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SONARGOAN UNIVERSITY



BSC IN ELECTRICAL AND ELECTRONICS ENGINEERING.

SONARGAON UNIVERSITY.

Operation, Maintenance activities of Diesel Generator and production of Power by it.

Submitted

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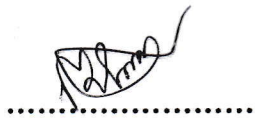
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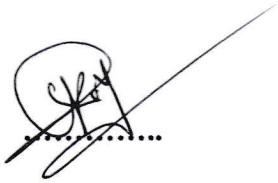
Candidates' Declaration

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.



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Abstract

Abstract: The diesel power plant is designed for base load operation for stationary application and is intended for electricity production in parallel operation with a public supply as well as "island mode" operation. This paper presents the case study of DPA diesel power plant. The capacity of the plant is 50 MW. The power plant is equipped with 41 generating sets consisting of a MTU 16V4000G23 as prime mover driving a three phase brushless, self cooled, synchronous, STAMFORD generator. The capacity of each DG is 1.5 MW. The plant is designed for operating on Diesel fuel. The fuel is being received by river oil tankers from the nearest oil terminal of chittagong . By following generally recognized diesel maintenance procedures and specific manufacturer recommendations will assure that standby power system will start and run when it need the most.

Acknowledgement

It gives us a great pleasure to have the privilege of expressing our indebtedness and gratitude to my supervisor Rajib Baran Roy.Associate prof...& Head of the Department of EEE University of Sonargaon University (SU) for his deep interest, advice and encouragement throughout The internship work. We also sincerely wish to acknowledge our gratitude to the faculty Members of the SU for extending their help and assistance to work on this report.

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Certificate

This is to certify that the internship entitled "Operation and maintenance of diesel generator of Primordial Energy Ltd & Dpa Power Generation International Ltd" By Md Mosheur Rahman.Subrata Roy.Md Rubel Mia. Have been carried out under my supervision.

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Chapter 1

Introduction

1.1 Source of the Report:

This report has been prepared as an integral part of the internship program for the Program at the **Sonargaon University,Dhaka.**"Primordial Energy Ltd"& "DPA power Generation int.Ltd" was nominated as the organization for the internship while honorable faculty Rajib Barun Roy,Department of Electrical & Electronic Engineering, rendered his kind consent to academically supervise the internship program.

1.2 Objective:

The main objective of the report has been done to show the total working procedure and the related other aspect of the "Primordial Energy Ltd". It is discussed generally about the factor and the terms of the pacific garment:

The specific objective of this report includes:

- To study operation maintenance activities of Diesel Generator.
- To study the process of operating other instruments of generators.
- To make an analysis of total maintenance of the generators.

1.3 Methodology:

A qualitative practicum method has been used to conduct this study.The information of this report has been collected from the following sources:

- Information Source of this company
- To get the primary information the following sources has been contacted:
- Personal interviews to the employees and management of the company
- Official documents of the company.

Chapter 2

Company Overview

2.1 Company Profile:

2.1.1 Primordial Energy Ltd:

Primordial Energy Ltd. (PEL) was established in 2009 as a sister company of Primordial Group. PEL has become a major player in the power and energy sector of Bangladesh. The company focuses on power plants, generators, manufacturing of power equipment, solar and other renewable energy systems. The company proudly represents and sells Deutz ADG generators, engines, irrigation pumps, MTU generators and power plant solutions. PEL's professional technical team is able to provide affordable solutions and support for any power or electrical need scenario. The company is committed to operational excellence and assures to meet the rapid changing power needs of the country. PEL maintains the highest level of safety standards and believes in an effective well informed approach to planning, design and development that prospers in completion of a successful project, on time and within budget, to facilitate the client's needs well into the future.

2.1.2 Vision & Mission:

Primordial's vision is to be a global power and energy solution provider with highest level of safety standard and workmanship.

Our mission is to deliver innovative way of need assessment for energy solutions that exceeds customer expectations and constantly creates value for our stakeholders.

We are determined to add value in all that we do - in the best way possible and to the best of our ability. We work together to grow our people, markets and businesses around the world, to consistently create power and energy solutions that win in the marketplace to meet and exceed our customers' expectations.

We empower ourselves as an organization, as teams and as individuals through small and large acts of courage in our everyday work and at more challenging moments of uncertainty, without fear of failure or the desire to stick with the status quo. Courage enables us to face the plain realities of the situation at hand (favorable or unfavorable), to address concerns over change, to promote out-of-box thinking and to explore and commit to bold new possibilities for our business.

We are determined and energized to achieve our shared vision, mission and strategic objectives together. This dedication to a common purpose stands behind our commitments to customers, partners, stakeholders and one another, driving us to excellence in our results and in how we achieve them.

Along with our passion to succeed and prosper as individuals, as teams and as a business, we also reach out to express our genuine care and responsibility for one another, our communities and the broader world community. We rally around those in difficulty to understand their troubles and actively help them with our time, energy and financial resources.

We believe that every problem has multiple solutions and that our job is to find the right solution at the right time with an affordable price for our client.

2.1.3 Location & Contact Details:

Company: **Primordial Energy Ltd**

Business Office: House- 39, 4th floor, Road-13, Block-D, Banani, Dhaka-1213.

Bangladesh Tel: 88-2-8813285, 880-2-88194074 Fax: 880-2-8811785.

E-mail: info@primordial-energy.com

Web: www.primordial-energy.com.

Register Office: 113,Jahanara Garden, Green Road,Dhaka-1205.

Tel:880 28124182, 880 29129013 Fax- 880 28119034

2.1.4 Product and service Offered by PEL:

- Diesel Engine
- Gas Engine
- **Diesel Generator**
- Gas Generator
- Power Plant Solutions
- Electrical Control
- Solar Home Systems

PEL Represents:

- Deutz AG, Germany
- MTU, Germany
- NAPS System

We like to build a long term relationship with our valued customers. "We grow as you grow" is the basic motto of our team spirit with our customers. This is reflected to our

Pre-sales and After-sales support to our customers. Good quality product, competitive price, on time delivery, commissioning and strong after sales service altogether has created the synergy of our company.

Our sales and support serve you both on site and in house. We invite you to learn more about us, our products, and our team.

2.2 Service:

We offer services from designing, installation, up-gradation to overhaul and maintenance contract backed by professionals. Our experienced mechanical and electrical engineering team have the tools and the training to keep you running. Our facilities are capable of providing custom solutions for your unique needs.

We like to serve you no matter where you are – in any where in Bangladesh with Commitment to full customer satisfaction. This includes –

- Genuine manufacturer
- Genuine Parts support
- Full manufacturer's Warrantee
- After sales service
- Engine Components repair/rebuild
- Engine, Generator and Gear repair, reconditioning and Overhaul
- Empower and Replacement

2.3 Power Generation Application:

We can supply both emergency generator and industrial generators. We provide generators ranging up to 2000 KVA. Our Generators are tailored to suit Client's requirements and are designed for manual, automatic, synchronized operation.

2.4 Alternators:

Our alternators feature Marathon, Stamford, MeccAlte etc. We stock almost complete range of alternator from 30 KVA to 1000 KVA to match every need of our customers.

With our large inventory and our extensive industry contacts, we can find the products you want whether new, used or even the most hard-to-find parts almost right away.

2.5 Parts:

We provide the products and services you want in power industry. The parts you need the service you want. With our professional team, we have all you need. We offer a complete line of engine parts, filters, engine and generator control, and other accessories – Genuine parts, Filter, Holset Turbo, Twin Disc Gear, Word wards control. We stock almost every part you will need for your engines or generators.

2.6 Project Details: DPA power generation Int. Ltd.(50 MW Rental Power Plant):

Project at Pagla, Army Camp, Narayangonj.

DPA Power Generation International Limited is engaged in rental power business in Bangladesh and establishing a 50 MW Rental Power Plant Project at Pagla, Army Camp, Narayangonj. DPA Power Generation Int. Ltd. is a Joint Venture Company formed by Primordial Energy Ltd., Bangladesh Diesel Plant Ltd. (a state owned company administered and managed by Bangladesh Army) and MTU, Germany. The power plant is fully operational now. PEL is doing operation and maintenance of the power plant.

Salient Features of the Project:

Instead of having small number of high capacity generator sets the project will have more number of lower capacity sets. Total output will remain same, i.e. 50 MW. Such technique seems to have more advantages than the other. Some information related to generator sets are:

Sl	Item	Information
1	Manufactureer	MTU,Germany
2	Number	41 Units
3	Capacity	1.5 Mw 32 units & 1.2 Mw 9 Units.



DPA Power Generation int.Ltd.

2.7 40MW Power backup to Dhaka WASA water pumps all over Dhaka city:

40MW Power backup to Dhaka WASA water pumps all over Dhaka city ,PEL successfully completed a project of supply delivery & commissioning of 200nos 250KVA heavy duty diesel generators with Deutz engines to all the 10 DWASA zones of Dhaka city. The project was not limited to supply & commissioning. PEL is fully responsible 24/7 operation of those generating sets for two years. This project ensures the citizens of Dhaka city against any unwanted water crisis due to power interruption.

2.8 Distribution Network:

We can cover all the major districts in Bangladesh by our dedicated service team within48 hours. Besides, we have our 2 service centers at Dhaka and Sylhetwherewe offer emergency support within 24 hours. These 2 centers

Dhaka Service Center:

House-39, Road-13, Block-D, 4th floor

Banani Model Town, Dhaka, Bangladesh

Tel: 88-02-8819407, 8819408

Fax: 88-02-8811785

E-mail: info@primordial-energy.com

Chapter 3

Operation and maintenance of diesel generator

3.1 Generator magnetic –conductor burn:

Why:

1) Over current flow.
2) Short circuit fault .
3) Under voltage.

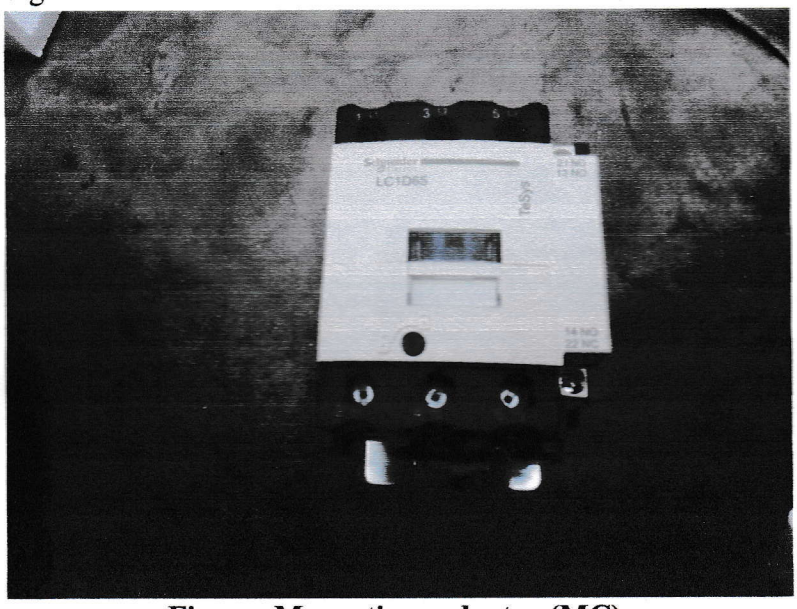


Figure: Magnetic conductor (MC).

Solve:

1) Change the coil of the magnetic-conductor.
2) Voltage stabilizer added.
3) Voltage level adjust.

3.2 Generator power cable insulation problem:

Why:

1. Short Circuit fault.
2. Over current flow.
3. For over heat temperature of the sun.

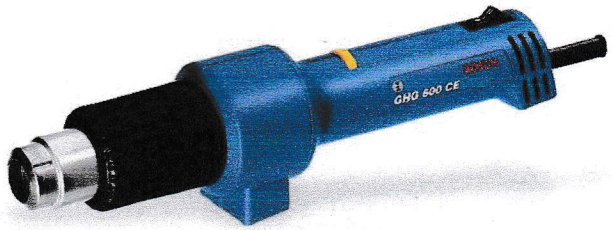


Figure: Heat gun.

Solve:

1. Individually wear the insulation pipe of the power cable than give the heat by the heat gun.

3.3 <u>Alternator Problem:</u>

Why:

1. Diode fault.
2. AVR fault.
3. Coil burn.
4. Coupling plate broken.

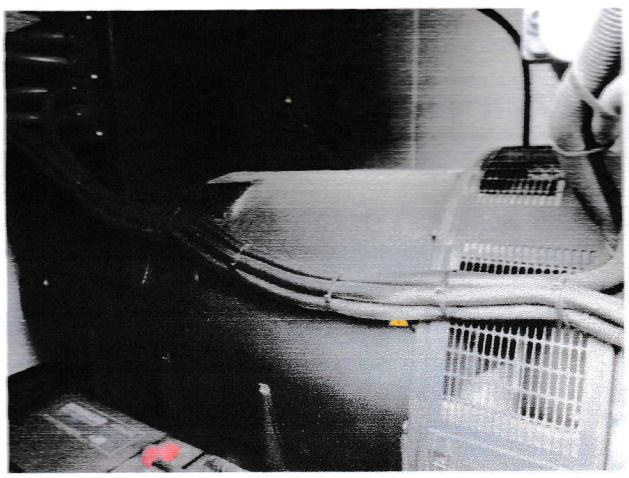
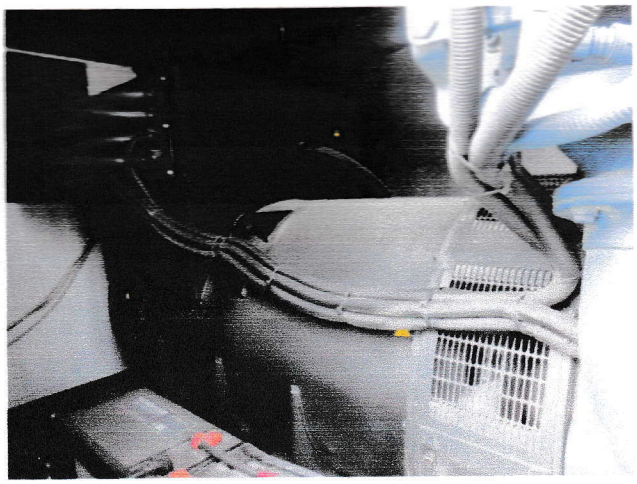



Figure: Alternator.

Solution:

1. Diode change.
2. AVR change.
3. Coil rewinding.
4. Coupling plate change.

3.4 Self Starter Burn:

Why:

1. Engine block.
2. Voltage low or high.
3. Gear broken.
4. Magnetic Coil burn.

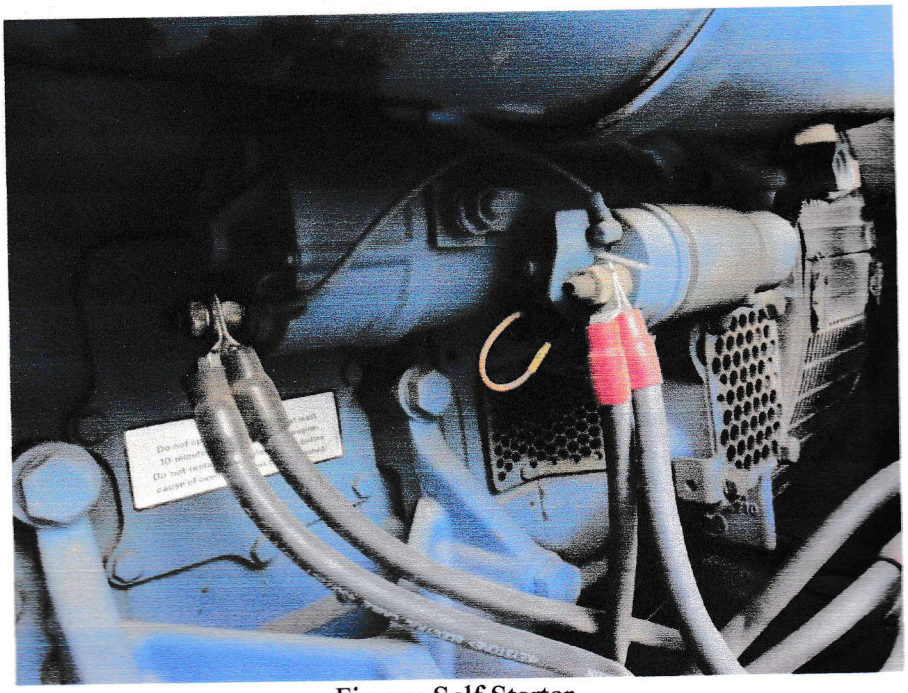


Figure: Self Starter.

Solution:

1. Coil change.
2. Gear change.
3. Necessary Voltage adjust.

3.5 Fuel pump damage:

Why:

1. Over temperature for kit damage.
2. Ash or water mixt fuel.

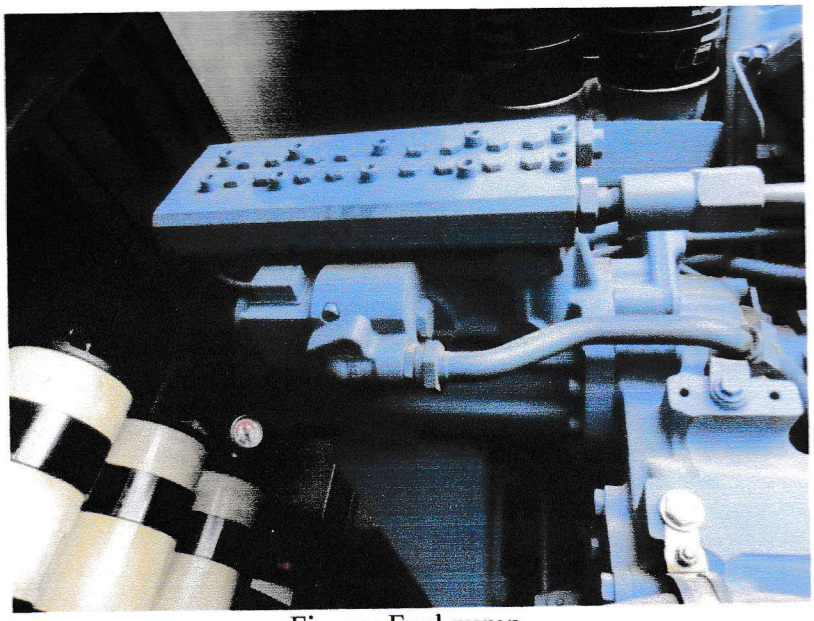


Figure: Fuel pump.

Solution:

1. Over flow fuel line clear.
2. Clean fuel supply.
3. Fuel filter change.

3.6 Controller damage:

Why:

1. Short circuit.
2. Power voltage high.
3. Enter water.

Solution:

1. Controller wiring cheek or rewiring.
2. Voltage level adjust.
3. Controller change.

3.7 Temperature high:

Why:

1. Radiator block.
2. Water pump block.
3. Air filter block
4. Injector block.



Figure: Generator Radiator

Solution:

1. Radiator repairing or change.
2. Water pump repairing or change.
3. Air filter repairing or change.
4. Injector repairing or change.

3.8 Piston broken:

Why:

1. Lube oil level low.
2. Temperature high.
3. Head gasket fault.

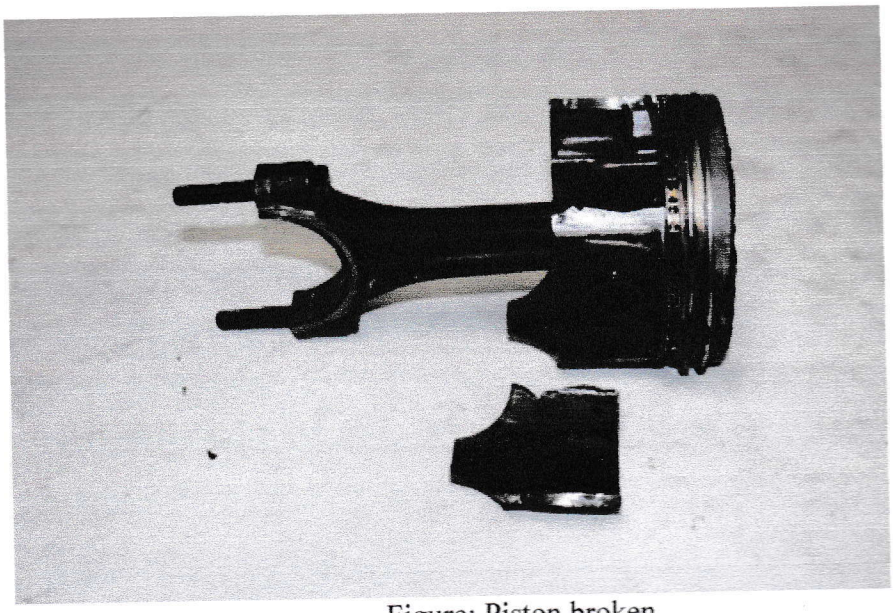


Figure: Piston broken.

Solution:

1. Lube oil adjust.
2. Head gasket change.
3. Piston ring or piston change.

Chapter 4

AC Generator

4.1 Components of an AC Generator:

- Field.
- Armature.
- Prime mover.
- Rotor.
- Stator.
- Slip rings.

Field:

- The field in an AC generator consists of coils of conductors within the generator that receive a voltage from a source (called excitation)and produce a magnetic flux.
- The magnetic flux in the field cuts the armature to produce a voltage. This voltage is ultimately the output voltage of the Ac generator.

Armature:

- The armature is the part of an AC generator in which voltage is produced.
- This component
  consists of many coils of wire that are large enough to carry the full-load current of the generator.

Prime Mover:

- The prime mover is the component that is used to drive the AC generator.
- The prime mover may be any type of rotating machine, such as a diesel engine, a steam turbine, or a motor.

Rotor:

- The rotor is a coil of wire that spins inside the magnetic field. The material used for the wire has to be a good conductor (made of atoms with loosely held electrons). When the wire is close to the south pole, electrons flow one way and when it is close to the north pole, electrons flow the other way. Because the wire spins from the north pole to the south pole of the magnet and back to the north pole and so on, the electrical current reverses direction constantly.

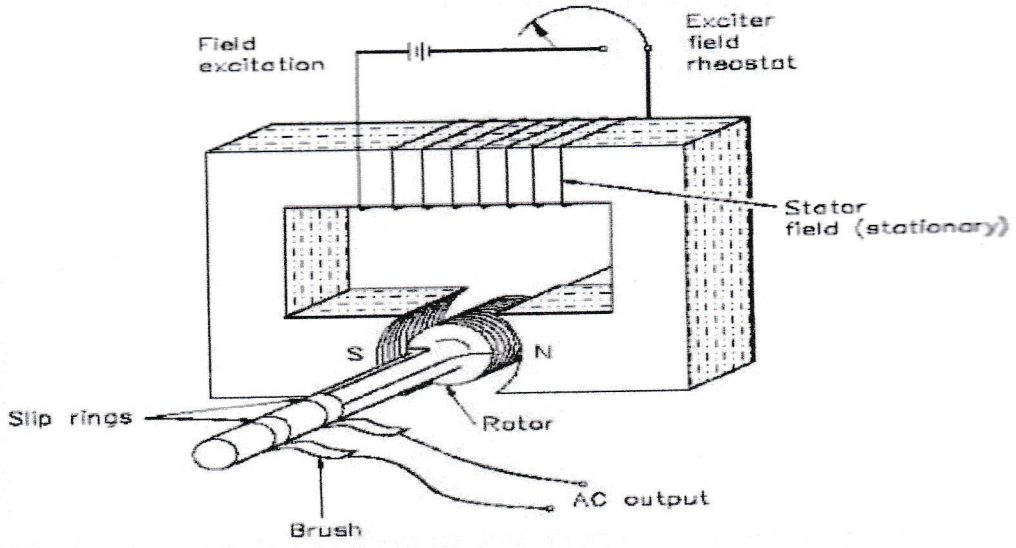


Figure 1: Basic AC Generator

Stator:

- The stator of an AC generator is the part that is stationary (refer to Figure l).
- Like the rotor, this component may be the armature or the field, depending on the type of generator.
- The stator will be the armature if the voltage output is generated there; the stator will be the field if the field excitation is applied there.

Slip rings:

- Slip rings are electrical connections that are used to transfer power to and from the rotor of an AC generator (refer to Figure l).
- The slip ring consists of a circular conducting material that is connected to the rotor windings and insulated from the shaft.
- Brushes ride on the slip ring as the rotor rotates.
- The electrical connection to the rotor is made by connections to the brushes.
- Slip rings are used in AC generator because the desired output of the generator is a sine wave.

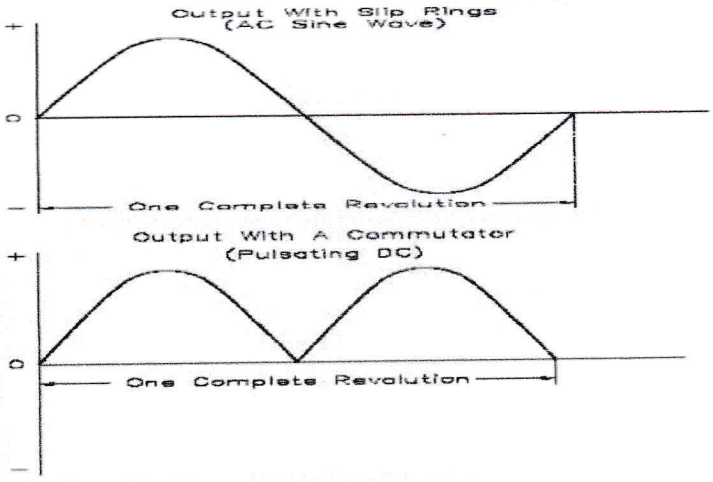


Figure 2: Comparison of DC and AC Generator outputs.

- In a DC generator, a commutator was used to provide an output whose current always flowed
- This is not necessary for an AC generator.
- Therefore, an AC generator may use slip rings, which will allow the output current and voltage to oscillate through positive and negative values.

4.2 Theory of Operation:

- The strong magnetic field is produced by a current flow through the field coil of the rotor.
- The field coil in the rotor receives excitation through the use of slip rings and brushes.
- Two brushes are spring-held in contact with the slip rings to provide the continuous connection between the field coil and the excitation circuit.
- The armature is contained within the windings of the stator and is connected to the output.
- Each time the rotor makes one complete revolution, one complete cycle of AC is developed.
- A generator has many turns of wire wound in to the slots of the rotor.
- The magnitude of AC voltage generated by an AC generator is dependent on the field strength and speed of the rotor.
- Most generators are operated at a constant speed; therefore, the generated voltage depends on field excitation or strength.

4.3 A simple AC generator consists of:

- (a) a strong magnetic field,
- (b) conductors that rotate through that magnetic field, and
- (c) a means by which a continuous connection is provided to the conductors as they are rotating (Figure 3).

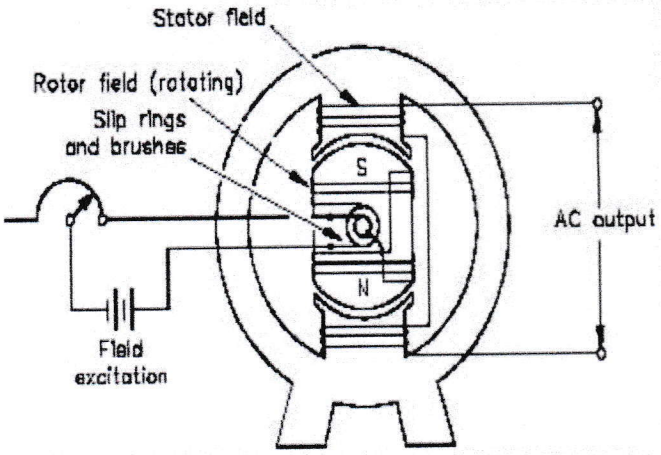


Figure 3: Simple AC Generator.

The frequency of the generated voltage is dependent on the number of field poles and at which the generator is operated as indicated in equation.

$$f = NP/120$$

where,

f = frequency (Hz)
p = total number of poles
N = rotor speed (rpm)
120 = conversion from minutes to seconds and from poles to pole pairs

The 120 in Equation is derived by multiplying the following conversion factors.

$$\frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{2 \text{ poles}}{\text{pole pair}}$$

In this manner, the unite of frequency (hertz or cycles/sec.) are derived.

4.4 Losses in an AC Generator:

1) **Internal Voltage Drop**

- The load current flows through the armature in all AC generators. The armature has some amount of resistance and inductive reactance.
- The combination of these make up what is known as the internal resistance, which causes a loss in an AC generator.
- When the load current flows, a voltage drop is developed across the internal resistance.

- This voltage drop subtracts from the output voltage and, therefore, represents generated voltage and power that is lost and not available to the load.

The voltage drop in an AC generator can be found using Equation:

$$\text{Voltage drop} = I_a R_a I_a X_{la}$$

Where,

I_a = armature current
R_a = armature resistance
X_{la} = armature inductive reactance

2) Hysteresis Losses:

- Hysteresis losses occur when iron cores in an AC generat or are subject to effects from a magnetic field.
- The magnetic domains of the cores are held in alignment with the field in varying numbers, dependent upon field strength.
- The magnetic domains rotate, with respect to the domains not held in alignment, one complete turn during each rotation of the rotor.
- This rotation of magnetic domains in the iron causes friction and heat.
- The heat produced by this friction is called magnetic hysteresis loss.
- After the heat-treated silicon steel is formed to the desired shape, the laminations are heated to a dull red and then allowed to cool.
- This process, known as annealing, reduces hysteresis losses to a very low value.
- To reduce hysteresis losses, most AC armatures are constructed of heat-treated silicon steel, which has an inherently low hysteresis loss.

3) Mechanical Losses:

- Rotational or mechanical losses can be caused by bearing friction, brush friction on the commutator, and air friction (called windage),which is caused by the air turbulence due to armature rotation.
- Careful maintenance can be instrumental in keeping bearing friction to a minimum.

- Clean bearings and proper lubrication are essential to the reduction of bearing friction.
- Brush friction is reduced by ensuring: proper brush seating, proper brush use, and maintenance of proper brush tension.
- A smooth and clean commutator also aids in the reduction of brush friction.
- In very large generators, hydrogen is used within the generator for cooling: hydrogen, being less dense than air, cause less winding losses than air.

4.5 Efficiency:

- Efficiency of an AC generator is the ratio of the useful power output to the total power input.
- Because any mechanical process experiences some losses, on AC generators can be 100 percent efficient.
- Efficiency of an AC generator can be calculated using Equation.
- Efficiency = (Output/Input) x 100

4.6 AC GENERATOR OPERATION:

Ratings:

Typical name plate data for an AC generator includes:

- Manufacturer.
- Serial number & type number.
- Speed (rpm), number of poles, frequency of output, number of phases, and maximum supply voltage.
- Capacity rating in KVA & KW at a specified power factor & maximum output voltage.
- Armature & field current per phases.
- Maximum temperature rise.

Power (KW) ratings of an AC generator:

- Are based on the ability of the prime mover to overcome generator losses and the ability of the machine to dissipate the internally generated heat.
- The current rating of an AC generator is based on the insulation rating of the machine.

4.7 Types of AC Generators:

- There are two types of AC generators:

1. The stationary field, rotating armature.
2. The rotating field, stationary armature.

- Small AC generators usually have a stationary field and a rotating armature.
- One important disadvantage to this arrangement is that the slip-ring and brush assembly is in series with the load circuit and because of worn or dirty components, may interrupt the flow of current.

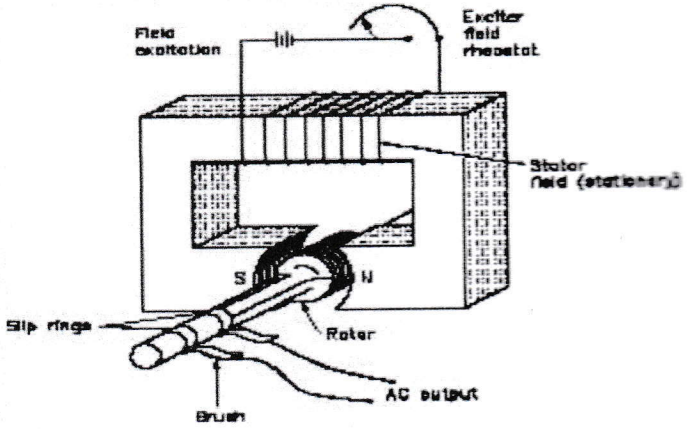


Figure 4: Stationary field, Rotating Armature AC Generator.

- If DC field excitation is connected to the rotor, the stationary coils will have AC induced into them.
- This arrangement is called a rotating field, stationary armature AC generator. The rotating field, stationary armature type AC generator is used when large power generation is involved.
- In this type of generator, a DC source is supplied to the rotating field coils, which produces a magnetic field around the rotating element.
- As the rotor is turned by the prime mover, the field will cut the conductors of the stationary armature, and an EMF will be induced into the armature windings.
- This type of AC generator has several advantages over the stationary field, rotating armature AC generator:
    1. A load can be connected to the armature without moving contacts in the circuit.
    2. It is much easier to insulate stator fields than rotating fields.
    3. Much higher voltages and currents can be generated.

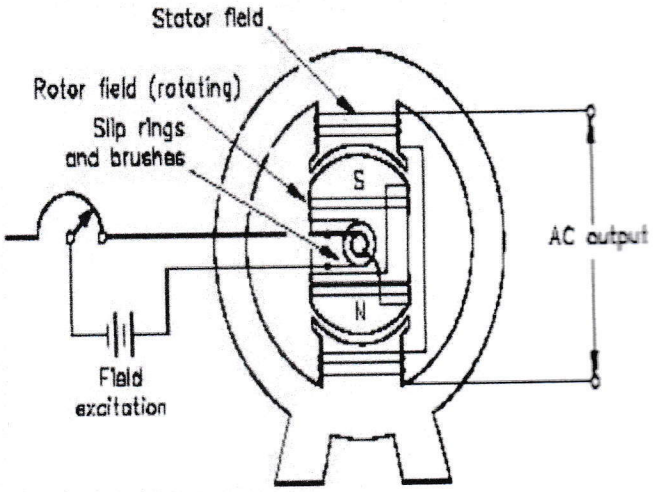


Figure 5: Simple AC Generator-Rotating Field, Stationary Armature.

4.8 Three-Phase AC Generators:

- The principles of a three-phase generator are basically the same as that of a single-phase generator ,except that there are three equally –spaced windings and three output voltage that are all 120^0 out of phase with one another.
- Physically adjacent loops (Figure-6) are separated by 60^0 of rotation, however, the loops are connected to the slip rings in such a manner that there are 120 electrical degrees between phases.
- The individual coils of each winding are combined and represented as a single coil. The significance of Figure-6 is that it shows that the three-phase generator has three separate armature windings that are 120 electrical degrees out of phase

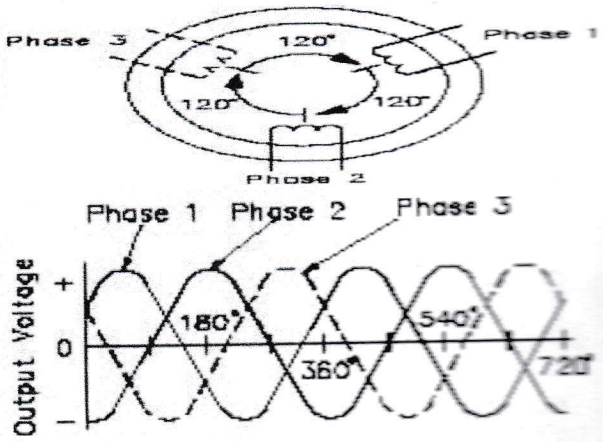


Figure 6: Stationary Armature 3f Generator.

Chapter 5

Operation of Diesel Generator

5.1 Diesel Power Generator:

A diesel power station uses a diesel engine as prime mover for the generation of electrical energy.

This power station is generally compact and thus can be located where it is actually required. This kind of power station can be used to produce limited amounts of electrical energy. In most countries these power stations are used as emergency supply stations.

The diesel burns inside the engine and the combustion process causes rotational mechanical energy that turns the engine shaft and drives the alternator. The alternator intern, converts mechanical energy into electrical energy.

This type of electricity generating power station will probably be used a long time into the future, due to a need for reliable stand-by electrical source for Electrical power at work can be seen everywhere you go. In our home, office, entertainment areas and so forth.

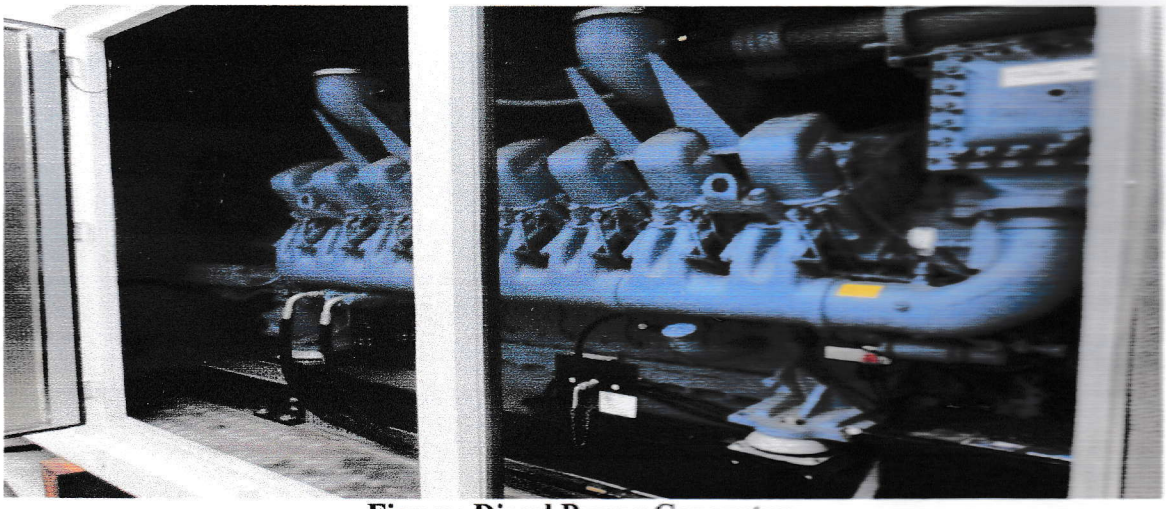


Figure: Diesel Power Generator

5.2 Power generation fundamental problem:

It is an undisputed fact that electrical energy is the most used form of energy everywhere. As seen in part 3, electrical energy is a result of conversion of other forms of energy that are abundant in nature. Those other forms of energy are usually generated and utilised at will.

Unfortunately, bulk storage of electrical energy for a long duration is not possible yet. This is the fundamental problem in electrical energy generation.

Electrical energy must be generated and transmitted to the point of consumption at the instant of demand. This instant is usually less than a second.

5.3 What is Diesel Engine:

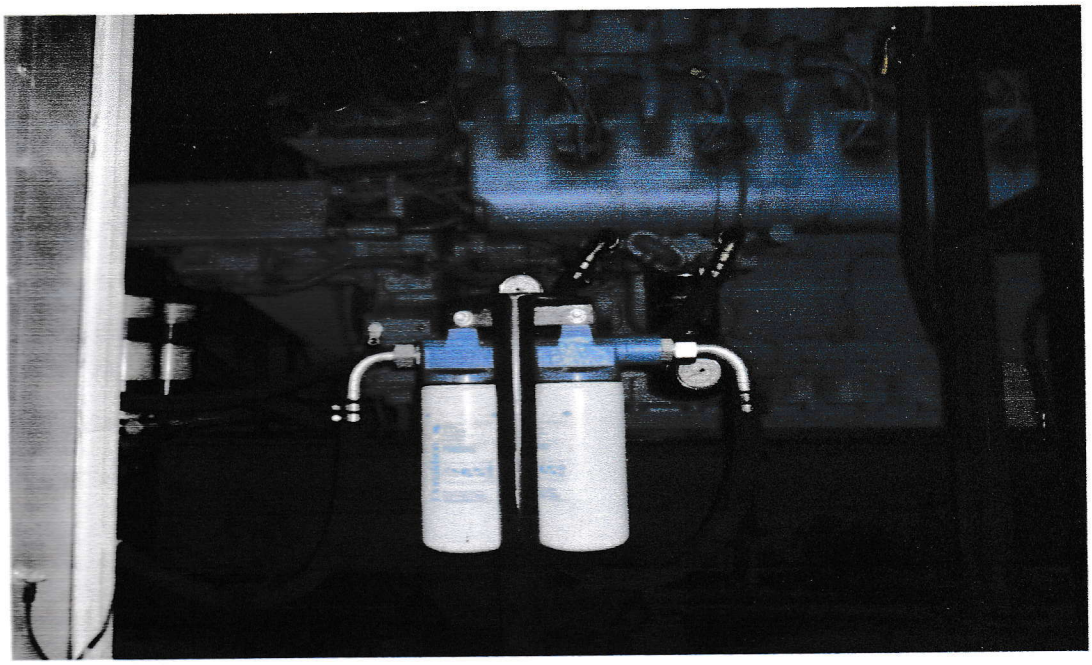


Figure: Diesel Engine

A diesel engine is an internal combustion engine that uses the heat of compression to initiate ignition to burn the fuel, which is injected into the combustion chamber during the final stage of compression. This is in contrast to a petrol engine or gas engine, which uses the Otto cycle, in which a fuel/air mixture is ignited by a spark plug.

It operates using the diesel cycle. Diesel engines have the highest thermal efficiency of any internal or external combustion engine, because of their compression ratio.

Diesel engines are manufactured in two stroke and four stroke versions. They were originally used as a more efficient replacement for stationary steam engines.

5.4 History:

Rudolf Diesel, of German nationality, was born in 1858 in Paris where his parents were Bavarian immigrants. He was educated at Munich Polytechnic. After graduation he was employed as a refrigerator engineer but his true love lay in engine design. Diesel designed many heat engines, including a solar-powered air engine. In 1893, he published a paper describing an engine with combustion within a cylinder, the internal combustion engine. In 1894, he filed for a patent for his new invention, dubbed the diesel engine. His engine was the first to prove that fuel could be ignited without a spark. He operated his first successful engine in 1897.

In 1898, Diesel was granted U.S. Patent 608,845 for an "internal combustion engine".

Though best known for his invention of the pressure-ignited heat engine that bears his name, Rudolf Diesel was also a well-respected thermal engineer and a social theorist. Diesel's inventions have three points in common: they relate to heat transference by natural physical processes or laws; they involve markedly creative mechanical design; and they were initially motivated by the inventor's concept of sociological needs. Rudolf Diesel originally conceived the diesel engine to enable independent craftsmen and artisans to compete with industry.

At Augsburg, on August 10, 1893, Rudolf Diesel's prime model, a single 10-foot (3.0 m) iron cylinder with a flywheel at its base, ran on its own power for the first time. Diesel spent two more years making improvements and in 1896 demonstrated another model with a theoretical efficiency of 75 percent, in contrast to the 10 percent efficiency of the steam engine. By

1898, Diesel had become a millionaire. His engines were used to power pipelines, electric and water plants, automobiles and trucks, and marine craft. They were soon to be used in mines, oil fields, factories, and transoceanic shipping.

5.5Classifications of internal combustion (IC) Engines:

A machine which converts heat into mechanical work or vice versa

The IC engines are those in which the combustion of fuel takes place inside the engine cylinder.

Classifications of I.C Engines:

1. According to the type of fuel used:
    a) Petrol engines
    b) Diesel engines
    c) Gas Engines
2. According to the number of strokes per cycle :
    a) Four stroke cycle engines
    b) Two stroke cycle engines
3. According to the speed of the engine:
    a) Slow speed engine
    b) Medium speed engine
    c) High speed engine
4. According to the cooling systems:
    a) Air-cooled engines
    b) Water-cooled engines
    c) Evaporative cooling engines
5. According to the number of cylinders
    a) Single cylinder engine
    b) Multi cylinder engine

5.6 Internal combustion engine:

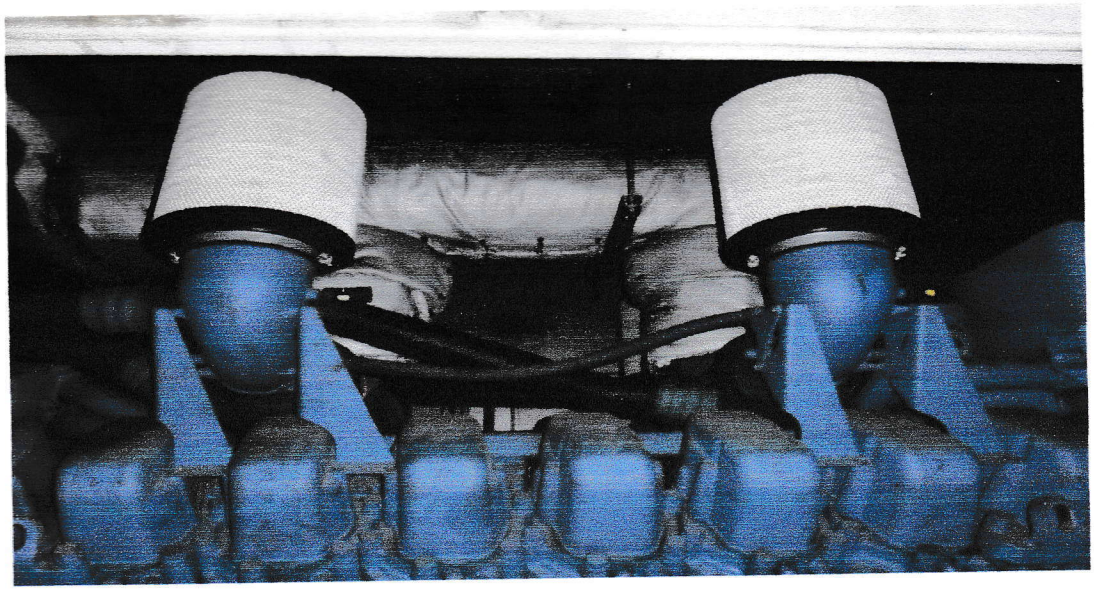


Figure: Internal Combustion Engine.

An automobile engine partly opened and colored to show components

The internal combustion engine is an engine in which the combustion of a fuel occurs with an oxidizer in a combustion chamber. In an internal combustion engine the expansion of the high temperature and pressure gases, that are produced by the combustion, directly apply force to a movable component of the engine, such as the pistons or turbine blades and by moving it over a distance, generate useful mechanical energy.

The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the Winkle rotary engine. A second class of internal combustion engines use continuous combustion: gas turbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described.

The internal combustion engine is quite different from external combustion engines, such as steam or Sterling engines, in which the energy is delivered to a working fluid not consisting of, mixed with or contaminated by combustion products. Working fluids can be air, hot water, pressurized water or even liquid sodium, heated in some kind of boiler by fossil fuel, wood-burning, nuclear, solar etc.

5.9 Four stroke configuration:

Operation:

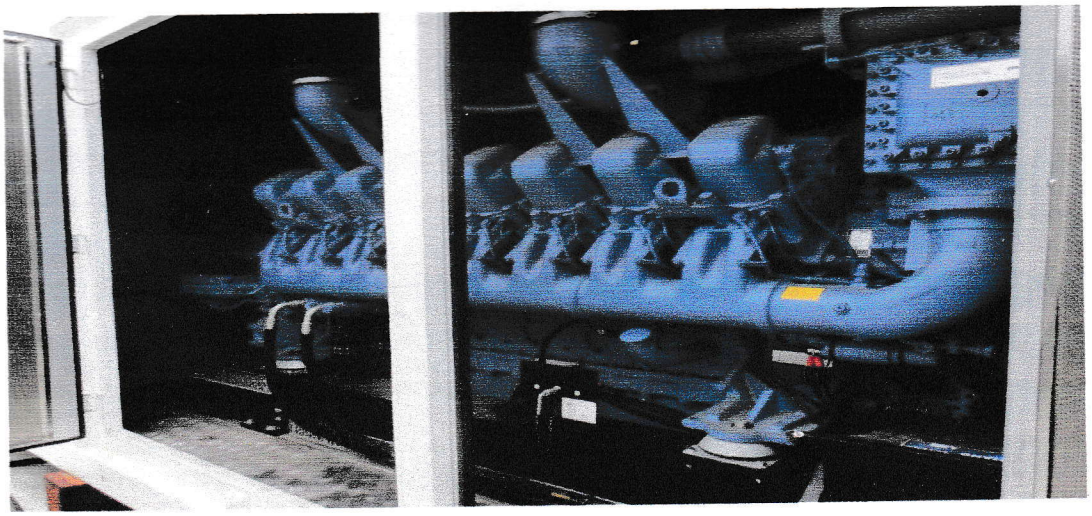


Figure: Four Stroke Diesel Engine

Four stroke cycle

1. Suction/Intake stroke
2. Compression stroke
3. Power stroke
4. Exhaust stroke

5.10 Basic process:

As their name implies, operation of a four stroke internal combustion engines have 4 basic steps that repeat with every two revolutions of the engine:

1. **Suction/Intakestroke**

   - ❖ Inlet Valve opens
   - ❖ Intake of pure air take place as piston moves downward from T.D.C to B.D.C
   - ❖ Continues till the piston reaches its bottom dead center (B.D.C)

2. ***CompressionStroke:***

- ❖ Both inlet & exhaust valves are closed
- ❖ Air is compressed as the piston moves upward from B.D.C to T.D.C
- ❖ As a result of Compression, the pressure & temperature of the air increases significantly.

3. **Power stroke**
4. Shortly before the piston recharges T.D.C, fuel oil is injected in the form of very fine spray into the engine cylinder, though the nozzle, known as fuel injection valve.

- ❖ Pressure and temperature suddenly increases & due to increased pressure, the piston is pushed down with a great force.
- ❖ Both the valves remain closed and the piston moves from TDC to BDC

5. **Exhaust stroke**

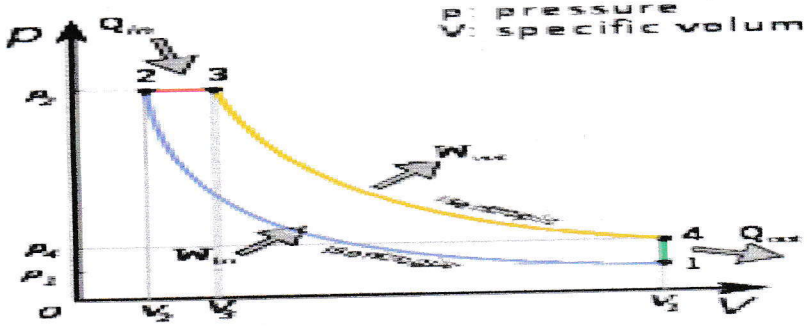
- ❖ The exhaust valves opens
- ❖ Piston moves from B.D.C to T.D.C
- ❖ Product of Combustion pushed out through exhaust valves into the atmosphere.

5.11 Diesel Ignition Process:

Diesel engines and HCCI (Homogeneous charge compression ignition) engines rely solely on heat and pressure created by the engine in its compression process for ignition. The compression level that occurs is usually twice or more than a gasoline engine. Diesel engines will take in air only, and shortly before peak compression, a small quantity of diesel fuel is sprayed into the cylinder via a fuel injector that allows the fuel to instantly ignite. HCCI type engines will take in both air and fuel but continue to rely on an unaided auto-combustion process, due to higher pressures and heat. This is also why diesel and HCCI engines are more susceptible to cold-starting issues, although they will run just as well in cold weather once started. Light duty diesel engines with indirect injection in automobiles and light trucks employ glow plugs that pre-heat the combustion chamber just before starting to reduce no-start conditions in cold weather. Most diesels also have a battery and charging system; nevertheless, this system is secondary and is added by manufacturers as a luxury for the ease of starting, turning fuel on and off and for

running auxiliary electrical components and accessories. Most new engines rely on electrical and electronic control system that also control the combustion process to increase efficiency and reduce emissions.

5.11.1 Diesel cycle:



P-v Diagram for the Ideal Diesel cycle. The cycle follows the numbers 1-4 in clockwise direction.

Most truck and automotive diesel engines use a cycle reminiscent of a four-stroke cycle, but with a compression heating ignition system, rather than needing a separate ignition system. This variation is called the diesel cycle. In the diesel cycle, diesel fuel is injected directly into the cylinder so that combustion occurs at constant pressure, as the piston moves, rather than with the four strokes with the piston essentially stationary.

5.12 Fuels:

Fuel:

A substance which on burning produce large amount of heat. The amount of heat produced is known as calorific value of fuel.

Fuel are mainly consists of carbon & hydrogen & also hydrocarbon fuel.

Classification:

a. Solid Fuels, **b.** Liquid Fuels, c. Gaseous Fuel,

Each for than can further be divided into: a. Natural Fuel, b. Prepared Fuel,

Calorific value(CV) of Fuels: 1. the amount of heat given by the complete combustion of 1kg (KJ/kg for solids & liquids & KJ/m3 for Gaseous fuels).

2. The amount of heat produced when unit quantity (One KJ of solids or liquids fuel or one cubic meter of Gaseous fuel) of fuel is completely burnt.

Two types:

1. Gross or Higher calorific value (H.C.V).

2. Net or Lower calorific value (L.C.V).

1. Gross H.C.V**:** is the total amount of heat produced when unit quantity of fuel is burnet completely & the products of combustion have been cooled to room temperature generally 15°C.

[H.C.V=33800C+144000H2+9270*S KJ/kg] of O2 is pressure then.

[H.C.V=33800C+144000(H2-O2/8)+92705KJ/kg] C, H2, O2 represents the percentage by weight.

2. Net or lower calorific value L.C.V is the net amount of heat produced when unit quantity of fuel is completely burnt & the product of combustion are not cooled to room temperature but are allowed to escape. (Actual Practice).

[L.C.V=H.C.V-9H2*2466KJ/kg]

Now a days, fuels used include:

- Petroleum:
  - Petroleum spirit (North American term: gasoline, British term: petrol)
  - Petroleum diesel.
  - Auto gas (liquefied petroleum gas).
  - Compressed natural gas.
  - Jet fuel (aviation fuel)
  - Residual fuel

- Coal:
  - Most methanol is made from coal.
  - Gasoline can be made from carbon (coal) using the Fischer-Tropsch process
  - Diesel fuel can be made from carbon using the Fischer-Tropsch process
- Biofuels and vegoils:
  - Peanut oil and other vegoils.
  - Biofuels:
  - Biobutanol (replaces gasoline).
  - Biodiesel (replaces petrodiesel).
  - Bioethanol and Biomethanol (wood alcohol) and other biofuels (see Flexible-fuel vehicle).
  - Biogas
- Hydrogen (mainly spacecraftrocket engines)

Even fluidized metal powders and explosives have seen some use. Engines that use gases for fuel are called gas engines and those that use liquid hydrocarbons are called oil engines, however gasoline engines are also often colloquially referred to as, "gas engines" .

The main limitations on fuels are that it must be easily transportable through the fuel system to the combustion chamber, and that the fuel releases sufficient energy in the form of heat upon combustion to make practical use of the engine.

Diesel engines are generally heavier, noisier, and more powerful at lower speeds than gasoline engines. They are also more fuel-efficient in most circumstances and are used in heavy road vehicles, some automobiles (increasingly so for their increased fuel efficiency over gasoline engines), ships, railwaylocomotives, and light aircraft. Gasoline engines are used in most other road vehicles including most cars, motorcycles, and mopeds. Note that in Europe, sophisticated diesel-engines cars have taken over about 40% of the market since the 1990s. There are also engines that run on hydrogen, methanol, ethanol, liquefied petroleum gas (LPG), and biodiesel. Paraffin and tractor vaporizing oil (TVO) engines are no longer seen.

5.13 Engine capacity:

For piston engines, an engine's capacity is the engine displacement, in other words the volume swept by all the pistons of an engine in a single movement. It is generally measured in liters or cubic inches for larger engines, and cubic centimeters for smaller engines.

Engines with greater capacities are usually more powerful and provide greater torque at lower rpm, but also consume more fuel. Apart from designing an engine with more cylinders, there are two ways to increase an engines' capacity. The first is to lengthen the stroke: the second is to increase the pistons' diameter. In either case, it may be necessary to make further adjustments to the fuel intake of the engine to ensure optimum performance.

5.14 Common components:

5.14.1 Combustion chambers:

Internal combustion engines can contain any number of combustion chambers, with numbers between one and twelve being common though as many as 36 have been used. Having more cylinders in an engine yields two potential benefits: first, the engine can have a larger displacement with smaller individual reciprocating masses, that is, the mass of each piston can be less thus making a smoother-running engine since the engine tends to vibrate as a result of the pistons moving up and down. Doubling the number of the same size cylinders will double the torque and power. The downside to having more pistons is that the engine will tend to weigh more and generate more internal friction as the greater number of pistons rub against the inside of their cylinders. This tends to decrease fuel efficiency and robs the engine of some of its power. For high-performance gasoline engines using current materials and technology such as the engines found in modern automobiles, there seems to be a break-point around 10 or 12 cylinders after which the addition of cylinders becomes an overall detriment to performance and efficiency.

- Most car engines have four to eight cylinders with some high performance cars having ten, twelve or even sixteen, and some very small cars and trucks having two or three.

- Motorcycles commonly have from one to four cylinders, with a few high performance models having six; although, some 'novelties' exist with 8, 10, or 12.
- Snowmobiles Usually have one to four cylinders and can be both 2 stroke or 4 stroke, normally in the in-line configuration however there are again some novelties that exist with V-4 Engines
- Small portable appliances such as chainsaws, generators, and domestic lawn mowers most commonly have one cylinder, but two-cylinder chainsaws exist.
- Large reversible two cycle marine diesels have a minimum of three to over ten cylinders. Freight diesel locomotives usually have around 12 to 20 cylinders due to space limitations as larger cylinders take more space (volume) per kwh, due to the limit on average piston speed of less than 30 ft/sec on engines lasting more than 40000 hours under full power.

5.14.2 Ignition system:

The ignition system of an internal combustion engines depends on the type of engine and the fuel used. Petrol engines are typically ignited by a precisely timed spark, and diesel engines by compression heating. Historically, outside flame and hot-tube systems were used, see hot bulb engine

5.14.3 Compression:

Ignition occurs as the temperature of the fuel/air mixture is taken over its auto ignition temperature, due to heat generated by the compression of the air during the compression stroke. The vast majority of compression ignition engines are diesels in which the fuel is mixed with the air after the air has reached ignition temperature. In this case, the timing comes from the fuel injection system. Very small model engines for which simplicity and light weight is more important than fuel costs use easily ignited fuels and adjustable compression to control ignition timing for starting and running.

5.14.4 Ignition Timing:

For reciprocating engines, the point in the cycle at which the fuel-oxidizer mixture is ignited has a direct effect on the efficiency and output of the ICE. The thermodynamics of the idealized Carnot heat engine tells us that an ICE is most efficient if most of the burning takes place at a high temperature, resulting from compression near top dead center. The speed of

The flame front is directly affected by the compression ratio, fuel mixture temperature, and octane or cetane rating of the fuel. Leaner mixtures and lower mixture pressures burn more slowly requiring more advanced ignition timing. It is important to have combustion spread by a thermal flame front not by a shock wave. Combustion propagation by a shock wave is called detonation and, in engines, is also known as pinging or Engine knocking.

So at least in gasoline-burning engines, ignition timing is largely a compromise between an earlier "advanced" spark which gives greater efficiency with high octane fuel and a later "retarded" spark that avoids detonation with the fuel used. For this reason, high-performance diesel automobile proponents such as, Gale Banks, believe that

There's only so far you can go with an air-throttled engine on 91-octane gasoline. In other words, it is the fuel, gasoline that has become the limiting factor. ... While turbo charging has been applied to both gasoline and diesel engines, only limited boost can be added to a gasoline engine before the fuel octane level again becomes a problem. With a diesel, boost pressure is essentially unlimited. It is literally possible to run as much boost as the engine will physically stand before breaking apart. Consequently, engine designers have come to realize that diesels are capable of substantially more power and torque than any comparably sized gasoline engine.

5.15 Fuel systems:

Animated cut through diagram of a typical fuel injector, a device used to deliver fuel to the internal combustion engine.

Fuels burn faster and more efficiently when they present a large surface area to the oxygen in air. Liquid fuels must be atomized to create a fuel-air mixture; traditionally this was done with a carburetor in petrol engines and with fuel injection in diesel engines. Most modern petrol engines now use fuel injection too

though the technology is quite different. While diesel must be injected at an exact point in that engine cycle, no such precision is needed in a

Petrol engine. However, the lack of lubricity in petrol means that the injectors themselves must be more sophisticated.

5.16 Fuel injection:

Larger gasoline engines used in automobiles have mostly moved to fuel injection systems have always used fuel injection because the timing of the injection initiates and controls the combustion.

5.17 Fuel pump:

Most internal combustion engines now require a fuel pump. Diesel engines use an all-mechanical precision pump system that delivers a timed injection direct into the combustion chamber, hence requiring a high delivery pressure to overcome the pressure of the combustion chamber. Petrol fuel injection delivers into the inlet tract at atmospheric pressure and timing is not involved, these pumps are normally driven electrically. Gas turbine and rocket engines use electrical systems.

5.18 Oxidizer-Air inlet system:

Some engines such as solid rockets have oxidizers already within the combustion chamber but in most cases for combustion to occur, a continuous supply of oxidizer must be supplied to the combustion chamber.

5.19 Natural aspirated engines:

When air is used with piston engines it can simply suck it in as the piston increases the volume of the chamber. However, this gives a maximum of 1 atmosphere of pressure difference across the inlet valves, and at high engine speeds the resulting airflow can limit potential power output.

5.20 Superchargers:

A supercharger is a system which uses a compressor powered by the shaft of the engine which forces air through the valves of the engine to achieve higher flow. When these systems are employed the maximum absolute pressure at the inlet valve is typically around 2 times atmospheric pressure or more.

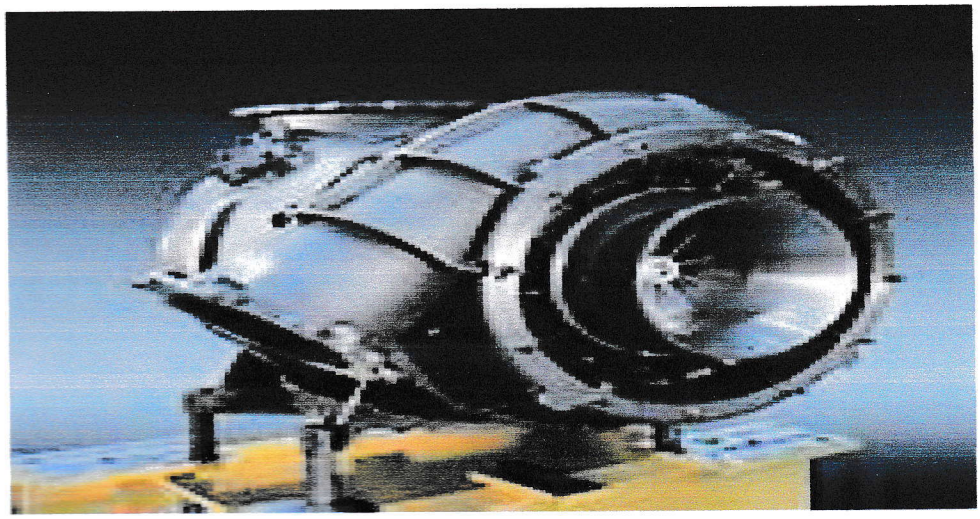


Figure: Supercharger

5.21 Exhaust systems:

Internal combustion engines have to manage the exhaust of the cooled combustion gas from the engine. The exhaust system frequently contains devices to control pollution, both chemical and noise pollution. In addition, for cyclic combustion engines the exhaust system is frequently tuned to improve emptying of the combustion chamber.

For jet propulsion internal combustion engines, the 'exhaust system' takes the form of a high velocity nozzle, which generates thrust for the engine and forms a collimated jet of gas that gives the engine its name.

5.22 Cooling systems:

Combustion generates a great deal of heat, and some of these transfers to the walls of the engine. Failure will occur if the body of the engine is allowed to reach too high a temperature; either the engine will physically fail, or any lubricants used will degrade to the point that they no longer protect the engine.

Cooling systems usually employ air (air cooled) or liquid (usually water) cooling while some very hot engines using radioactive cooling. Some high altitude rocket engines use ablative cooling where the walls gradually erode in a controlled fashion. Rockets in particular can use regenerative cooling which uses the fuel to cool the solid parts of the engine.

5.23 Starter systems:

All internal combustion engines require some form of system to get them into operation. Most piston engines use a starter motor powered by the same battery as runs the rest of the electric systems. Large jet engines and gas turbines are started with a compressed air motor that is geared to one of the engine's driveshaft. Compressed air can be supplied from another engine, a unit on the ground or by the aircraft's APU. Small internal combustion engines are often started by pull cords. Motorcycles of all sizes were traditionally kick-started, though all but the smallest are now electric-start. Large stationary and marine engines may be started by the timed injection of compressed air into the cylinders - or occasionally with cartridges. Jump starting refers to assistance from another battery while bump starting refers to an alternative method of starting by the application of some external force, e.g. rolling down a hill.

5.24 Lubrication Systems:

Internal combustions engines require lubrication in operation that moving parts slide smoothly over each other. Insufficient lubrication subjects the parts of the engine to metal-to-metal contact, friction, heat build-up, rapid wear often culminating in parts becoming friction welded together e.g. pistons in their cylinders. Big end bearings seizing up will sometimes lead to a connecting rod breaking and poking out through the crankcase.

Several different types of lubrication systems are used. Simple two-stroke engines are lubricated by oil mixed into the fuel or injected into the induction stream as a spray. Early slow-speed stationary and marine engines were lubricated by gravity from small chambers similar to those used on steam engines at the time with an engine tender refilling these as needed. As engines were adapted for automotive and aircraft use, the need for a high power-to-weight ratio led to increased speeds, higher temperatures, and greater pressure on bearings which in turn required pressure-lubrication for crank bearings and connecting-rodjournals. This was provided either by a direct lubrication from a pump, or indirectly by a jet of oil directed at pickup cups on the connecting rod ends which had the advantage of providing higher pressures as the engine speed increased.

5.25 Control Systems:

Most engines require one or more systems to start and shutdown the engine and to control parameters such as the power, speed, torque, pollution, combustion temperature, efficiency and to stabilize the engine from modes of operation that may induce self-damage such as pre-ignition. Such systems may be referred to as engine control units.

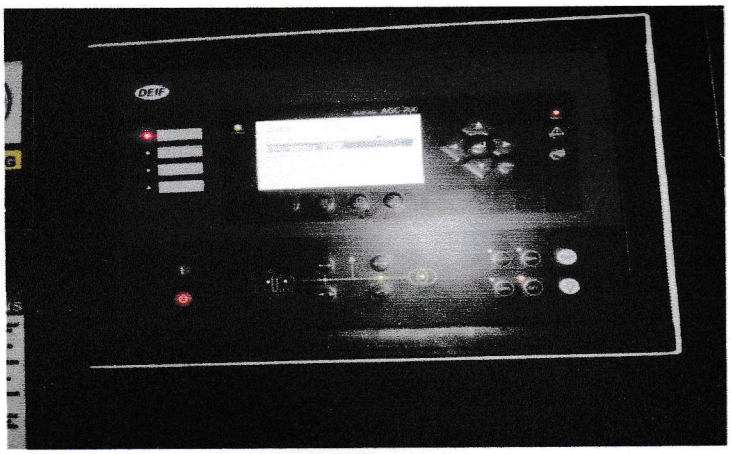


Figure: Control system of Switch box

Many control systems today are digital, and are frequently termed FADEC systems.

5.26 Engine main Parts:

- Engine Block
- Valves
- Piston
- Cylinder liner
- Crank shaft
- Fly wheel
- Cylinder head
- Crankcase
- Main bearing cap
- Cylinder liner
- Cylinder head gasket

5.26.1Engine Block:



Fig: An illustration of several key components in a typical four-stroke engine.

For a four-stroke engine, key parts of the engine include the crankshaft ,connecting rod one or more camshafts, and valves. For a two-stroke engine, there may simply be an exhaust outlet and fuel inlet instead of a valve system. In both types of engines there are one or more cylinders, and for each cylinder there is a spark plug, a piston , and a crankpin .A single sweep of the cylinder by the piston in an upward or downward motion is known as a stroke. The downward stroke that occurs directly after the air-fuel mix passes from the carburetor or fuel injector to the cylinder, where it is ignited. This is also known as a power stroke.

A Winkle engine has a triangular rotor that orbits in an epitrochoidal chamber around an eccentric shaft. The four phases of operation take place in what is effectively a moving, variable-volume chamber.

5.26.2 Valves:

All four-stroke internal combustion engines employ valves to control the admittance of fuel and air into the combustion chamber. Two-stroke engines use ports in the cylinder bore, covered and uncovered by the piston, though there have been variations such as exhaust valves.



Figure: Different types of Valves

5. 26.3 Piston:



Figure: Piston

A **piston** is a component of reciprocating engines. It is located in a cylinder and is made gas-tight by piston rings. Its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In two-stroke engines the piston also acts as a valve by covering and uncovering ports in the cylinder wall.

5.26.4 Cylinder liner:

A cylinder liner is a cylindrical part to be fitted into an engine block to from a cylinder. It is one of the most important functional parts to make up the interior of an engine. This is called Cylinder liner in Japan, but some countries call this cylinder.

5.26.5 Crankshaft:

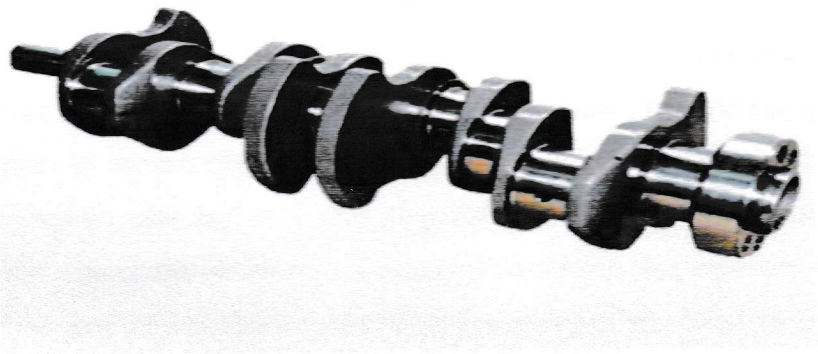


Figure: Crankshaft

Most reciprocating internal combustion engines end up turning a shaft. This means that the linear motion of a piston must be converted into rotation. This is typically achieved by a crankshaft.

5.26.6 Flywheels:

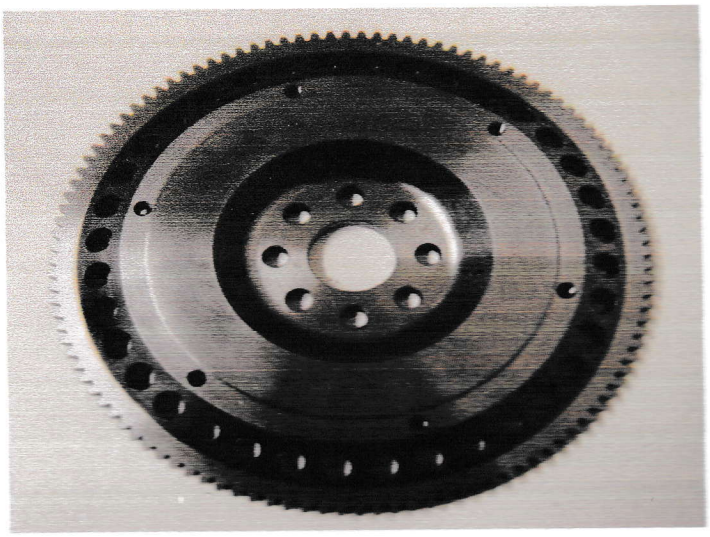


Figure: Flywheel

The flywheel is a disk or wheel attached to the crank, forming an inertial mass that stores rotational energy. In engines with only a single cylinder the flywheel is essential to carry energy over from the power stroke into a subsequent compression stroke. Flywheels are present in most reciprocating engines to smooth out the power delivery over each rotation of the crank and in most automotive engines also mount a gear ring for a starter. The rotational inertia of the flywheel also allows a much slower minimum unloaded speed and also improves the smoothness at idle. The flywheel may also perform a part of the balancing of the system and so by itself be out of balance, although most engines will use a neutral balance for the flywheel, enabling it to be balanced in a separate operation. The flywheel is also used as a mounting for the clutch or a torque converter in most automotive applications.

5.26.7 Cylinder head:

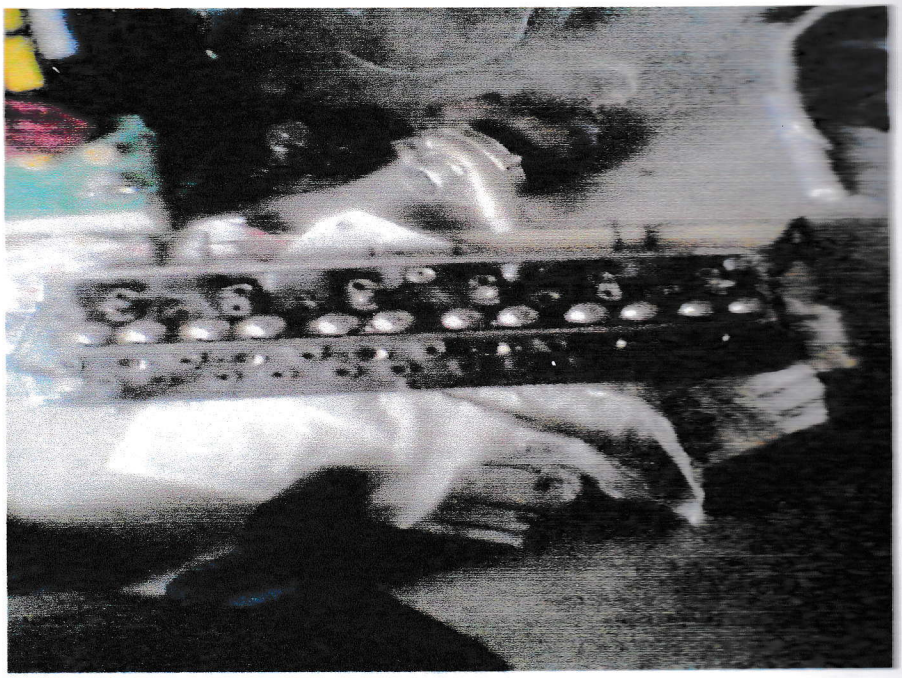


Figure: Cylinder head

In an internal combustion engine, the cylinder head sits atop cylinders and consists of a platform containing part of the combustion chamber and the location of the valves and spark plugs.

5.26.8 Crankcase:

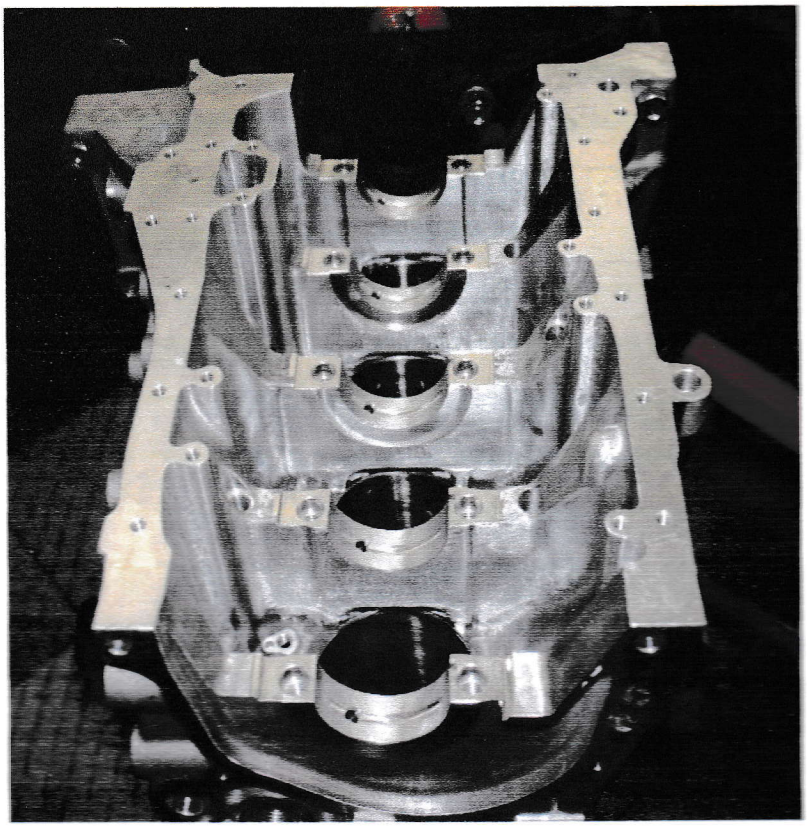


Figure: Crankcase

In a piston engine, the crankcase is the housing for the crankshaft.

5.26.9 Cylinder head gasket:

A head is a gasket that sits between the engine block and cylinder head in an internal combustion engine. Its purpose is to seal the cylinders to ensure maximum compression and avoid leakage of coolant or engine oil into the cylinder.

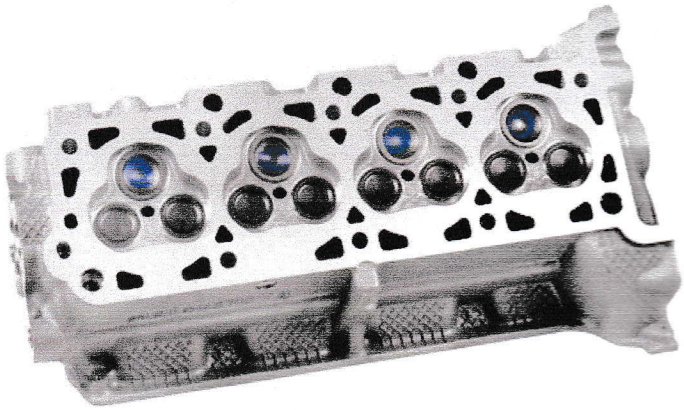


Figure: Cylinder head gasket

5.27 Measures of Engine Performance:

Engine types vary greatly in a number of different ways:

- Energy efficiency
- Fuel/propellant consumption
- Power to weight ratio
- Thrust to weight ratio
- Torque curvesthrust lapse
- Compression ratio for piston engines, Overall pressure ratio for jet engines and gas turbines.

5.28 Energy efficiency:

Once ignited and burnt, the combustion products hot gases have more available thermal energy than the original compressed fuel-air mixture .The available energy is manifested as high temperature and pressure that can be translated into work by the engine. In a reciprocating engine, the high-pressure gases inside the cylinders drive the engine's pistons.

Once the available energy has been removed, the remaining hot gases are vented and this allows the piston to return to its previous position (top dead center, or TDC). The piston can then proceed to the next phase of its cycle, which varies between engines. Any heat that isn'ttranslated

into work is normally considered a waste product and is removed from the engine either by an air or liquid cooling system.

Engine efficiency can be discussed in a number of ways but it usually involves a comparison of the total chemical energy in the fuels, and the useful energy extracted from the fuels in the form of kinetic energy. The most fundamental and abstract discussion of engine efficiency is the thermodynamic limit for extracting energy from the fuel defined by a thermodynamic cycle. The most comprehensive is the empirical fuel efficiency of the total engine system for accomplishing a desired task; for example, the miles per gallon accumulated.

Internal combustion engines are primarily heat engines and as such the phenomenon that limits their efficiency is described by thermodynamic cycles. None of these cycles exceed the limit defined by the Carnot cycle which states that the overall efficiency is dictated by the difference between the lower and upper operating temperatures of the engine. A terrestrial engine is usually and fundamentally limited by the upper thermal stability derived from the material used to make up the engine. All metals and alloys eventually melt or decompose and there is significant researching into ceramic materials that can be made with higher thermal stabilities and desirable structural properties. Higher thermal stability allows for greater temperature difference between the lower and upper operating temperatures—thus greater thermodynamic efficiency.

5.29 Measures of fuel/propellant efficiency:

For stationary and shaft engines including propeller engines, fuel consumption is measured by calculating the brake specific fuel consumption which measures the number of pounds of fuel that is needed to generate an hours' worth of horsepower-energy. In metric units, the number of grams of fuel needed to generate a kilowatt-hour of energy is calculated.

For internal combustion engines in the form of jet engines, the power output varies drastically with airspeed and a less variable measure is used: thrust specific fuel consumption, which is the number of pounds of propellant that is needed to generate impulses that measure a pound an hour. In metric units, the number of grams of propellant needed to generate an impulse that measures one kilo Newton per second.

5.30 How Diesel Engines Work:

The diesel internal combustion engine differs from the gasolinepowered Otto cycle by using a higher compression of the air to ignite the fuel rather than using a spark plug.

In the diesel engine, only air is introduced into the combustion chamber. The air is then compressed with a compression ratio typically between 15 and 22 resulting into a 40 bar (about 600 psi) pressure compared to 8 to 14 bar (about 200 psi) in the gasoline engine. This high compression heats the air to 550 °C (about 1000 °F). At about this moment (the exact moment is determined by the fuel injection timing of the fuel system), fuel is injected directly into the compressed air in the combustion chamber. This may be into a (typically toroidal) void in the top of the piston or a 'pre-chamber' depending upon the design of the engine. The fuel injector ensures that the fuel is broken down into small droplets, and that the fuel is distributed as evenly as possible. The more modern the engine, the smaller, more numerous and better distributed are the droplets. The heat of the compressed air vaporises fuel from the surface of the droplets. The vapour is then ignited by the heat from the compressed air in the combustion chamber, the droplets continue to vaporise from their surfaces and burn, getting smaller, until all the fuel in the droplets has been burnt. The start of vaporisation causes a delay period during ignition, and the characteristic diesel knocking sound as the vapour

reaches ignition temperature and causes an abrupt increase in pressure above the piston. The rapid expansion of combustion gases then drives the piston downward, supplying power to the crankshaft.

As well as the high level of compression allowing combustion to take place without a separate ignition system, a high compression ratio greatly increases the engine's efficiency. Increasing the compression ratio in a spark-ignition engine where fuel and air are mixed before entry to the cylinder is limited by the need to prevent damaging pre-ignition. Since only air is compressed in a diesel engine, and fuel is not introduced into the cylinder until shortly before top dead center (TDC), premature detonation is not an issue and compression ratios are much higher.

5.31 Starting:

In cold weather high speed diesel engines, which are mostly prechambered, can be difficult to start because the mass of the cylinder block and cylinder head absorb the heat of compression, preventing ignition because of the higher surface to volume ratio. Prechambered engines therefore make use of small electric heaters inside the rehabbers called glow plugs. These engines also generally have a higher compression ratio of 19:1 to 21:1. Low speed and compressed air started larger and intermediate speed diesels do not have glow plugs and compression ratios are around 16:1. Some engines use resistive grid heaters in the intake manifold to warm the inlet air until the engine reaches operating temperature. Engine block heaters (electric resistive heaters in the engine block) connected to the utility grid are often used when an engine is turned off for extended periods (more than an hour) in cold weather to reduce startup time and engine wear. In the past, a wider variety of cold-start methods were used. Some engines, such as Detroit Diesel engines and Lister-Patter engines, used a system to introduce small amounts of ether into the inlet manifold to start combustion. Saab marine engines, Field Marshall tractors (among others) used slow-burning solid-fuel 'cigarettes' which were fitted into the cylinder head as a primitive glow plug. Lucas developed the 'Thermostat', where an electrical heating element was combined with a small fuel valve. Diesel fuel slowly dripped from the valve onto the hot element and ignited. The flame heated the inlet manifold and when the engine was turned over the flame was drawn into thecombustion chamber to start combustion. International Harvester developed a WD-40 tractor in the 1930s that had a 7-liter 4-cylinder engine which ran as a diesel, but was started as a gasoline engine. The cylinder head had valves which opened for a portion of the compression stroke to reduce the effective compression ratio, and a magneto produced the spark. An automatic ratchet system automatically disengaged the ignition system and closed the valves once the engine had run for 30 seconds. The operator then switched off the gasoline fuel system and opened the throttle on the diesel injection system. Recently direct-injection systems advanced to the extent that rehabbers systems were not needed using a common rail with electronic fuel injection.

5.32 Fuel Delivery:

A vital component of all diesel engines is a mechanical or electronic governor which regulates the idling speed and maximum speed of the engine by controlling the rate of fuel delivery. Unlike Otto-cycle engines, incoming air is not throttled and a diesel engine without a governor can not have a stable idling speed and can easily overspend, resulting in its destruction. Mechanically governed fuel injection systems are driven by the engine's gear train. [13] These systems use a combination of springs and weights to control fuel delivery relative to both load and speed.[13] Modern, electronically controlled diesel engines control fuel delivery by use of an electronic control module (ECM) or electronic control unit (ECU). The ECM/ECU receives an engine speed signal, as well as other operating parameters such as intake manifold pressure and fuel temperature, from a sensor and controls the amount of fuel and start of injection timing through actuators to maximize power and efficiency and minimize emissions. Controlling the timing of the start of injection of fuel into the cylinder is a key to minimizing emissions, and maximizing fuel economy (efficiency), of the engine. The timing is measured in degrees of crank angle of the piston before top dead center. For example, if the ECM/ECU initiates fuel injection when the piston is 10 degrees before TDC, the start of injection, or timing, is said to be 10° BTDC. Optimal timing will depend on the engine design as well as its speed and load. Advancing the start of injection (injecting before the piston reaches TDC) results in higher in-cylinder pressure and temperature, and higher efficiency, but also results in elevated engine noise and increased oxides of nitrogen (NO_x) emissions due to higher combustion temperatures. Delaying start of injection causes incomplete combustion, reduced fuel efficiency and an increase in exhaust smoke, containing a considerable amount of particulate matter and unburned hydrocarbons .

5.33 Major Advantages:

Diesel engines have several advantages over other internal combustion engines:

- They burn less fuel than a gasoline engine performing the same work, due to the engine's high efficiency.
- They have no high-tension electrical ignition system to attend to, resulting in high reliability and easy adaptation to damp environments. The absence of coils, spark plug wires, etc., also eliminates a source of radio frequency emissions which can interfere with navigation and

communication equipment and the like, which is especially important in marine and aircraft applications.

- They can deliver much more of their rated power on a continuous basis than a gasoline engine.
- The life of a diesel engine is generally about twice as long as that of a gasoline engine due to the increased strength of parts used, also because diesel fuel has better lubrication properties than gasoline.
- Diesel fuel is considered safer than gasoline in many applications. Although diesel fuel will burn in open air using a wick, it will not explode and does not release a large amount of flammable vapour. The low vapor pressure of diesel is especially advantageous in marine applications, where the accumulation of explosive fuel-air mixtures is a particular hazard.

5.34 Mechanical and Electronic Injection:

Many configurations of fuel injection have been used over the past century (1900–2000).

Most present day (2008) diesel engines make use of a camshaft, rotating at half crankshaft speed, lifted mechanical single plunger high pressure fuel pump driven by the engine crankshaft. For each cylinder, its plunger measures the amount of fuel and determines the timing of each injection. These engines use injectors that are basically very precise spring-loaded valves that open and close at a specific fuel pressure. For each cylinder a plunger pump is connected with an injector with a high pressure fuel line. Fuel volume for each single combustion is controlled by a slanted groove in the plunger which rotates only a few degrees

releasing the pressure and is controlled by a mechanical governor, consisting of weights rotating at engine speed constrained by springs and a lever. The injectors are held open by the fuel pressure.

A cheaper configuration on high speed engines with less than six cylinders is to use an axial-piston distributor pump ,consisting of one rotating pump plunger delivering fuel to a valve and line for each cylinder (functionally analogous to points and distributor cap on an Otto engine). This contrasts with the more modern method of having a single fuel pump which supplies fuel constantly at high pressure with a common rail (single fuel line common) to each injector. Each injector has a solenoid operated by an electronic control unit, resulting in more accurate control of injector opening times that depend on other control conditions, such as engine speed and

loading, and providing better engine performance and fuel economy. This design is also mechanically simpler than the combined pump and valve design, making it generally more reliable, and less noisy, than its mechanical counterpart.

Both mechanical and electronic injection systems can be used in either direct or indirect injection configurations.

5.35 Direct Injection:

Modern diesel engines make use of one of the following direct injection methods:

Direct injection injectors are mounted in the top of the combustion chamber. The problem with these vehicles was the harsh noise that they made. Fuel consumption was about 15 to 20 percent lower than indirect injection diesels, which for some buyers was enough to compensate for the extra noise.This type of engine was transformed by electronic control of the injection pump, pioneered by the Volkswagen Group in 1989. The injection pressure was still only around 300 bar (4350 psi), but the injection timing, fuel quantity, EGR and turbo boost were all electronically controlled. This gave more precise control of these parameters which made refinement more acceptable and emissions lower.

5.36 Power and fuel economy:

The MAN S80ME-C7 low speed diesel engines use 155 gram fuel per kWh for an overall energy conversion efficiency of 54.4%, which is the highest conversion of fuel into power by any internal or external combustion engine. Diesel engines are more efficient than gasoline (petrol) engines of the same power, resulting in lower fuel consumption. A common margin is 40% more miles per gallon for an efficient turbo diesel. For example, the current model Kodak Octavia, using Volkswagen Group engines, has a combined Euro rating of 6.2 L/100 km (38 miles per US gallon) for the 102 bhp (76 kW) petrol engine and 4.4 L/100 km (54 mpg) for the 105 bhp (78 kW) diesel engine. However, such a comparison doesn't take into account that diesel fuel is denser and contains about 15% more energy by volume. Although the calorific value of the fuel is slightly lower at 45.3 MJ/kg (mega joules per kilogram) than gasoline at 45.8 MJ/kg,

liquiddiesel fuel is significantly denser than liquid gasoline. This is important because volume of fuel, in addition to mass, is an important consideration in mobile applications. No vehicle has an unlimited volume available for fuel storage.

Adjusting the numbers to account for the energy density of diesel fuel, the overall energy efficiency is still about 20% greater for the diesel version.

Weight can be an issue, since diesel engines are typically heavier than gasoline engines of similar power output. This is essentially because the diesel must operate at lower engine speeds. Diesel fuel is injected just before the power stroke. As a result of this, the fuel cannot burn completely until it has encountered the right amount of oxygen. This results in incomplete combustion with too much fuel, poor design or failing injectors resulting in black exhaust. In the gasoline engine, air and fuel are mixed for the entire compression stroke, ensuring complete mixing even at higher engine speeds.

Diesel engines usually have longer stroke lengths to achieve the necessary compression ratios. As a result piston and connecting rods are heavier and more force must be transmitted through the connecting rods and crankshaft to change the momentum of the piston. This is another reason that a diesel engine must be stronger for the same power output.

Yet it is this same build quality that has allowed some enthusiasts to acquire significant power increases with turbocharged engines through fairly simple and inexpensive modifications. A gasoline engine of similar size cannot put out a comparable power increase without extensive alterations because the stock components would not be able to withstand the higher stresses placed upon them. Since a diesel engine is already built to withstand higher levels of stress, it makes an ideal candidate for performance tuning with little expense. However, it should be said that any modification that raises the amount of fuel and air put through a diesel engine will increase its operating temperature which will reduce its life and increase service requirements. These are issues with newer, lighter, *high performance* diesel engines which are not "overbuilt" to the degree of older engines and are being pushed to provide greater power in smaller engines. The addition of a turbocharger or supercharger to the engine greatly assists in increasing fuel economy and power output, mitigating the fuel-air intake speed limit mentioned above for agiven

engine displacement. Boost pressures can be higher on diesels than gasoline engines, due to the latter's susceptibility to knock, and the higher compression ratio allows a diesel engine to be more efficient than a comparable spark ignition engine. Because the burned gases are expanded further in a diesel engine cylinder, the exhaust gas is cooler, meaning turbochargers require less cooling, and can be more reliable, than on spark-ignition engines.

With a diesel, boost pressure is essentially unlimited. It is literally possible to run as much boost as the engine will physically stand before breaking apart. Consequently, engine designers have come to realize that diesels are capable of substantially more power and torque than any comparably sized gasoline engine

5.37 Safety:

Diesel fuel has low flammability, leading to a low risk of fire caused by fuel in a vehicle equipped with a diesel engine.

Chapter 6

Maintenanceof Four Stroke Diesel Generator

6.1 Maintenance hazards:

Fuel injection introduces potential hazards in engine maintenance due to the high fuel pressures used. Residual pressure can remain in the fuel lines long after an injection-equipped engine has been shut down. This residual pressure must be relieved, and if it is done so by external bleed-off, the fuel must be safely contained. If a high-pressure diesel fuel injector is removed from its seat and operated in open air, there is a risk to the operator of injury by hypodermic jet-injection, even with only 100 psi pressure.

6.2 Defining Maintenance planning (MP):

The maintenance procedure is an enterprise resource planning package produced by company that targets business requirements of small, midsize and large organizations in all industries and sectors to organize effectively the resources of the organization.

MP is arranged into distinct functional modules, covering the typical functions in place in an organization. The most widely used modules are Financials and Controlling (F), Human Resources (HR), Materials Management (MM), Sales & Marketing (SM), Production Planning (PP), and Factory Maintenance (FM).

Each module handles specific business tasks on its own, but is linked to the others where applicable. For instance, an invoice from the Billing transaction of Sales & Marketing will pass through to accounting, where it will appear in accounts receivable and cost of goods sold.

Company has typically focused on best practice methodologies for driving its software processes, but has more recently expanded into vertical markets. In these situations, MP produces specialized modules toward a particular market segment, such as utilities or retail.

Over the course of three decades, MP has evolved from a small, regional enterprise into a world-class international company. Today, MP is the global market leader in collaborative, inter-enterprise business solutions. The company now employs more

than 500 people, whose commitment and innovative spirit pace our future and success.

6.3 Plant Maintenance Module of MP:

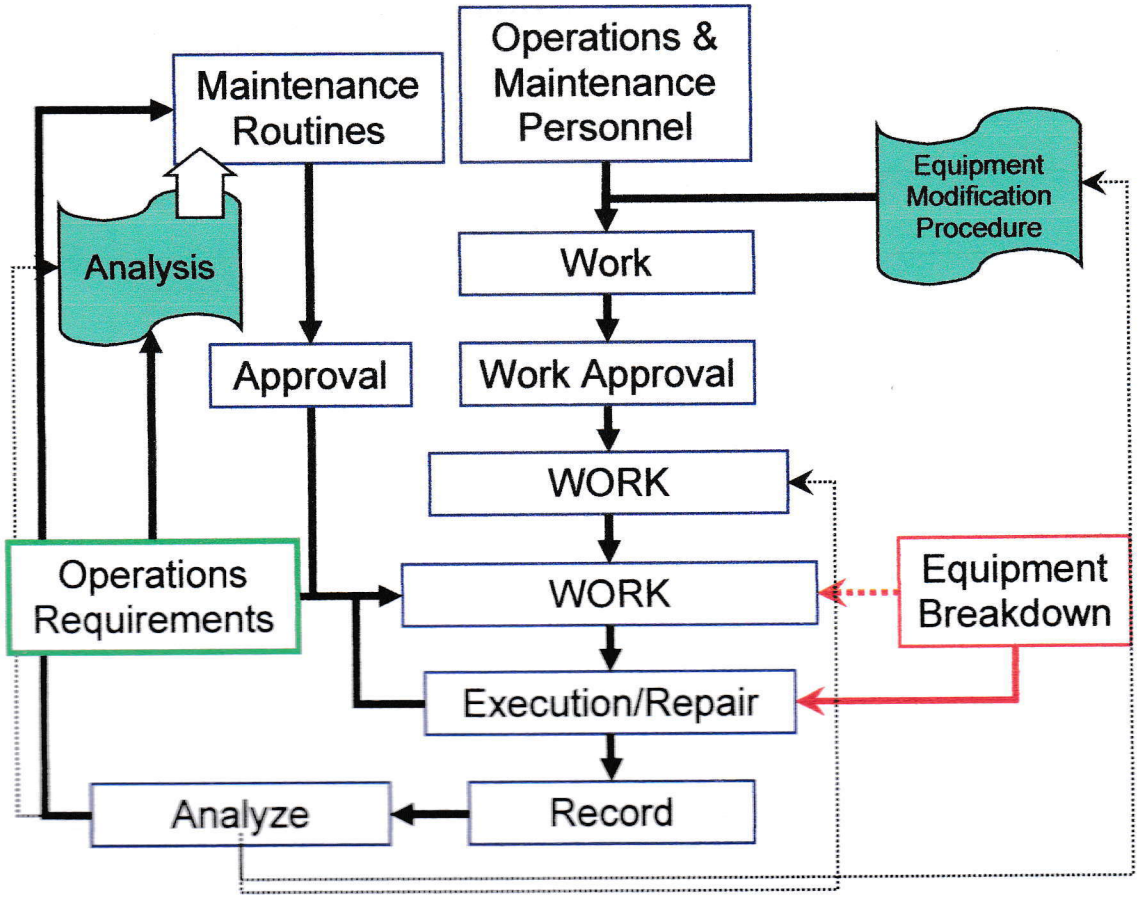
PM Module of EP System is a solution for all maintenance activities that are performed within a company.

It is highly efficient EP module of MP for the proper tracking of the equipment, Spare maintenance, managing refurbishment process, calculation of costing for the repair work due to man-hour, transportation that is require for the maintenance of the factory. PM module eliminates all the manual process to keep information related to factory maintenance activities and set a standard among the organization for factory maintenance activities.

So in brief it can said that PM Module is tool for the following activities is an organization-

- Managing
- Decision Support
- Compliance
- Spare Parts Purchasing / Inventory
- Accounting
- Safety

6.4 High Level Flow Diagram for Generator Maintenance:



The request for maintenance can come from any of source mentioned below-

1. Alarms through INMS
2. Performance report
3. Input from network monitoring
4. Feedback from follow-up work
5. Request from Optimization, O&M etc
6. Some Schedule maintenance activity

Maintenance planning can be done to describe the dates and scope of maintenance and inspection activities at technical objects. This ensures that the technical objects are maintained on time and thereby function optimally.

6.5 Maintenance Order Planning:

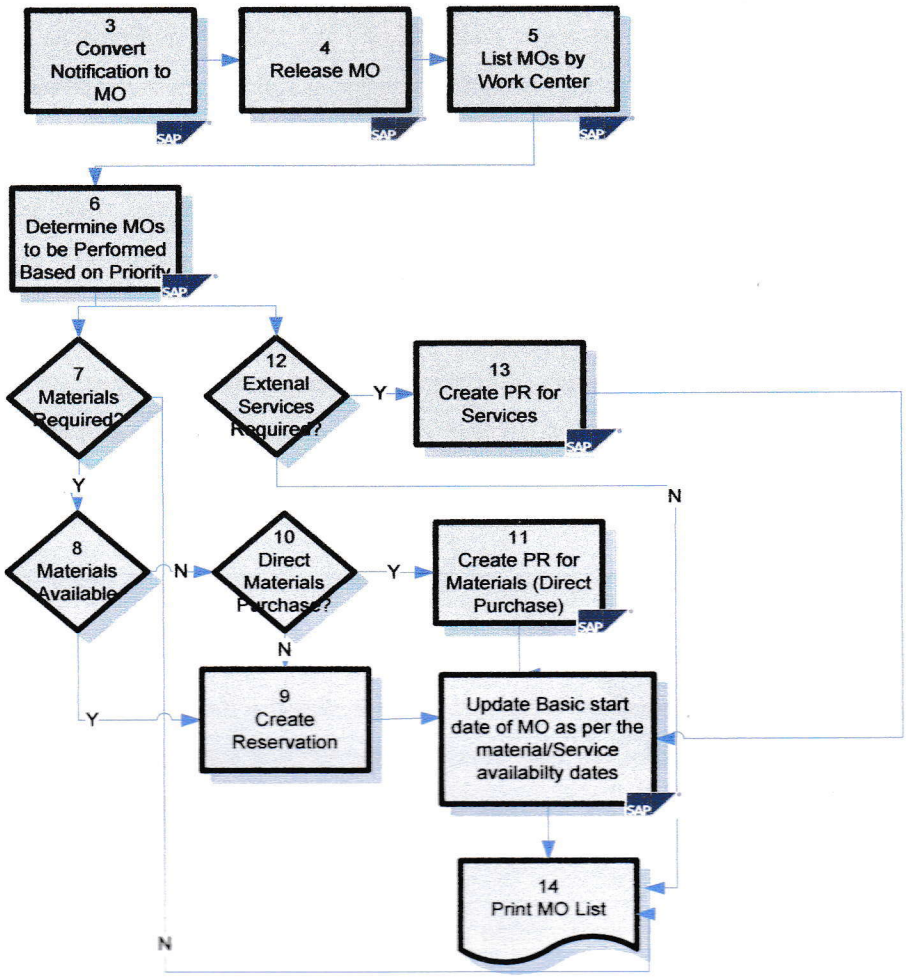


Fig: Maintenance Order Planning;

6.5.1 Maintenance Order Planning is as follows:

1) Based on analysis by the maintenance personnel, equipment are identified, where planned maintenance needs to be carried out.

2) The maintenance planner will also need to identify the units for the maintenance plans - time (weekly, monthly, yearly, etc.) or performance (every 100 running hours etc.). For performance based maintenance plans, adequate measuring counter needs to be defined on the technical object and measurement readings need to be regularly updated.

3) The maintenance planner decides which maintenance call objects for example maintenance order. The system generates for a maintenance order when maintenance need or due. The end result of the plan is to generate a call object from the data fed into the plan, when the maintenance is due. The maintenance planner decides initially which object is required. The possible objects are PM Order, a PM Notification or if the work is to be done wholly by a contractor, service entries.

4) Maintenance plans can be single cycle, strategic or multiple counter plans as per the requirement of each equipment. These plans will be equipment specific.

and required, to help in maintenance planning. The task lists will detail the sequence of activities to be performed and the spares, and estimated time required for completing the job. For those activities, which are common among group of equipment, a general task list will be prepared.

6) A maintenance plan will include the task list along with the scheduling parameters.

7) Whenever a schedule falls due, the system will create either a maintenance order, or a service entry sheet depending on what is decided as the output of the plan.

8) The maintenance planner will schedule the maintenance plan. Once the maintenance order is generated by the system, the maintenance planner can manually skip the job; manually reschedule, call the job, depending on the 5) Maintenance task lists will be prepared for equipment/Functional Location, where ever possible situation.

9) In case the call object is a maintenance order, then presently it will not be released automatically, but maintenance planner will release it, for further action. However, later, the system can be configured to release the generated orders automatically.

10) In those cases where external service will be required then a service entry sheet is created by the system so that the service offered is entered by the inspecting personnel and then accepted by the authorized personnel.

11) There is provision in the system to shift the next scheduled maintenance date of a maintenance plan, if there is considerable delay in completing the order/service acceptance or these maintenance objects are

completed much ahead of the schedule. These tolerance ranges for shifting are decided by the maintenance planner depending on the nature of the job.

Maintenance execution means actual job is started in this phase. All spares material is issued from stores & services of all the external vendors are taken at this stage to perform the job.

Maintenance completion takes placeonce the actual maintenance task is finished. Here in SAP system the following steps needs to complete:

- Confirmation of the actual timing
- Returning excess material back to stores
- Making service entry sheet by Contractor/Vendor if required.
- Updating the notification with dates, times & Failure analysis data if any.
- Technically closing the Maintenance order and notifications
- Settlement of Maintenance order to the cost receiving object
- Business completion of the maintenance order

6.6 Preventive Maintenance Process:

Preventive maintenance is a generic term for inspection & planned repairs. Preventive maintenance is done to restore the Target condition of the technical system by condition.Monitoring. This process includes all the task for which time & scope of the work can be planned in advance .The Process like Monthly inspection, Towers etc.

6.7 Corrective Maintenance Process:

Corrective maintenance is a generic term for Corrective actions to prevent major breakdowns of the equipment's so that equipment availability is maximum. Through corrective maintenance we maintain the target condition of the equipment by making some corrective repair from time to time or as & when the need arise.

6.8 Emergency Maintenance Process:

The Emergency maintenance process starts with identification of malfunction/Breakdown on an equipment or System, then the responsible person is notified immediately & they are required to attend & fix the problem within a timeframe defined as per the criticality of the system/equipment. If the issue is not resolved within the timeframe defined then it is escalated to next level & respective set of employee should be notified & then it should be fixed based

on the fault type by the specialized department. Finally after completing the job, the system should be updated with actual data .Reports will be generated based on the data which is fed by user. The management should be able to see all the breakdown reports & Root cause analysis reports.

6.9 Maintenance Process:

Refurbishment process is a process which is suited for repair of high value faulty items. This may include in-house repair & repairs with subcontracting. Almost all the engineering system faulty parts are repaired by external vendors.

6.10 Engineering Maintenance Process:

Capital Investment process/Engineering work order is PM Process which is suited for capacity enhancement or network modification which either increases the capacity or increases the life of network. Initially the Objects for capacity enhancement will be identified & a capital Investment order will be created which will be assigned to PM

module. Then the actual job will be done & all costs of material manpower, External services will be booked to the maintenance order. Then Business closure of the order will take place.

6.11 Calibration Process:

Calibration maintenance is a generic term for inspection, Calibration maintenance Calibration maintenance is done to restore the Target condition & to check the accuracy of the technical system by condition monitoring. This process includes the entire task for which time & scope of the work can be planned in advance.

Chapter 7

Switchgear

The apparatus used for switching, controlling and protecting the electrical circuits and equipment isknown as switchgear.The switchgear equipment is essentially concerned with switching and interrupting currentseither under normal or abnormal operating conditions. The tumbler switch with ordinary fuse is thesimplest form of switchgear and is used to control and protect lights and other equipment in homes,offices etc. For circuits of higher rating, a high-rupturing capacity (H.R.C.) fuse in conjunction with aswitch may serve the purpose of controlling and protecting the circuit. However, such a switchgearcannot be used profitably on high voltage system (3·3 kV) for two reasons. Firstly, when a fuseblows, it takes sometime to replace it and consequently there is interruption of service to the customers.Secondly, the fuse cannot successfully interrupt large fault currents that result from the faults onhigh voltage system.With the advancement of power system, lines and other equipments operate at high voltages andcarry large currents. When a short circuit occurs on the system, heavy current flowing through theequipment may cause considerable damage. In order to interrupt such heavy fault currents, automaticcircuit breakers (or simply circuit breakers) are used. A circuit breaker is switchgear which can open or closes an electrical circuit under both normal and abnormal conditions. Even in instanceswhere a fuse is adequate, as regards to breaking capacity, a circuit breaker may be preferable. It isbecause a circuit breaker can close circuits, as well as break them without replacement and thus has wider range of use altogether than a fuse.



Fig: 7.1 SWGR

Switchgear component

Switchgear covers a wide range of equipment concerned with switching and interrupting currents under both normal and abnormal conditions. It includes switches, fuses, circuit breakers, relays and other equipment. A brief account of these devices is given below. However, the reader may find the detailed discussion on them in the subsequent chapters.

- Bushings
- Circuit breaker contacts
- Instrument transformers
- Bus-bar and conductors
- Vacuum circuit breakers (VCB)
- Fuses

7.1. Bushings.

when a high voltage conductor passes through a metal sheet or frame which is at earth potential ,the necessary is provide in the form of bushing. The primary function of the bushing is to prevent electrical breakdown between the enclosed conductor and the surrounding earth metal work. The use bushing for a plain-break oil circuit breaker .the high voltage conductor passes through the bushing made insulating material .Although there are several types of bushing (condenser type, oil filed etc) , they perform the same function of isolating the conductor from earthed tank. The failure of bushing can in two ways. Firstly the breakdown may be caused by puncture ,dielectric failure of the insulating material of the bushing .Secondly, the breakdown may occur in the form of flash-over between the exposed conductor at either end of the bushing and the earthed metal .Illustrates these two possibilities .The bushings are so designed that flash-over take place before they get puncture. It because the puncture generally renders the bushing insulation un serviceable and incapable of withstanding the normal voltage.

7.2. Circuit breaker contacts.

The circuit breaker contacts are required to carry normal as well as short-circuit current. In carrying the normal current, it is desirable that the temperature should not rise above the specified limits and that there should be low voltage drop at the point of contact. in carrying breaking and making short-circuit current, they chief effects to be dealt with are melting and vaporization by the heat of arc and those due to electromagnetic force. Therefore, the design of contacts is of considerable importance for satisfactory operation of the circuit breakers.

7.3.Instrument transformers

1. Current transformer (CT)

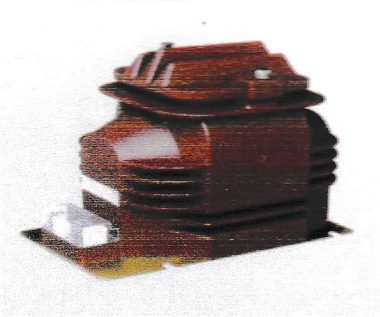


Fig. 7.3.1 CT

2. Potential transformer (PT)



Fig.7.3.2 PT

The primary of current transformer is connected in the power line. The secondary winding provides for the instruments and relays a current which is a constant fraction of the current in the line. Similarly, a potential transformer is connected witch its primary in the power line. The secondary provide for the instrument and the relays a voltage which is a known fraction of the line voltage

7.4. Bus-bar and conductors

The current carrying members in a circuit breaker consist of fixed and moving contacts and the conductors connecting these to the point external to the breaker .If the switchgear is of outdoor type ,these connections are connected directly to the overhead line. In case indoor type switchgear, the incoming conductors to the circuit breaker are connected to bus-bar.

7.5 Vacuum circuit breakers (VCB)

in such breakers, vacuum(degree of vacuum being in the range from 10^{-7} to 10^{-5} torr) is used as the arc quenching medium .since vacuum offers the high insulating strength, it is far superior arc quenching properties then any others medium. For example, When contact of a breaker are open in vacuum, the interruption occurs at first current zero with dielectric strength between the contacts building up at a rate thousands of time higher than that obtained with others circuit breakers.

Chapter-8

Conclusion

8.1 Conclusion:

A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine-generator. A diesel compression-ignition engine often is designed to run on fuel oil, but some types are adapted for other liquid fuels or natural gas.

Diesel generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid.

Sizing of diesel generators is critical to avoid low-load or a shortage of power and is complicated by modern electronics, specifically non-linear loads. In size ranges around 50 MW and above, an open cycle gas turbine is more efficient at full load than an array of diesel engines, and far more compact, with comparable capital costs; but for regular part-loading, even at these power levels, diesel arrays are sometimes preferred to open cycle gas turbines, due to their superior efficiencies.

8.2Recommendations:

As a very fast blooming with its proper generation sources there are Gas Generator, Diesel Generator and Rural power supply working together. When it is necessary that only Gas Generator is enough for supplying the total load for two or three section then it is done so easily. If needed Diesel is almost ready to supply further. Sometimes it is also seen that for some unexpected problems or interruptions either of the generators is off. Then it is necessary to he helped by the Rural power source.

Although, the system has got a balance with the mentioned procedure but it should be better if the industry might take some good move towards future with some remarkable steps. Those should be like.

- More Generating plant should be made to meet the future demand.
- All the equipment should be kept orderly.
- Proper instructions should be followed for any kind of power failure or problem.
- More expert people should be given in charge,
- More Protection should have been taken for the safe operation of the generator as well as switchgear protection.
- The Generator should be overhauling before it runs 10000 hours long.
- For time being, more skilled people should be appointed.
- The Diesel Generator is not capable of running the industry so it is needed to replace it with a new one.
- For safety purpose more steps should be made as there substations is running just by the general people area.
- There need a individual section for generator section.

8.3Bibliography

1. Power plant engineering (G.R Nagpal, Khanna publishers,15th edition,2-B,Nath market,delhi)
2. Power system engineering by M.L.Soni, P.V.Gupta, U.S.Bhatnagar, A. Chakrabarti
3. Principle of power system (V.K Mehta &Rohit Mehta)