

Diesel Power Generating Plants

Introduction

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- Dean of Engineering
- Worked for 30 years in Industrial Automation
- 30 years experience in mining, oil and gas, electrical and manufacturing industries

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Learning Objectives

- Energy sources
- The choice between AC and DC power
- Single phase vs. three-phase AC power
- Prime movers used for power generation
- Power plant components/types
- Types of engines used in power generation
- Diesel engine and its advantages in power generation applications

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Energy Sources

- Conventional energy sources
 - Involves a combustion process
 - Depletion of natural resources like coal, Oil, etc
 - Major Air Pollution contributors
- Non conventional/Renewable energy sources
 - Combustion process not a must
 - Use Sun, wind, etc directly to produce power
 - Bio degradable wastes also can be used
 - Air pollution is avoided

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Energy Sources- Calorific Values

- Calorific value decides the efficiency of an energy source per unit weight
- Typical calorific values in kilo calories per kg

Fuel	Calorific Value (kCal/kg)
Paraffin	10,400
Diesel Petroleum	9,800
Charcoal	7,100
Dried Wood	4,700
Lignite	4,000
Wood (25-30% Moisture)	3,500

AC and DC Power

- Flow of electrons decide the type
- Initial inventions were based on DC
- AC power gained importance with
 - Invention of transformers
 - Advantages in Long distance transmission
 - Can easily be converted to DC
- Generators comprise of conductors and magnetic field with relative motion that results in current flow in conductors

Three phase and single phase AC

- Three phase help in carrying more power compared to single phase
- Today's AC generation beyond a few kilowatts is in three phase
- Prime mover is used to rotate a generator which produces three phase power in three sets of conductors used in the generator
- Alternator is the common term for AC generators

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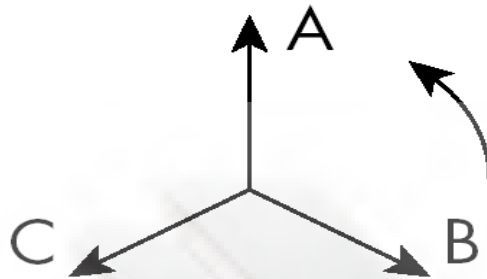


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AC wave form
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3 Phase AC Vectors



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Capacity of generator

- Normally given in kVA
- Useful power kW = kVA × power factor
- Diesel generators rated for 0.8 lagging power factor
- Engine capacity limits the maximum kVA that can be drawn from the generator
- Power plant incorporate multiple generators.
- Capacity of a power plant is given by the total kW or MW produced by all the generators.
- Voltage rating limited to around 25kV due to practical limitations

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AC Generator Components

- Stator – Incorporate the main windings that ultimately carry the load current
- Rotor – Coupled to prime mover to convert mechanical energy to Electrical energy transferred through the stator and the speed of rotation decides the output frequency
- Exciter / Field – Exciter Provides DC supply to the field windings that are responsible for a rotating magnetic field cutting across stator windings

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A Large Generator



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Prime Movers

- Internal combustion and External combustion
- Internal combustion: Fuels combusted internal to prime movers
 - Diesel engines
 - Gas Turbine
- External combustion: Fuels burnt external to prime movers
 - Steam Generators

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Prime Mover Features

Type	Output Range	Typical Fuels	Typical Heat to Power Ratio	Heat Output
Steam Turbine	0.5MW to 600MW	Any, but used for producing steam	3:1 to 10:1	Medium
Gas Turbine	0.5MW to 250MW	Natural gas, Liquefied Gas, Biogas, Mine gas	1.6:1 up to 5:1 with after firing	High
Compression ignition engines	Upto 20 MW	Natural gas with diesel oil, Heavy fuel oil	1:1 to 1.5:1 up to 2.5:1 with after firing	Low and High
Spark Ignition	Up to 4MW	Natural gas, Landfill gas, Biogas, Mine gas	1:1 to 1.7:1	Low and High
Heat Recovery gas turbines	1MW to 100MW	Same as gas turbine	Down to 0.7:1	Medium

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Prime Mover Choice

- Heat to Power Ratio
- Quality of heat requirement at power plant location
- Higher heat demand in industry may tilt favour towards gas turbines
- Utility companies – Heat requirement is minimal and hence combined cycle plants may be preferred
- Diesel Engine power plants limited in size.

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Steam Turbines

- Steam boiler is used to produce the high pressure steam to run the turbines.
- The plant may be based on coal, diesel, oil, nuclear, etc but all are used to exchange their heat to produce super heated steam
- Higher capital investment with cost becoming feasible for large size power plants

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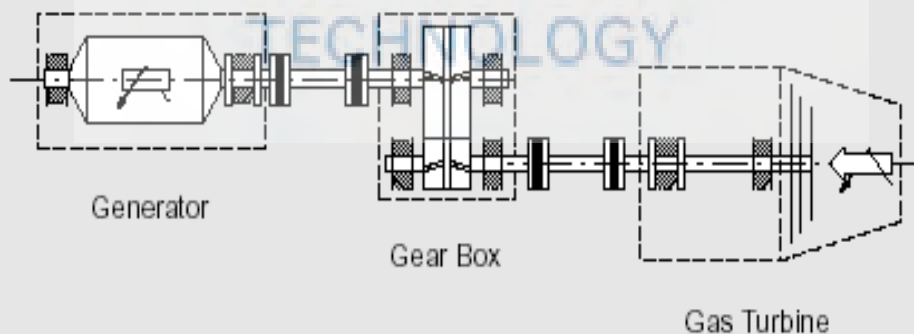
Gas Turbines

- Gas is internally combusted in a pressurized combustion chamber
- Air from atmosphere is compressed by integral compressor coupled to the prime mover flywheel
- Hot gases turn the turbine blades
- Increased natural gas findings have resulted in stand alone capacities to over 250 MW.
- Space requirements low but highly capital intensive.
- Operate at very high rpm with Generator coupled using a reduction gear box

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Typical Gas Turbine Components



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Combined Cycle Plants

- Normally combination of gas turbine and comparatively a smaller capacity steam turbine.
- Hot exhaust gases are used to produce steam for running the steam turbines
- Steam generator named as heat recovery steam generator (HRSG) and the plant is named combined cycle Gas turbine Plant (CCGT)
- Cogeneration plants are similar but use the recovered steam directly for process needs.

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Typical Combined Cycle Plant



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Reciprocating Engines

- Compression Ignition Diesel engines
- Spark Ignition Diesel engines
- The later type applied for smaller size engines in the order of tens of kilowatts
- The diesel power plants use compressed air to ignite the fuel which is sustained thereafter unless interrupted.
- Require planned maintenance which can ensure 90~95% availability.

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Typical Diesel Generators



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Power Plant Components

- Prime Mover
- Generator
- Fuel storage and handling system
- Cooling system
- Exhaust system
- Electrical substation and control

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Power Plant Types

Normally named after the prime over.

- Gas Turbines
- Steam Turbines
- Hydel Turbines
- Diesel Engines
- Wind Turbines
- Gasoline Engines
- Heavy fuel engines, etc.

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Coal Based Power Plants

Advantages

- Economical
- Good availability in many countries

Drawbacks

- Not economical for smaller sizes
- Calorific values differ
- CO₂, Ash and sulphur issues

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Natural Gas Power Plants

Advantages

- Lower capital cost.
- Compact sizes.
- Lesser CO₂ produced compared to coal or oil

Drawbacks

- Not economical for smaller sizes
- Location close to the source preferred.

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Oil Based Power Plants

Advantages

- Lower cost
- Compact Generators
- Produces less CO₂ than coal

Drawbacks

- Limited oil reserves.
- Oil spills, especially at sea, cause severe pollution
- Sulphur and Acid rains

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Diesel Power Plants

Advantages

- Small in size
- Relatively low cost
- Portability
- Faster installation time

Drawbacks

- Major noise and CO₂ producers.
- Fuels availability limitation

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Solar Power Plants

Advantages

- Abundant source
- Non polluting
- More useful for isolated locations

Drawbacks

- Higher capital cost
- Mainly DC power and smaller size units.
- High area requirements for large capacities.
- Alternate power during nights and no sun days

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Diesel Engines

Main Types

- Spark ignition Otto-cycle engine
- Compression ignition Diesel – cycle engine.

Main Differences

- Method of combustion
- Spark ignition types limited for smaller sizes
- Lower Compression ratio for spark type

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Spark Ignition Engines

- Natural Gas based engines
- Main Types
 - Lean Burn
 - Rich Burn
- Lean Burn Type preferred because of
 - Greater fuel efficiency
 - Lower emissions
 - Higher power density

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Engine Components

Major Components

- Drive Train – Pistons, rods, etc
- Valve Train – Camshaft, valves, etc
- Governor – Speed controller
- Turbocharger – Centrifugal compressor used to compress the intake air for better combustion
- After cooler – To reduce turbocharger output air temperature

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Diesel Power Plants

Support Systems

- Generator
- Fuel oil system
- Lube oil system
- Intake air system
- Cooling system
- Control and Instrumentation
- Exhaust and ventilation systems

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Typical Operation procedures

- Lube oil system startup and ensure proper pressure
- Engine started without any load on alternator
- Bring up to full speed and start applying loads
- Ensure minimum loading of 50% to avoid carbon formation and maintenance issues
- Idle run is recommended before shutdown of engine

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Diesel Plant Advantages

- Faster installation time
- Quick start up when needed
- Follow the load with governor control
- Good part-load efficiencies
- Higher reliability and availability.
- Easier maintenance
- Comparatively lower capital cost
- Adaptability to different fuel including bio fuels

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Review

- Three Phase AC generation is the most common
- Conventional and non conventional types of power generation
- Comparison of different generating types
- Spark Ignition and Compression Ignition engines
- Diesel Power Plant components
- Advantages of diesel power plants

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