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NEWSLETTER FOR MANUFACTURING COMMUNITY

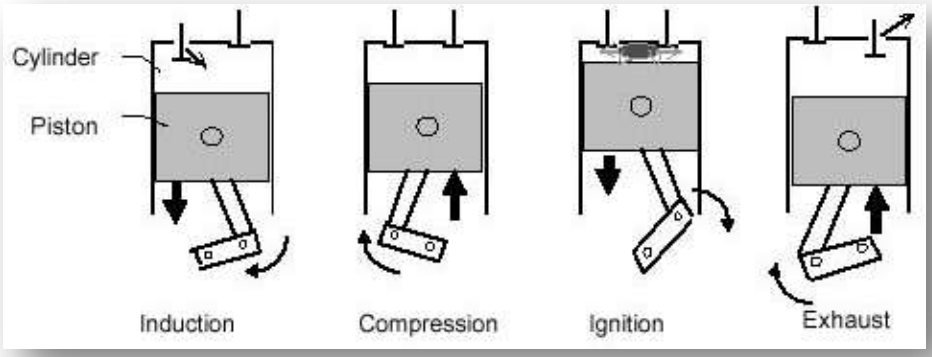
Introduction

Diesel engine is the prime mover, which drives an alternator to produce electrical energy. In the diesel engine, air is drawn into the cylinder and is compressed to a high ratio (14:1 to 25:1). During this compression, the air is heated to temperature of 700–900°C. A metered quantity of diesel fuel is injected, at high pressure, into the cylinder, which ignites spontaneously because of the high air temperature. Hence, diesel engine is also known as compression ignition (CI) engine. DG set can be classified according to cycle type two stroke and four strokes. However, majority of engines use four stroke cycle. Let us look at the principle of operation of the four-stroke diesel engine.

Four Stroke Diesel Engine

The 4 stroke operation in a diesel engine are: induction, compression, ignition, power and exhaust strokes.

1st: Induction (Suction) stroke - while the inlet valve is open, the descending piston draws fresh air.
2nd: Compression stroke - while the valves are closed, the air is compressed to a pressure of up to 25 bar.
3rd: Ignition and power stroke - fuel is injected, while the valves are closed (fuel injection actually starts at the end of the previous stroke), the fuel ignites spontaneously and the piston is forced downwards by the combustion gases.
4th: Exhaust stroke - the exhaust valve is open and the rising piston discharges the spent gases from the cylinder.



Since power is developed during only one stroke, the single cylinder four-stroke engine has a low degree of uniformity. Smoother running is obtained with multi cylinder engines because the cranks are staggered in relation to one another on the crankshaft. There are many variations of engine configuration, for example. 4 or 6 cylinder, in-line, horizontally opposed, V or radial configurations.

DG Set as a System

A diesel generating set should be considered as a system since its successful operation depends on the well-matched performance of the components, namely:

- Diesel engine and its accessories
- AC Generator (Alternator)
- Control systems and switchgear
- Foundation and power house civil works
- Connected load with its own components like heating, motor drives, lighting and others

It is necessary to select the components with highest efficiency and operate them at their efficient levels to conserve energy in this system.

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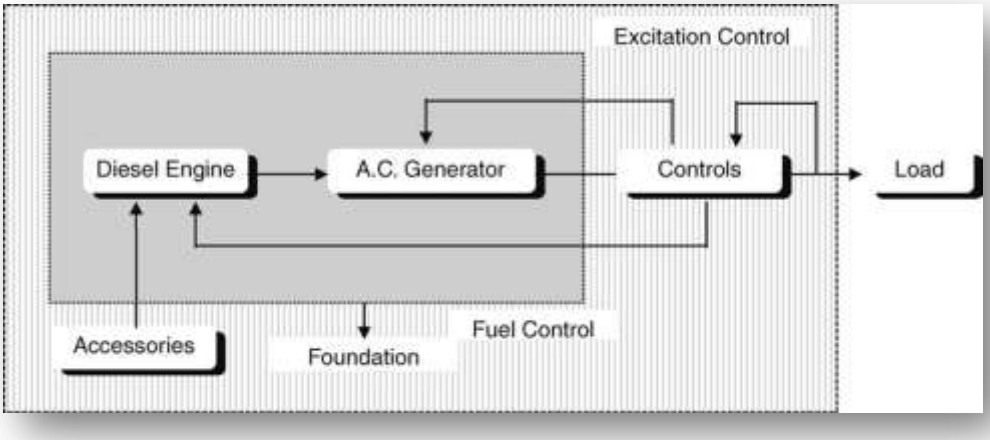
Selection Considerations



To make decision on the type of engine, which is most suitable for a specific application, several factors need to be considered. The two most important factors are: power and speed of the engine. The power requirement is determined by the maximum load. The engine power rating should be 10 – 20 % more than the power demand by the end use. This prevents overloading the machine by absorbing extra load during starting of motors or switching of some types of lighting systems or when wear and tear on the equipment pushes up its power consumption. Speed is measured at the output shaft and given in revolutions per minute (RPM). An engine will operate over a range of speeds, with diesel engines typically running at lower speeds (1300 – 3000 RPM). There will be an optimum speed at which fuel efficiency will be greatest. Engines should be run as closely as possible to their rated speed to avoid poor efficiency and to prevent build up of engine deposits due to incomplete combustion – which will lead to higher maintenance and running costs. To determine the speed requirement of an engine, one has to again look at the requirement of the load.

For some applications, the speed of the engine is not critical, but for other applications such as a generator, it is important to get a good speed match. If a good match can be obtained, direct coupling of engine and generator is possible; if not, then some form of gearing will be necessary - a gearbox or belt system, which will add to the cost and reduce the efficiency.

There are various other factors that have to be considered, when choosing an engine for a given application. These include the following: cooling system, abnormal environmental conditions (dust, dirt, etc.), fuel quality, speed governing (fixed or variable speed), poor maintenance, control system, starting equipment, drive type, ambient temperature, altitude, humidity, etc.

Suppliers or manufacturers literature will specify the required information when purchasing an engine. The efficiency of an engine depends on various factors, for example, load factor (percentage of full load), engine size, and engine type.

Diesel Generator Captive Power Plants

Diesel engine power plants are most frequently used in small power (captive non-utility) systems. The main reason for their extensive use is the higher efficiency of the diesel engines compared with gas turbines and small steam turbines in the output range considered. In applications requiring low captive power, without much requirement of process steam, the ideal method of power generation would be by installing diesel generator plants. The fuels burnt in diesel engines range from light distillates to residual fuel oils. Most frequently used diesel engine sizes are between the range 4 to 15 MW. For continuous operation, low speed diesel engine is more cost-effective than high speed diesel engine.

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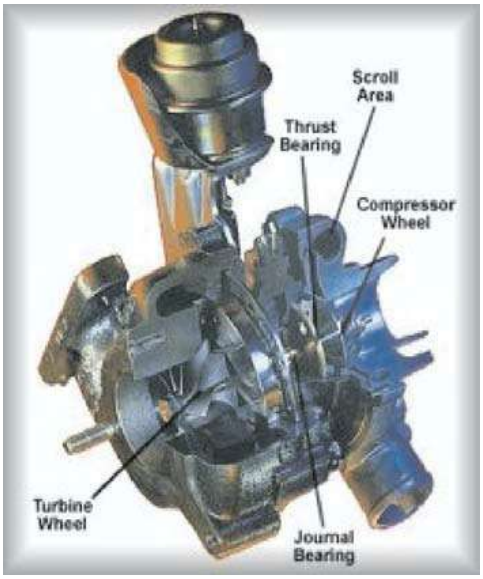
Advantages of adopting Diesel Power Plants are:

- Low installation cost
- Short delivery periods and installation period
- Higher efficiency (as high as **43 – 45** %)
- More efficient plant performance under part loads
- Suitable for different type of fuels such as low sulfur heavy stock and heavy fuel oil in case of large capacities
- Minimum cooling water requirements,
- Adopted with air cooled heat exchanger in areas where water is not available
- Short start up time

Diesel Engine Power Plant Developments

The diesel engine developments have been steady and impressive. The specific fuel consumption has come down from a value of 220grams/KWh in the 1970s to around 160grams/KWh in recent times. Slow speed diesel engine, with its flat fuel consumption curve over a wide load range (50%–100%), compares very favorably over other prime movers such as medium speed diesel engine, steam turbines and gas turbines. With the use of modern, high efficiency turbochargers, it is possible to use an exhaust gas driven turbine generator to further increase the engine rated output. The net result is lower fuel consumption per KWh and further increase in overall thermal efficiency. The diesel engine is able to burn the poorest quality fuel oils, unlike gas turbine, which is able to do so with only costly fuel treatment equipment. Slow speed *dual* fuel engines are now available using high-pressure gas injection, which gives the same thermal efficiency and power output as a regular fuel oil engine.



Selection and Installation Factors Sizing of a DG set:

a) If the DG set is required for 100% standby, then the entire connected load in HP / KVA should be added. After finding out the diversity factor, the correct capacity of a DG set can be found out.

Example:
Connected Load = 650 KW
Diversity Factor = 0.54
(Demand / connected load)

Max. Demand = 650 x 0.54 = 350 KW
% Loading = 70
Set rating = 350/0.7 = 500 KW
At 0.8 PF, rating = 625 KVA

b) For an existing installation, record the current, voltage and power factors (KWh / KVAh) reading at the main bus-bar of the system at every half-an-hour interval for a period of 2–3 days and during this period the factory should be having its normal operations. The non-essential loads should be switched off to find the realistic current taken for running essential equipment. This will give a fair idea about the current taken from which the rating of the set can be calculated.

For existing installation:
KVA = √3 V I KVA Rating = KVA / Load Factor where Load factor = Average KVA / Maximum KVA

c) For a new installation, an approximate method of estimating the capacity of a DG set is to add full load currents of all the proposed loads to be run in DG set. Then, applying a diversity factor depending on the industry, process involved and guidelines obtained from other similar units, correct capacity can be arrived at.

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High Speed Engine or Slow/Medium Speed Engine

The normal accepted definition of high speed engine is 1500 rpm. The high speed sets have been developed in India, whereas the slow speed engines of higher capacities are often imported. The other features and comparison between high and medium / slow speed engines are shown in the table.

Factor	Slow speed engine	High speed engine
Break mean effective pressure - therefore wear and tear and consumption of spares	Low	High
Weight to power ratio- therefore sturdiness and life	More	Less
Space	High	Less
Type of use	Continuous use	Intermittent use
Period between overhauls*	8000 hours	3200
Direct operating cost (includes lubricating oils, filters etc.	Less	High

Keeping the above factors and available capacities of DG set in mind, the cost of economics for both the engines should be worked out before arriving at a decision.

Capacity Combinations

From the point of view of space, operation, maintenance and initial capital investment, it is certainly economical to go in for one large DG set than two or more DG sets in parallel. Two or more DG sets running in parallel can be a advantage as only the short-fall in power–depending upon the extent of power cut prevailing - needs to filled up. Also, flexibility of operation is increased since one DG set can be stopped, while the other DG set is generating at least 50% of the power requirement. Another advantage is that one DG set can become 100% standby during lean and low power-cut periods.

Air Cooling Vs. Water Cooling

The general feeling has been that a water cooled DG set is better than an air cooled set, as most users are worried about the overheating of engines during summer months. This is to some extent is true and precautions have to be taken to ensure that the cooling water temperature does not exceed the prescribed limits. However, from performance and maintenance point of view, water and air cooled sets are equally good except that proper care should be taken to ensure cross ventilation so that as much cool air as possible is circulated through the radiator to keep its cooling water temperature within limits. While, it may be possible to have air cooled engines in the lower capacities, it will be necessary to go in for water cooled engines in larger capacities to ensure that the engine does not get over-heated during summer months.

Safety Features

It is advisable to have short circuit, over load and earth fault protection on all the DG sets. However, in case of smaller capacity DG sets, this may become uneconomical. Hence, it is strongly recommended to install a circuit protection. Other safety equipment like high temperature, low lube oil pressure cut-outs should be provided, so that in the event of any of these abnormalities, the engine would stop and prevent damage. It is also essential to provide reverse power relay when DG sets are to run in parallel to avoid back feeding from one alternator to another.

Parallel Operation with Grid

Running the DG set in parallel with the mains from the supply undertakings can be done in consultation with concerned electricity authorities. However, some supply undertakings ask the consumer to give an undertaking that the DG set will not be run in parallel with their supply. The reasons stated are that the grid is an infinite bus and paralleling a small capacity DG set would involve operational risks despite normal protections like reverse power relay, voltage and frequency relays.

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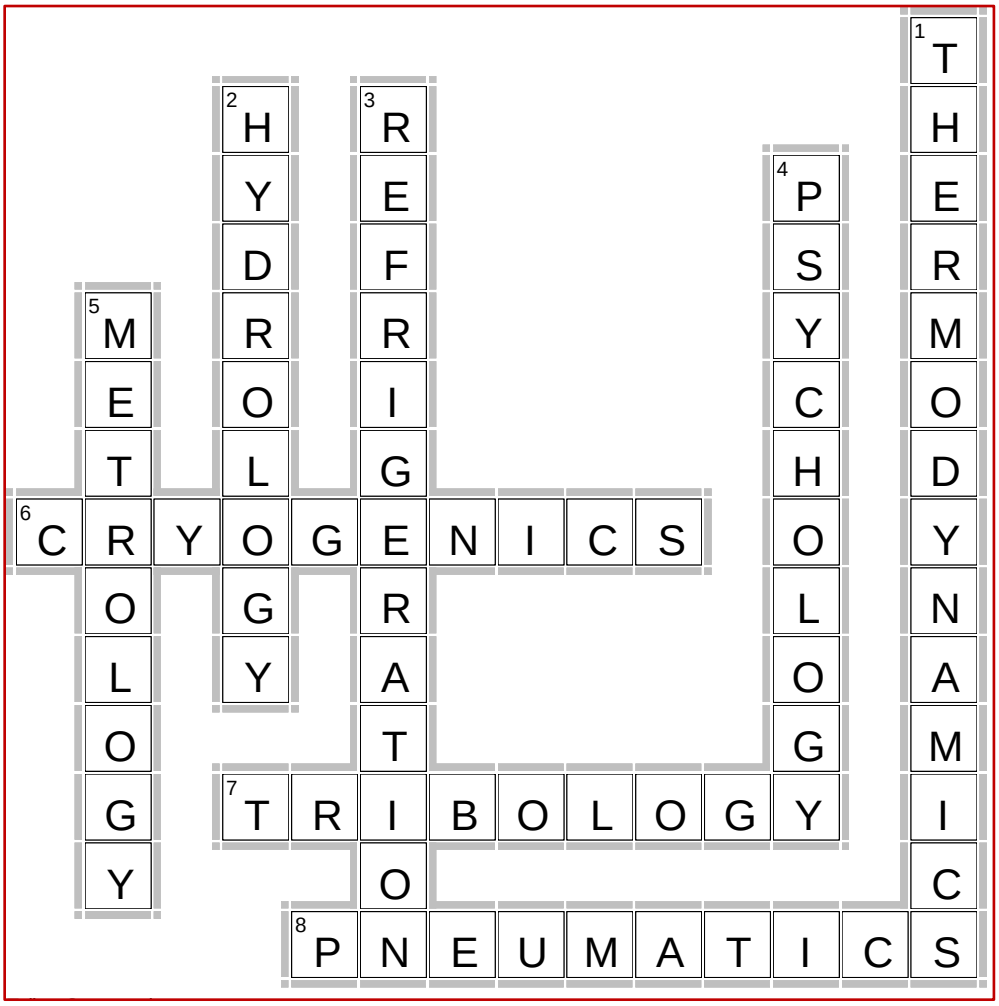
Solution for Last fortnight Techuzzle



Across

6. CRYOGENICS—Study of achieving very low temperatures, below -150°C
7. TRIBOLOGY—the science of lubrication, friction & wear
8. PNEUMATICS—Study of Compressed air systems

Down

1. THERMODYNAMICS—The study of heat, its use and transfer
2. HYDROLOGY—Study of Water, its movement and distribution
3. REFRIGERATION—Study of achieving cold temperatures
4. PSYCHOLOGY—Study of human behavior, so important for team work
5. METROLOGY—The study of measurements and instruments

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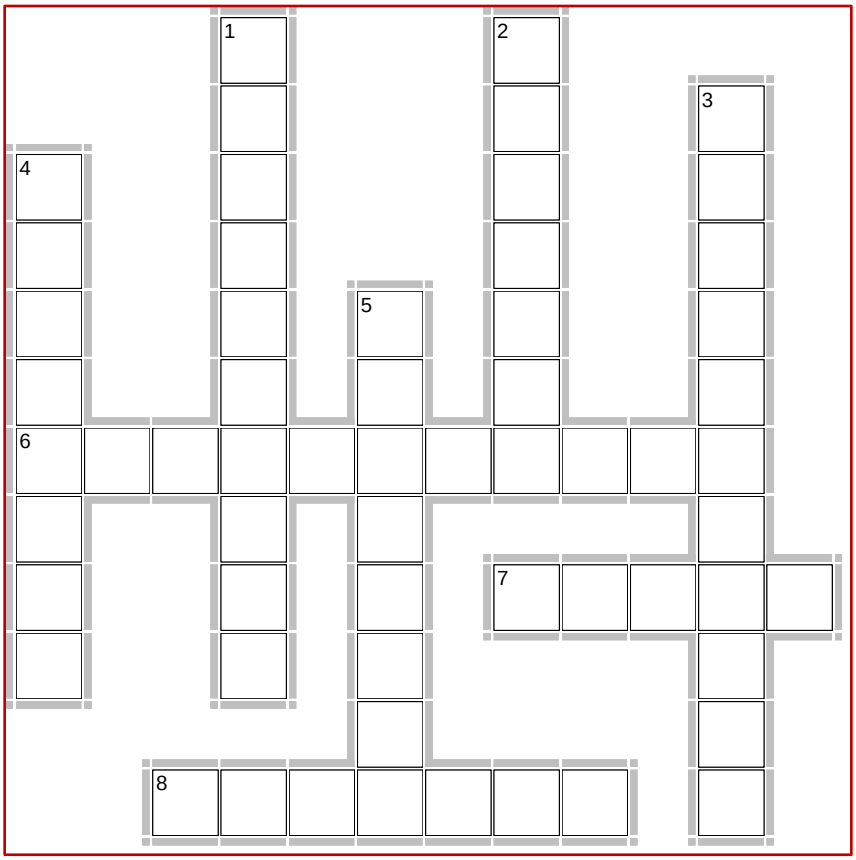
This fortnight Techuzzle



Across

6. Diesel Engine works on _____ ignition principle
7. Petrol engine works on ____ ignition principle
8. This chemical, present in fuel, acts as lubricant

Down

1. HS means _____ in HSD, the common engine fuel
2. Exhaust temperature is also referred as _____ temperature
3. CR means _____ in CRDI engines
4. Diesel is pushed into cylinder using ____
5. The device, supplying HSD at high pressure is _____

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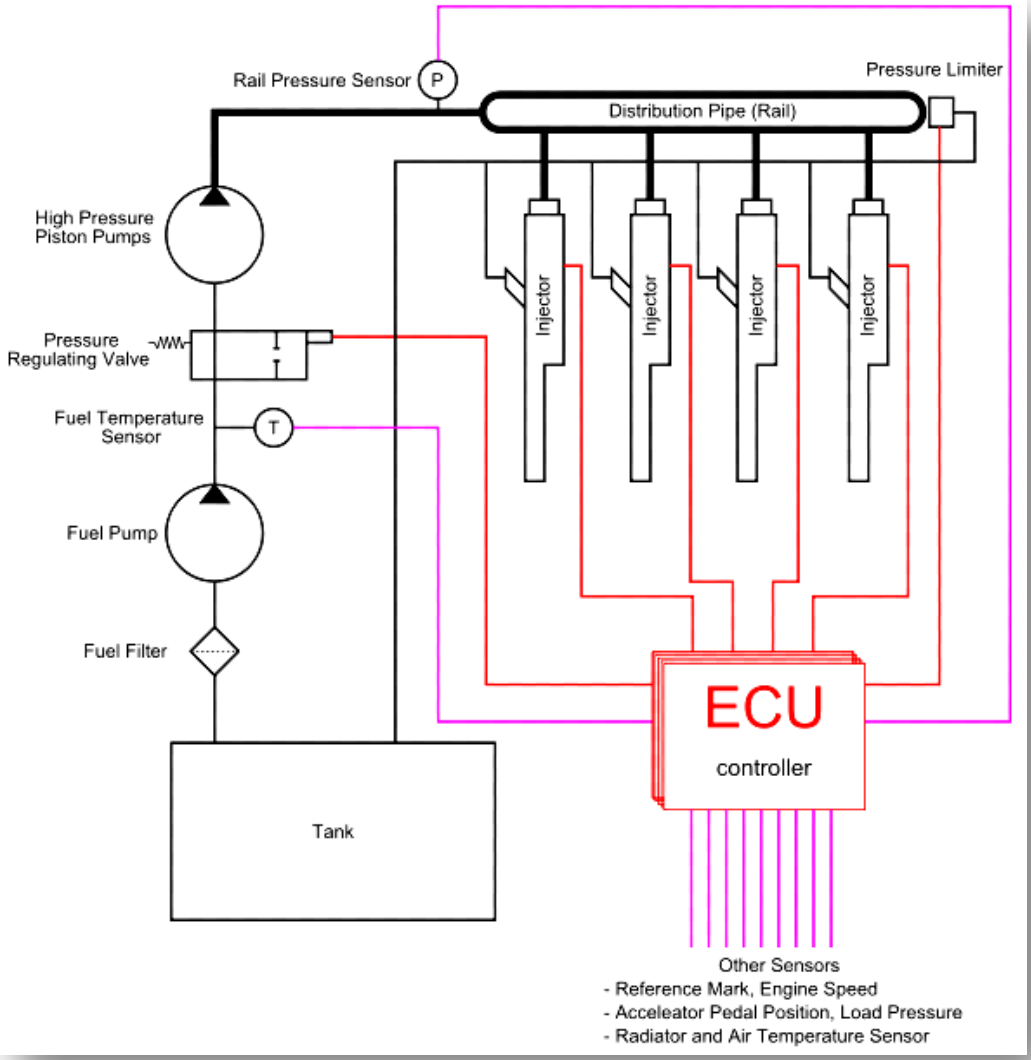

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CRDI - Common Rail Direct Injection

On latest diesel engines, whatever may be its purpose, there has been a revolutionary change in the way fuel is injected into cylinder during power stroke. This new technology, CRDI, eliminates multiple-port (equal to number of cylinders) fuel pump. It, instead, has a "high-pressure" pump which supplies fuel, at up to 2000 bar pressure, to a "common rail." Electronically controlled actuators open at precise points feeding this pressurized fuel into cylinders. In almost all CRDI engines, the "fuel-injection" timing is precisely controlled by electronic board called Engine Control Unit (ECU) and hence it eliminates the third CAMSHAFT which was opening fuel injectors. CRDI has many advantages some of which include: Increased fuel combustion, Better efficiency, faster response and reduced moving components.

Refer to the block diagram above for clear comprehension.

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Robert Bosch - Industry Pioneer

Born in Germany in 1861, Bosch, by nature, was an innovative man who worked with legendaries including Thomas Alva Edison, before setting up his own Workshop for Precision Mechanics and Electrical Engineering. His work there led him to improvise "magneto" for igniting air-fuel mixture in an internal combustion engine. This device led to invention of "electric spark ignition" system in engines which greatly improved automobile industry. Apart from this, Bosch also engineered in designing, improving fuel injection systems for diesel and other fuel engines. His contribution to this field is immense. Apart from these, he was also instrumental in designing the "8-hour" work period in factories.

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