



Electrical Power Generation & Economics– BEE405A

Module-2A Thermal Power Plants

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Course Outline

POWER GENERATION AND ECONOMICS			
Course Code	18EE42	CIE Marks	40
Teaching Hours/Week (L: T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Module-2 - Thermal Power Plant, Gas and Diesel Power Plant

- BTL: L1 – Remembering, L2 – Understanding

Course Outline

Module-2

- **Steam Power Plants:** Introduction, Efficiency of steam plants, Merits and demerits of plants, selection of site. Working of steam plant, Power plant equipment and layout, Steam turbines, Fuels and fuel handling, Fuel combustion and combustion equipment, Coal burners, Fluidized bed combustion, Combustion control, Ash handling, Dust collection, Draught systems, Feed water, Steam power plant controls, plant auxiliaries.
- **Diesel Power Plant:** Introduction, Merits and demerits, selection site, elements of diesel power plant, applications.
- **Gas Turbine Power Plant:** Introduction Merits and demerits, selection site, Fuels for gas turbines, Elements of simple gas turbine power plant, Methods of improving thermal efficiency of a simple steam power plant, Closed cycle gas turbine power plants. Comparison of gas power plant with steam

INTRODUCTION

- Thermal power plant converts heat energy of a coal into electrical energy.
- Coal is burnt in boilers which convert water into steam.
- The expansion of steam in turbine produces mechanical power which drives an alternator.
- main equipment of a plant is boiler, steam turbine and alternator
- And other auxiliary equipment which helps in efficient conversion of heat energy.

- The Vindhyachal Thermal Power Station in the Singrauli district of Madhya Pradesh, with an installed capacity of 4,760MW, is currently the biggest thermal power plant in India
- Raichur Thermal Power Station with installed capacity of 1720MW

Selection of Site for a Steam Power Plant

- **Availability of raw materials:** it uses coal or a oil as a fuel a large quantity of it is required say about 5000-6000 tons per day. Storage of raw materials to be done so which increases the investment cost. And to be located near the coalfields or at the railways so it is easy to get raw materials required.
- **Nature of land:** the dead land to be selected which can bare the dead load. The capacity being $1\text{MN}/\text{m}^2$
- **Cost of a land:** it should be very economical so it can be located at the heart of the city.
- **Availability of water:** water is used as a working fluid here large quantity is required for evaporation and condensation so that there should not be any loss in water, it is better located where the water source is easily available.

Contd..

- **Transportation:** it is economical when located near the railway lines so that bringing equipments and fuels will be easier.
- **Ash disposal facilities:** as the ash comes out in a hot condition it is corrosive and pollutes air. In concern with human health it should be disposed in a larger and safer area.
- **Size of a plant:** The larger plant is more economical compared to the low capacity plant.
- **Load center:** to be located as far as possible to the load center in order to reduce the transmission line cost and losses in it.
- **Public problems:** in concern with the human health from smoke, fly ash and heat discharge to be located away from the towns.

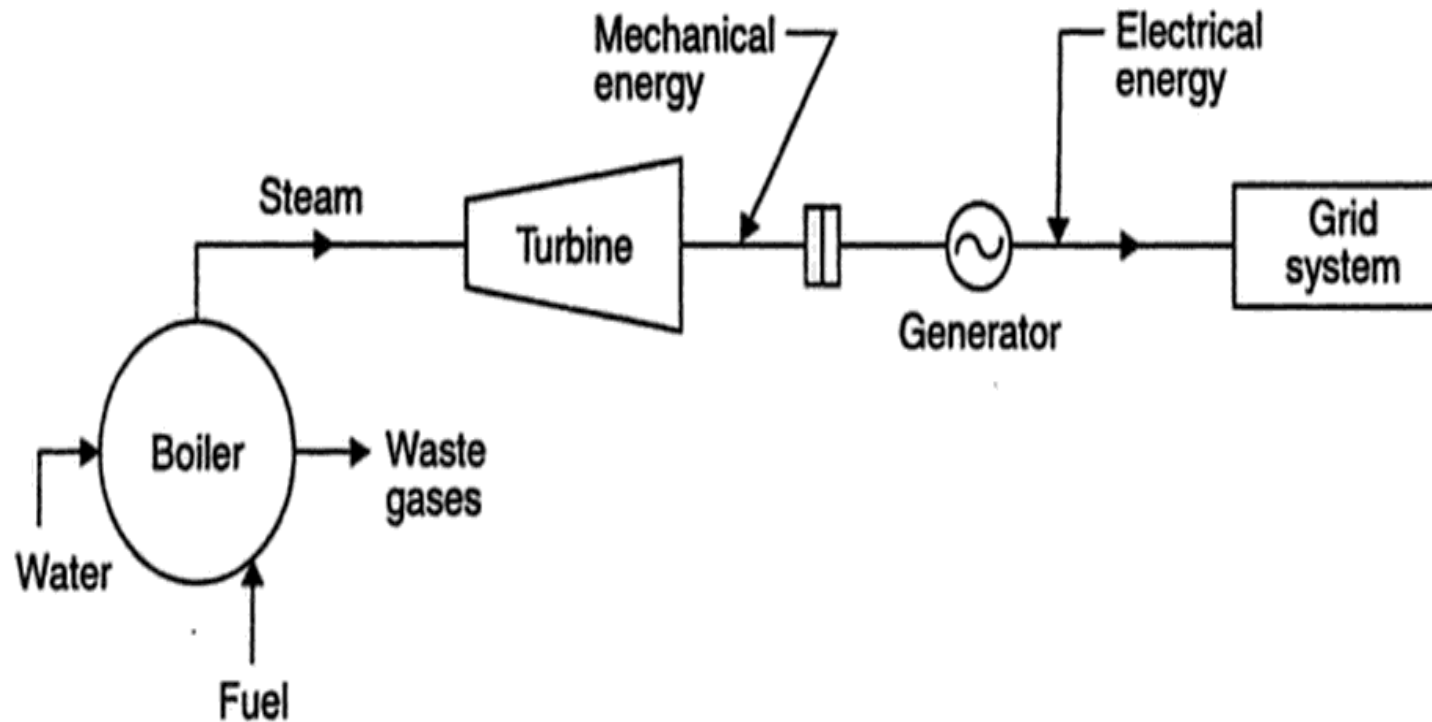
Merits and Demerits of the Plant

- **Advantages:**
- They can respond to rapidly changing loads without difficulty.
- A process of the steam generated can be used as a processed steam in different industries.
- Can be located near the load center.
- Can be set up near the industries so the transmission cost will reduce.
- Fuel is cheaper.
- Steam turbine and engines can be over loaded upto 25%.
- Less space is required for Thermal plant.
- Production cost and initial cost is less as compared to the diesel power plant.

Disadvantages:

- Maintenance and operating cost are high.
- The cost of a plant increases with increase in pressure and temperature.
- Long time is required setup and put the plant in action.
- Large quantity of water is required.
- Great difficulty in handling coal.
- Efficiency decreases below 75% of the load.
- Presence of problem due to smoke and heat in the plant.

Generation Outline Diagram

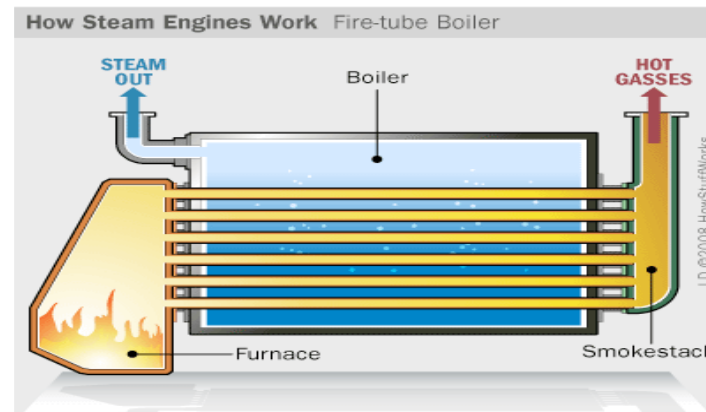


Main Equipments of Steam Plant

- **Boiler:** The heat of combustion of coal in the boiler is utilized to convert water into steam at high temperature and pressure.
- The flue gases from the boiler make their journey through super-heater, economizer, air pre-heater and are finally exhausted to atmosphere through the chimney.
- Major types of boilers are: (i) fire tube boiler and (ii) water tube boiler

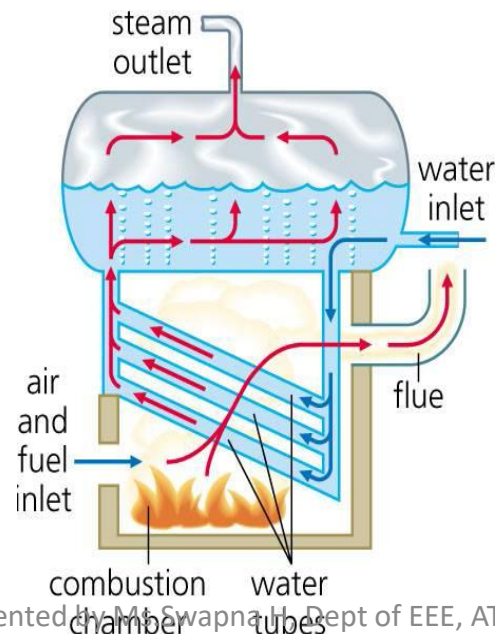
Fire Tube Boiler

- The boiler is named so because the production of combustion passes through the tubes which are surrounded by water.
- Depending on whether the tube is vertical or horizontal the fire tube boiler is divided into two types Vertical tube boiler and Horizontal tube boiler.
- A fire tube boiler is simple, compact and rugged in construction. Its initial cost is low.



Water Tube boilers

- In this boiler, the water flows inside the tubes and hot gases flow outside the tube.
- Water tube boiler are classified as vertical, horizontal inclined boiler
- The circulation of water in the boiler is may be natural or forced.



- **Super Heaters:** The steam produced in the boiler is wet and is passed through a super heater where it is dried and superheated (i.e., steam temperature increased above that of boiling point of water) by the flue gases on their way to chimney.
- **Economizer:** An economizer is essentially a feed water heater and derives heat from the flue gases.
- The feed water is fed to the economizer before supplying to the boiler.
- The economizer extracts a part of heat of flue gases to increase the feed water temperature.

- **Air preheater:** The air preheater extracts heat from flue gases and increases the temperature of air used for coal combustion. The principal benefits of preheating the air are increased thermal efficiency and increased steam capacity per square meter of boiler surface.
- **Steam turbine:** The dry and superheated steam from the super heater is fed to the steam turbine through main valve. The heat energy of steam when passing over the blades of turbine is converted into mechanical energy.

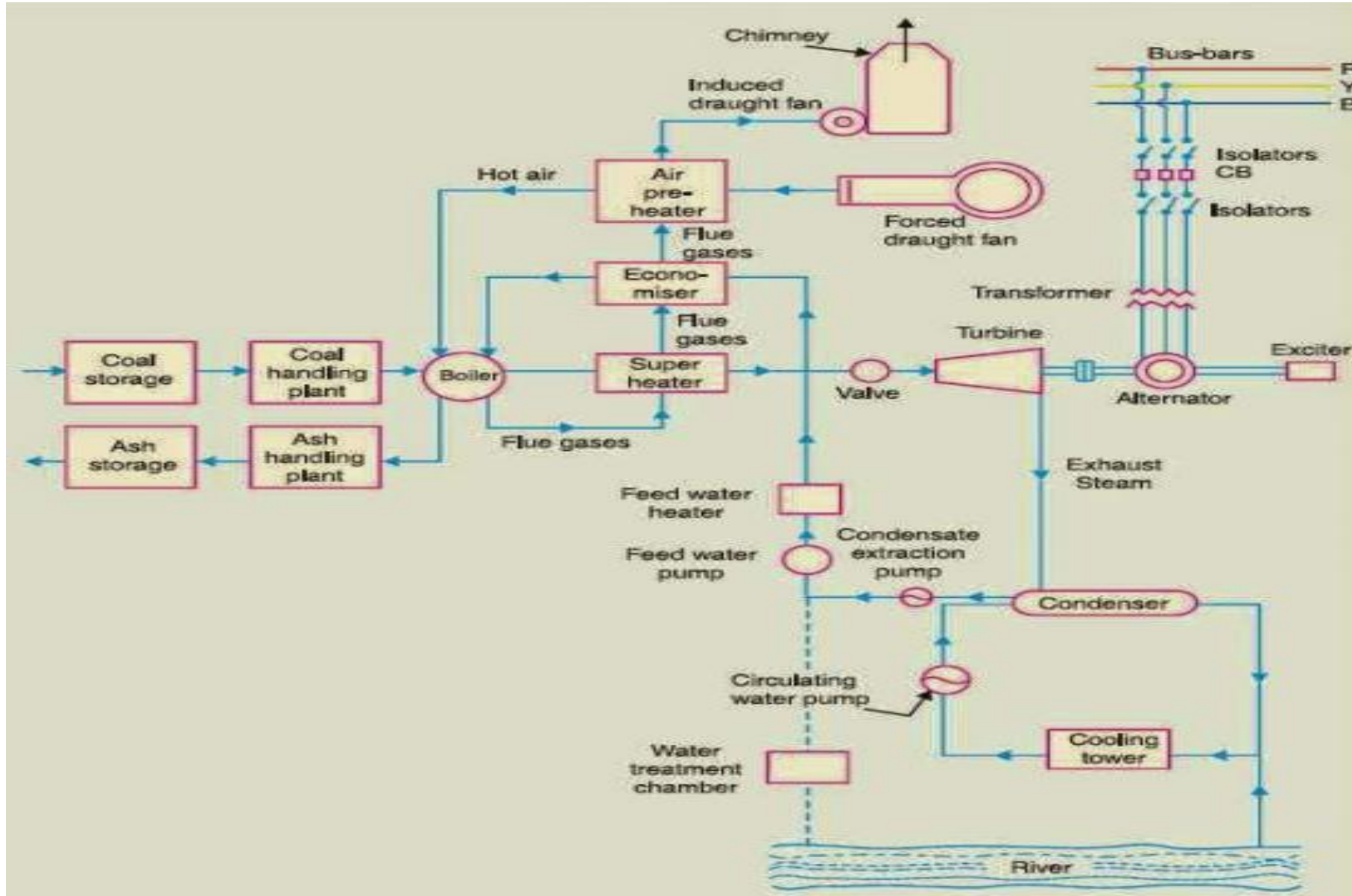
Impulse	Reaction
Expansion happens in a nozzle	Expansion happens in turbine blades
High speed	Low speed

Alternator: The steam turbine is coupled to an alternator. The alternator converts mechanical energy of turbine into electrical energy

- **Feed water:** The condensate from the condenser is used as feed water to the boiler. Some water may be lost in the cycle which is suitably made up from external source.

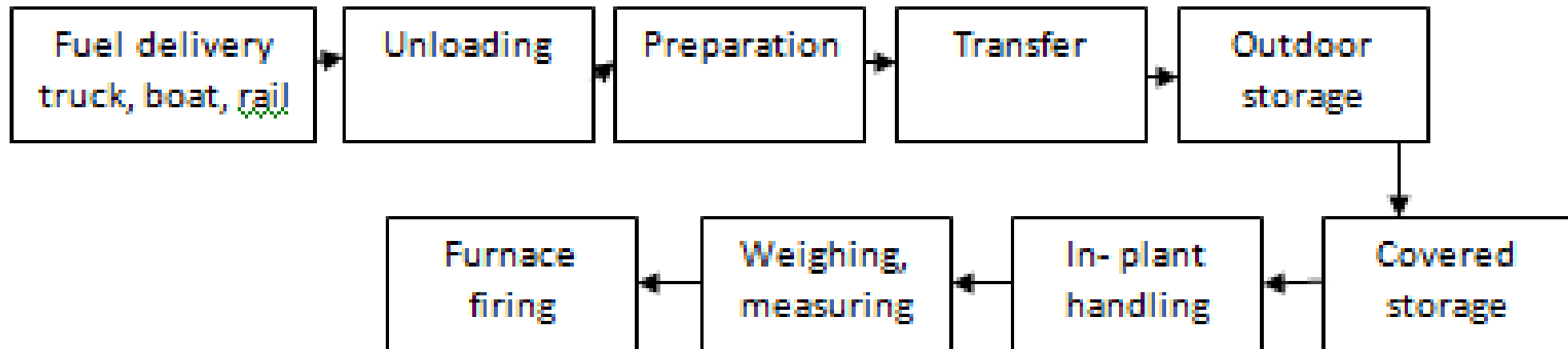
- **Cooling arrangement:** In order to improve the efficiency of the plant, the steam exhausted from the turbine is condensed by means of a condenser.
- natural source of supply such as a river, canal or lake and is circulated through the condenser

Schematic Diagram of Thermal Power Plant

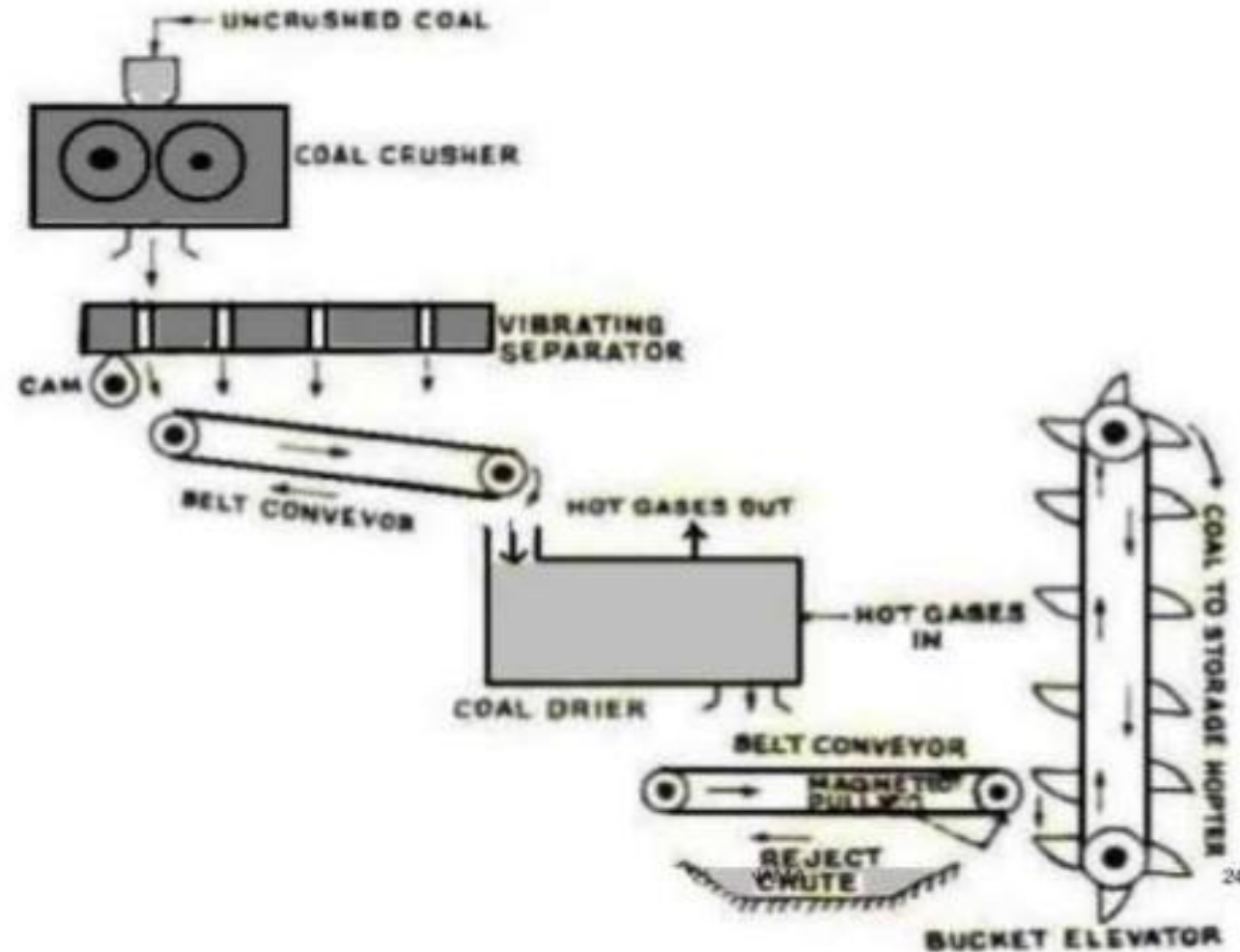


Fuels and Fuel Handling System

- The majority of fuel used in steam power plant is coal
- Coal Handling is very important because it contributes to the half of the cost of a steam power plant.



Coal Preparation Plant



Outdoor Storage

- Storage of coal is essential for two reasons namely-
 1. To Avoid Shut-Down of plant during failure of normal coal delivery
 2. Beneficial on the seasonal Market conditions

Inplant Handling:

- Coal Handling between the final storage to the firing equipment.
- According to the load on the plant, gates and valves are operated to control the flow

Ash Disposal and Dust Collection

- **1. Ash Handling Plant**
- coal is generally used as fuel and hence the ash is produced as the ByProduct of Combustion.
- Ash generated in power plant is about 30-40% of total coal consumption
- hence the system is required to handle Ash for its proper utilization or disposal.
- *The steam power plant produces 5000 tons of ash daily (2000MW)*
- The ash may be to types,
 - **Fly Ash** (Around 80% is the value of fly ash generated)
 - **Bottom ash** (Bottom ash is 20% of the ash generated in coal based power stations.

- **Fly Ash**
- Ash generated in the ESP(electro static precipitator) which got carried out with the flue gas is generally called Fly ash.
- **Bottom ash**
- Ash generated below furnace of the steam generator is called the bottom ash.
- **The operation of ash handling plants is**
- Removal of ash from the furnace ash hoppers
- Transfer of the ash to a fill or storage
- disposal of stored ash

The ash may be disposed in the following way

- Waste land site may be reserved for the disposal of ash.
- Building contractor may utilize it to fill the low lying area.
- Deep ponds may be made and ash can be dumped into these ponds to fill them completely
- Barrage may take the ash to sea for disposal into water grave.

Draught System

- The combustion in the boiler requires supply of sufficient quality of air and removal of exhaust gases
- A draught tube may be
 1. Natural Draught
 2. Mechanical Draught

Natural Draught

- A natural Draught is provided by the chimney or stack.
- Natural draught has its limitation . Modern plants has high rate of heat transfer and Draught
- Natural draught is used only for small boilers.

Mechanical Draught

- In a mechanical draught system the movement of air is due to the action of fan. A mechanical Draught consist of **forced Draught or induced draught** or both.
- In forced draught system the fan is installed near the boiler .the fan force the air through the furnace , economizer, air pre-heater and chimney. The pressure of air, throughout the system, is above atmospheric and air is forced to flow through the system
- In an induced draught system the , the fan is installed near the base of the chimney .The burnt gases are sucked out from the boiler , thus reducing the pressure inside the boiler, to less than atmosphere. This induces fresh air to enter the furnace.

Turbo Alternators

- Turbo alternators in central power stations are usually 2 pole, 50Hz, 3000RPM.
- Their size vary upto 1000MW.
- The rotor and stator of a turbo alternator are cooled by air upto 40MW greater than that hydrogen cooling is used.
- Turbo alternator are rated for 11,12,22-33KV. But higher voltages are not suggested because of site, transmission problem, etc.
- Have 0.8 PF lag, 230 V and can be overloaded 20% of rated PF.

Steam Station Control

- Control are provided at boiler, turbine and generator for best operating condition.
- We use automatic combustion control for best boiler efficiency.
- In modern steam station, boiler and turbine is controlled at turbine room and the generator and feeder at control room, in some case all may be centralized at one place in control room.

Steam Station Control Room





Electrical Power Generation & Economics– BEE405A

Module-2b_Diesel Power Plants

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Course Outline



- Introduction
- Definition of Diesel Electric Power Plant
- Basic Principal of Diesel Electric Power Plant
- List of Diesel Electric Power Plant in India
- Uses of Diesel Electric Station
- Selection of Site for a Diesel Power Station
- Schematic arrangement of Diesel-Electric Power Plant
- Main Components of Diesel Electric Power Plant
- Advantages, Disadvantages & Application of Diesel Power Plant

INTRODUCTION

- In a diesel power station, diesel engine is used as the prime mover.
- The diesel burns inside the engine and the products of this combustion act as the working fluid to produce mechanical energy.
- The diesel engine drives alternator which converts mechanical energy into electrical energy.

Definition of Diesel Electric Power Plant

- A generating station in which diesel engine is used as the prime mover for the generation of electrical energy is known as **diesel power station**.

Basic Principal of Diesel Electric Power Plant



List of Diesel Electric Power Plant in India

Power station	State	Capacity (MW)
GMR Vasavi Diesel Power Plant	Tamil Nadu	-
Kozhikode Diesel Power Station	Kerala	96
Yelahanka Diesel Power Station	Karnataka	127.92
Belgaum Diesel Power Station	Karnataka	32.52
Brahmapuram Diesel Power Plant	Kerala	64
LVS Power Station	Andhra Pradesh	36.8
Samalpatti Diesel Power Station	Tamil Nadu	105.7
Samayanallur Diesel Power Station	Tamil Nadu	106
Bellary Power Station	Karnataka	25.2
<i>Southern</i>		<i>950.04</i>
Suryachakra Diesel Power Station	Andaman & Nicobar	20
<i>Islands</i>		<i>20</i>
Bemina Diesel Power Station	Jammu & Kashmir	5
Leh Diesel Power Station	Jammu & Kashmir	2.18
Ambala Diesel Power Station	Haryana	2.18
Upper Sindh Diesel Power Station	Jammu & Kashmir	1.70
Keylong Diesel Power Station	Himachal Pradesh	0.13
Kamah Diesel Power Station	Jammu & Kashmir	0.06
<i>Northern</i>		<i>11.25</i>
Gangtok Diesel Power Station	Sikkim	4
Ranipool Diesel Power Station	Sikkim	1
<i>Eastern</i>		<i>5</i>
Leimakhong Diesel Power Station	Manipur	36
<i>North Eastern</i>		<i>36</i>
<i>Total</i>		<i>1022.39</i>

Uses of Diesel Power Station

1. Central Station
2. Standby Plant
3. Peak Load Plant
4. Emergency Plant
5. Mobile Plant
6. Nursery Plant
7. Supply Units for Cinemas, Hospitals etc

Merits & Demerits of Diesel Power Plant

Merits

1. Simple design & layout of plant.
2. Occupies less space & is compact.
3. Can be started quickly and picks up load in a short time.
4. Requires less water for cooling.
5. Thermal efficiency better than that of Steam Power plant of same size.
6. Overall cost is cheaper than that of Steam Power plant of same size.
7. Requires no Operating staff.
8. No stand-by losses.
9. Free from ash handling problem
10. Located near the plant.
11. Can use different types of fuel.

Merits & Demerits of Diesel Power Plant

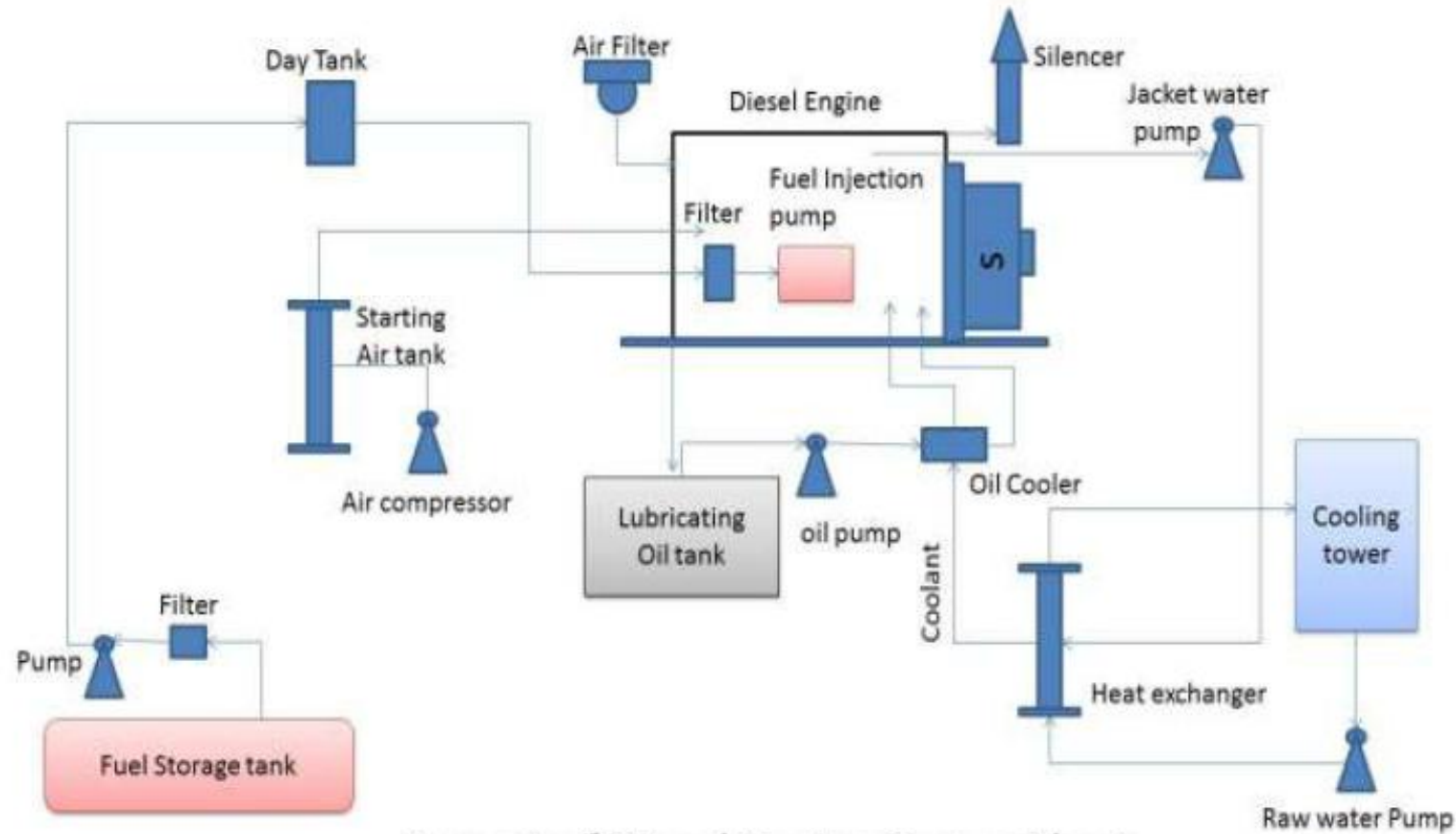
Demerits

1. High running charges due to costly price of Diesel.
2. Plant does not work efficiently under prolonged overload conditions.
3. Generates small amount of power.
4. Cost of lubrication very high.
5. Maintenance charges are generally high.
6. The plant does not work satisfactorily under overload conditions for a longer period.
7. The plant can only generate small power.

Selection of Site for a Diesel Power Station

- Near to Load Center
- Availability of Land
- Availability of Water
- Foundations
- Local Conditions
- Noise Pollution

Layout of Diesel Electric Power Plant



Layout of Diesel Engine Power Plant

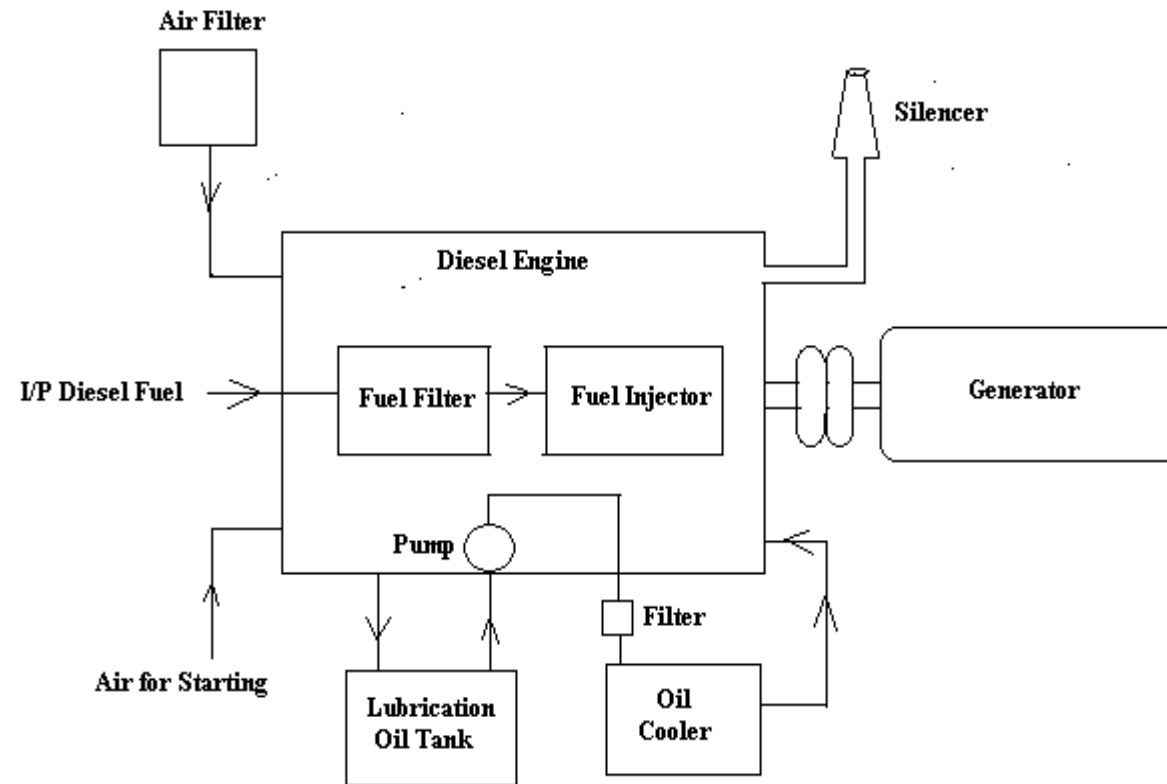
Main Components of Diesel Electric Power Plant

1. Diesel Engine
2. Engine Fuel Supply System
3. Engine Air Intake System
4. Engine Exhaust System
5. Engine Cooling System
6. Engine Lubrication System
7. Engine Starting System
8. AC or DC Generators

Main Components of Diesel Electric Power Plant

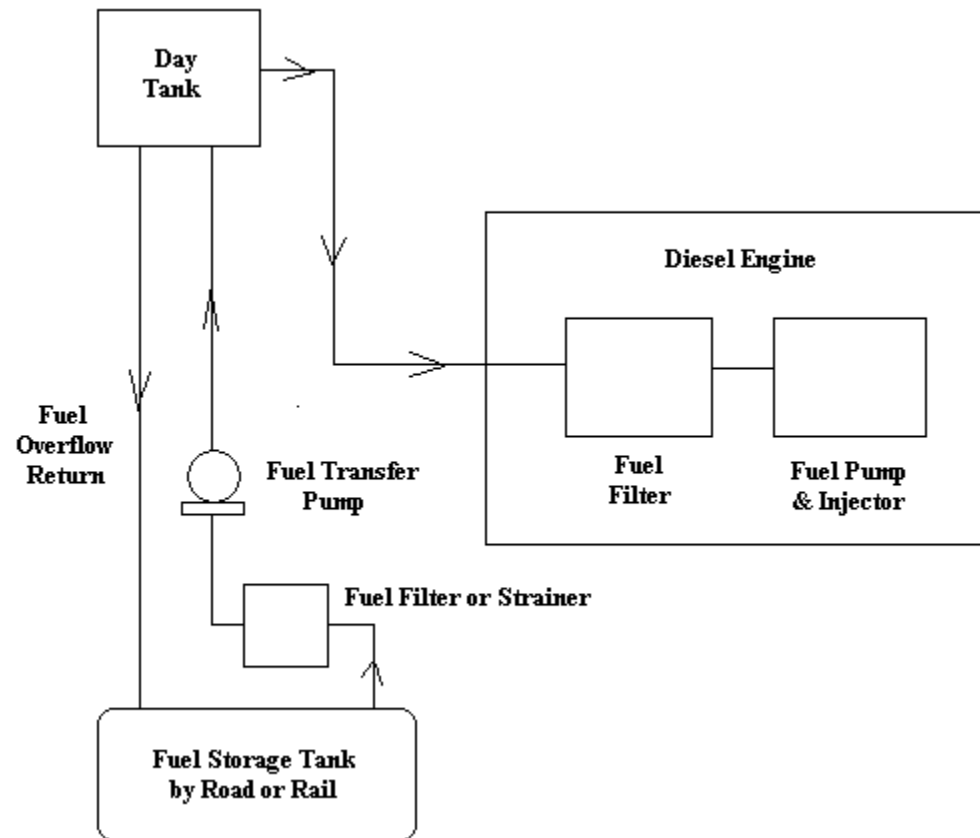
Let us get into the details of each component

1. Diesel Engine



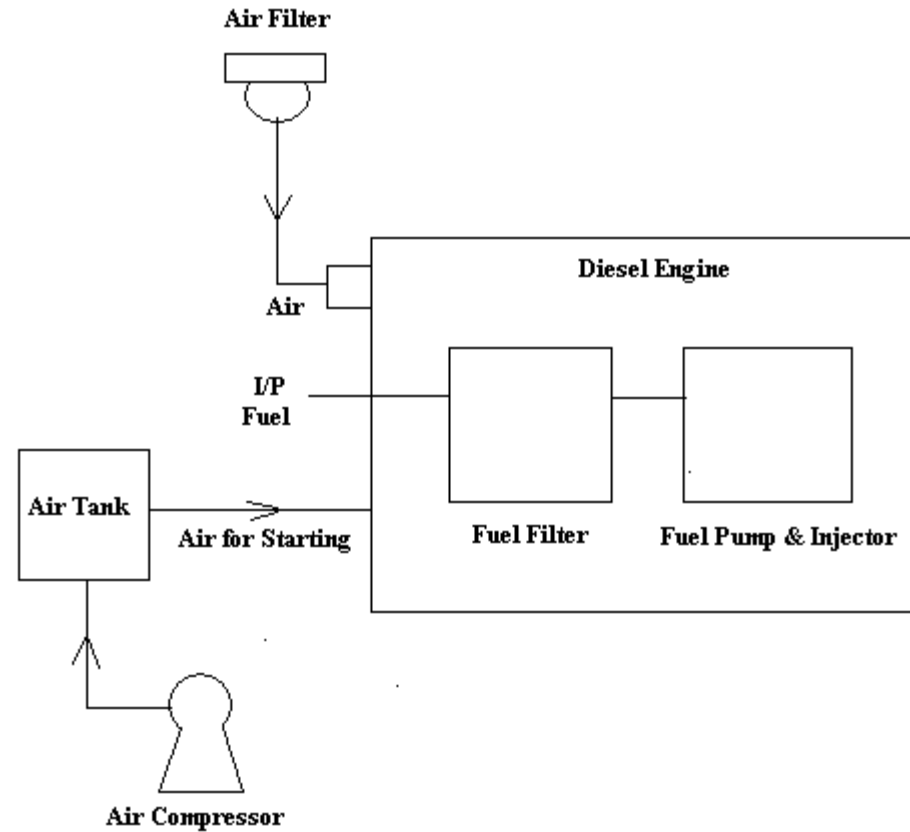
Main Components of Diesel Electric Power Plant

2. Engine Fuel Supply System



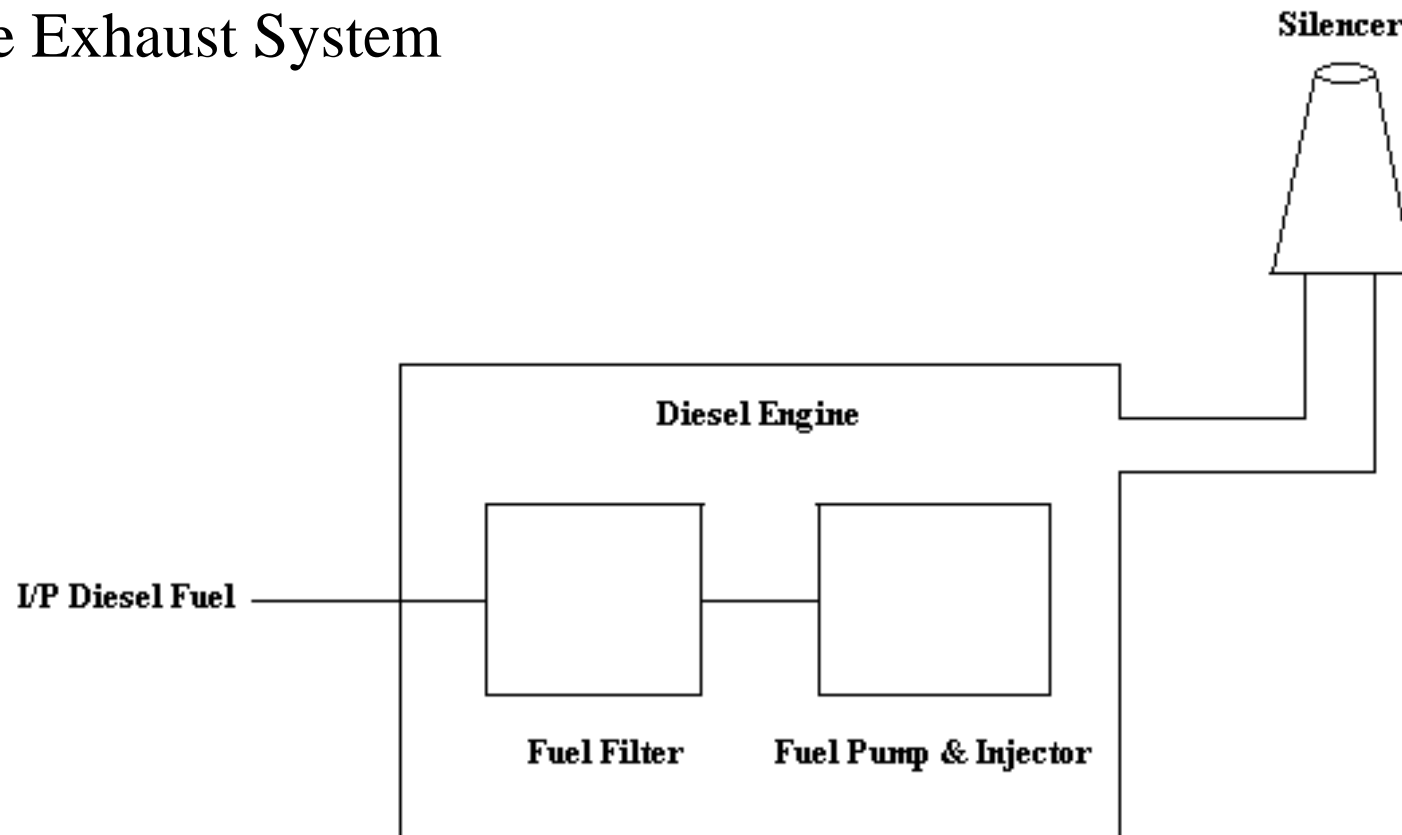
Main Components of Diesel Electric Power Plant

3. Engine Air Intake System



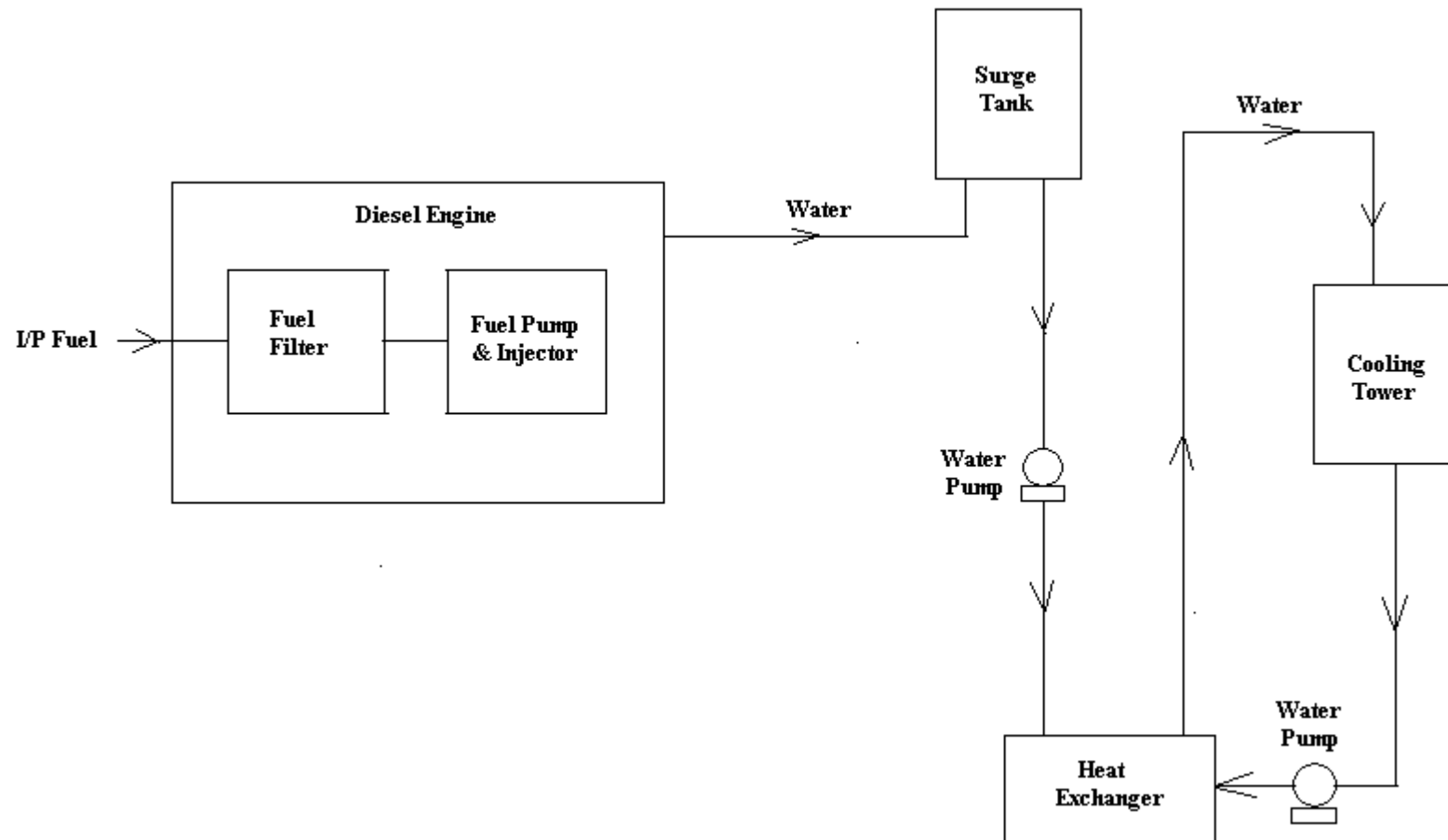
Main Components of Diesel Electric Power Plant

4. Engine Exhaust System



Main Components of Diesel Electric Power Plant

5. Engine Cooling System



Main Components of Diesel Electric Power Plant

6. Engine Starting System

This system includes storage compressed air tank, self starter, auxiliary engines & electrical motors (battery) etc.

1. Starting of Small Engine:
2. Starting with the help of Auxiliary Engine:
3. Starting with the help of batteries:

Application of Diesel Power Plant

1. In case of any emergency diesel engines are used.
2. It is also used for peak load during small period of time.
3. It is used to restart the boilers.
4. It is used in remote places.
5. It can be used in areas having low load factor.



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Thank You



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Module-2c_Gas Turbine Power Plant

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Introduction

- Gas turbines are one of the most widely-used power generating technologies.
- Gas turbines are a type of internal combustion (IC) engine in which burning of an air-fuel mixture produces hot gases that spin a turbine to produce power
- It is the production of hot gas during fuel combustion gives the name as Gas Turbines
- Gas turbines can utilize a variety of fuels, including natural gas, fuel oils, and synthetic fuels

Selection of site

The factors to be considered for site selection of gas turbine power plants are

- Distance from load centre
- Availability of land at reasonable rate,
- Availability of fuel at reasonable rate,
- Availability of transportation facilities,
- Distance from populated area and Type of land (land should be of high bearing capacity).

Fuels for Gas turbines

One main advantage of gas turbines is their fuel flexibility.

- They can be adapted to use almost any flammable gas and petroleum products such as gasoline (petrol), diesel and kerosene (paraffin) which happen to be available locally
- Majorly natural gas is the most commonly used fuel. Crude and other heavy oils and can also be used to fuel gas turbines if they are first heated to reduce their viscosity to a level suitable for burning in the turbine combustion chambers.

Advantages of gas power plant comparison with steam and diesel power plants

- It is smaller in size and weight as compared to an equivalent steam power plant.
- The initial cost and operating cost of the plant is lower than an equivalent steam power plant. A thermal plant of 250 MW capacity cost about Rs. 250 crores. Presently whereas gas turbines plant of that same-size cost nearly 70 crores.
- The plant requires less water as compared to a condensing steam power plant.
- The plant can be started quickly, and can be put on load in a very short time.
- There are no standby losses in the gas turbine power plant whereas in steam power plant these losses occur because boiler is kept in operation even when the turbine is not supplying any load.
- The maintenance of the plant is easier and maintenance cost is low.
- The lubrication of the plant is easy. In this plant lubrication is needed mainly in compressor, turbine main bearing and bearings of auxiliary equipment.
- Gas power plant is much Simpler than a steam plant due to the absence of boilers with their feed water evaporator and condensing system.

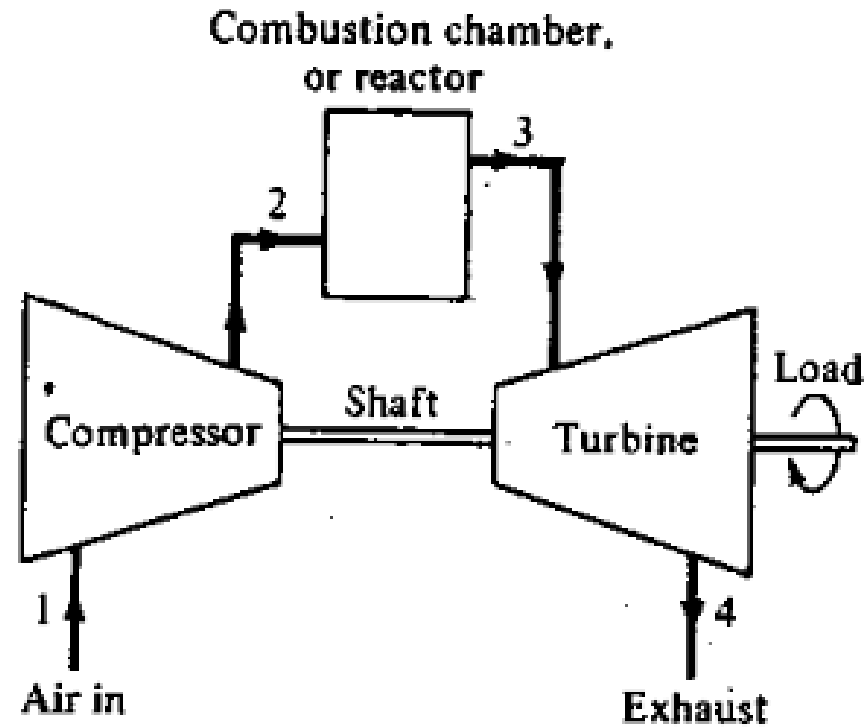
Elements of Gas Turbine power plant

The major components are

- Compressor
- Regenerator
- Combustion chamber
- Alternator
- Starting motor
- Gas turbine

Gas Turbines Types

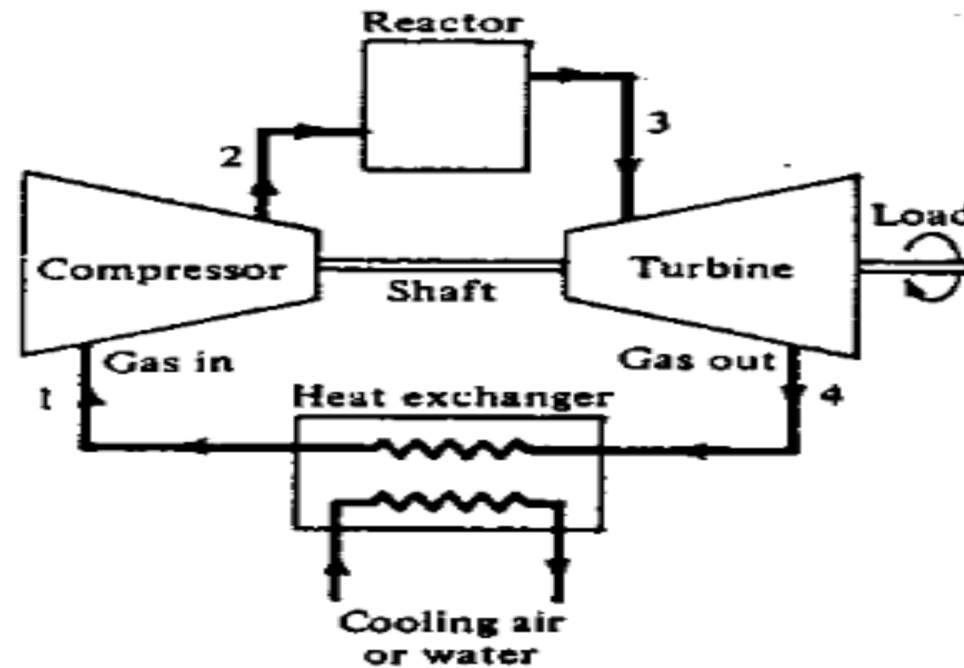
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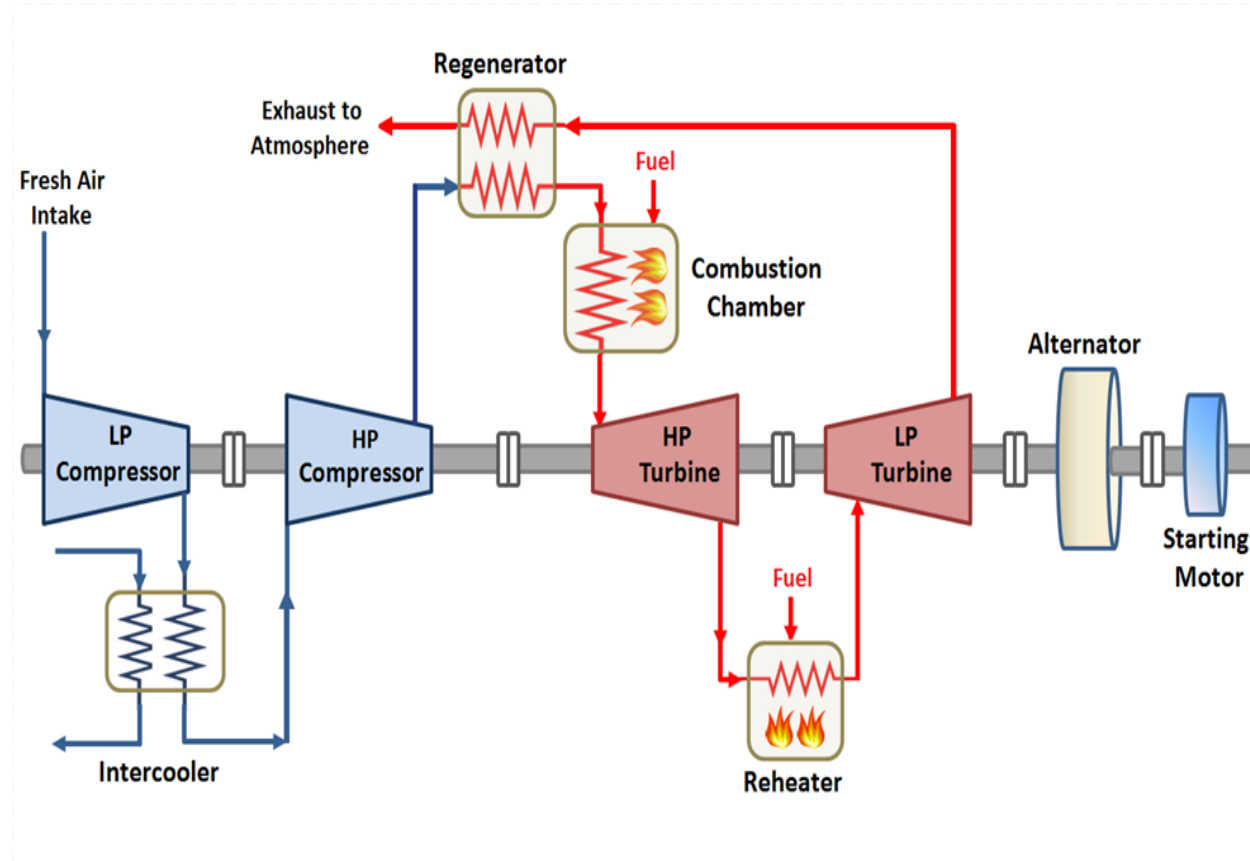
- Closed Cycle



Methods of Improving Thermal Efficiency

Thermal Efficiency can be improved by incorporating three main components in Gas turbine power Plants

- Regenerator
- Intercooler
- Reheater



Disadvantages of Gas turbine Power Plant

- The efficiency and net output power is less because some amount of mechanical power is used to drive the compressor.
- Initial external power is needed to drive the compressor until the plant starts generating.

Applications

- Gas turbines can be used for large scale power generation.
- Examples: Used for applications of delivering 600 MW or more from a 400 MW gas turbine coupled to a 200 MW steam turbine in a co-generating installation for bringing power to remote sites such as oil and gas fields
- Used in the major electricity grids in peak saving applications to provide emergency peak power.



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