument.
- To routinely check the fuel oil level.
- Removed undesired contaminants from the fuel by filtering it.
- Regularly clean the gasoline tank.

X. ADVANTAGES OF DIESEL POWER STATION

- When it comes to design, this is straightforward.
- Extremely tiny room was needed.
- It might be made to be portable as well.
- The compact diesel generator set may be started quickly—it just takes a few seconds.
- It is also even easier to halt a small diesel power station when needed than to start one.
- There might not be any standby loss in the system because these machines are simple to start and stop as needed.
- With this kind of power plant, cooling is simple and requires less water.
- Compared to other kinds of power plants, the initial cost is lower.

- Compared to coal, diesel has a far higher thermal efficiency.
- Little involvement is not as significant as a steam power plant.
- It needs fewer staff members to operate.
- Compared to a steam power plant with the same capacity, the whole cost is substantially lower.

XI. DISADVANTAGES OF DIESEL POWER STATION

- As we've just discussed, diesel is much more expensive than coal. This is the primary reason why diesel power plants are not more widely used than alternative methods of producing electricity. Put otherwise, the plant's operating expenses are more than those of steam and hydroelectric power plants.
- The plant that often produces little amounts of power needed.
- Lubricants are expensive.
- Maintenance is expensive and highly involved.
- The plant cannot operate in overload situations for an extended amount of time.
- Lubrication usually comes at a considerable expense.
- In general, maintenance costs are expensive.

XII. APPLICATIONS

- Diesel oil is a fuel utilized in the production of electricity.
- It generates both DC and AC voltages.
- It's employed in situations where producing little electricity is necessary.
- Diesel engines are used in an emergency.
- It can also be utilized for peak loads for brief intervals of time.
- The boilers are restarted with its help.
- It's utilized in isolated areas.
- It is applicable in regions with low load factors.

XIII. CONCLUSION

Diesel fuel utilized the production of electricity used in the industrial purposes. It has generated the voltages. This power plant is used in the agricultural purposes. It has given very high thermal efficiency.