

Lecture 5.39

Diesel Engine Power Plant Fundamentals:
Applications, Advantages, and Limitations

Lecture Agenda

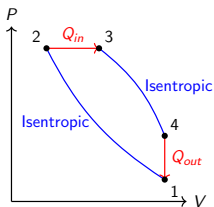
- Introduction to Diesel Power Plants
- Thermodynamic Fundamentals (Diesel Cycle Overview)
- Major Applications in the Power Grid
- Captive and Emergency Power Generation
- Advantages of Diesel Power Plants
- Operational and Economic Limitations

Introduction to Diesel Power Plants

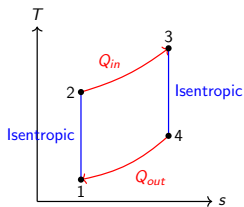
- A diesel power plant utilizes a compression-ignition internal combustion (IC) engine as the prime mover.
- The engine directly drives an alternating current (AC) generator (alternator) to produce electrical energy.
- Typically employs two-stroke or four-stroke engine configurations depending on the capacity and speed requirements.
- Uses liquid fuels, primarily High-Speed Diesel (HSD) or Heavy Fuel Oil (HFO) for larger marine-style engines.

Thermodynamic Fundamentals

- Operates on the ideal Diesel Cycle, characterized by constant-pressure heat addition.
- Relies on a high compression ratio (typically 14:1 to 25:1) to auto-ignite the injected fuel.
- Air-standard efficiency increases with higher compression ratios and decreases with higher cut-off ratios.
- Actual thermal efficiency typically ranges from 35% to 45%, making it more efficient than simple steam turbine cycles of comparable small scale.



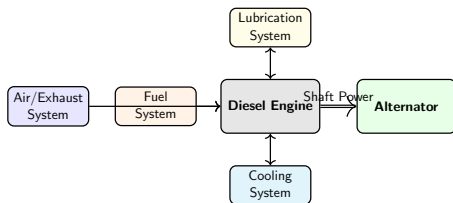
P-V Diagram



T-s Diagram

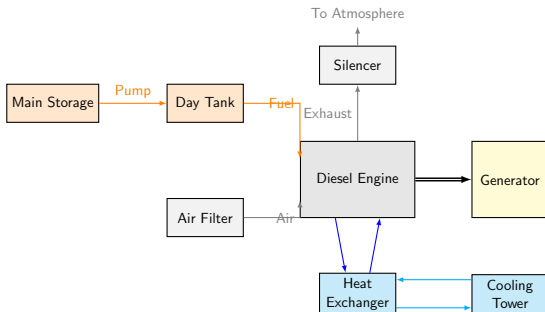
General Arrangement Overview

- **Prime Mover:** The diesel engine itself.
- **Alternator:** Converts mechanical shaft power to electrical power.
- **Air Intake & Exhaust System:** For supplying clean combustion air and expelling exhaust gases safely.
- **Fuel System:** Storage tanks, transfer pumps, filters, and injectors.
- **Cooling System:** Removes waste heat via water jackets and radiators/cooling towers.
- **Lubrication System:** Minimizes wear on reciprocating parts using forced oil circulation.



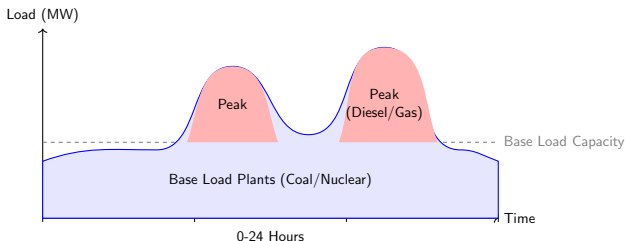
Schematic Layout of a Diesel Power Plant

- Integration of the main engine with auxiliary circuits.
- Shows the flow path of fuel from the main storage to the day tank, then to the engine.
- Illustrates the closed-loop cooling water system transferring heat to a secondary heat exchanger or cooling tower.



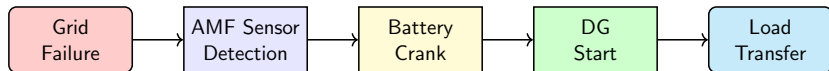
Applications: Peak Load Plants

- Grid demand fluctuates; base load plants (coal, nuclear) operate continuously at a steady rate.
- Diesel plants are deployed to handle short-duration peak loads on the grid.
- Ability to start from cold and reach full synchronous speed and load within 1 to 5 minutes.
- Prevents the need to operate large, less flexible thermal plants at inefficient part-load conditions during low demand.



Applications: Standby and Emergency Power

- Critical infrastructure requires uninterrupted power supply (UPS).
- Hospitals, data centers, telecommunications hubs, and continuous-process chemical plants.
- Utilize Automatic Mains Failure (AMF) panels to start the diesel generator immediately upon grid power failure.
- Ensures life-safety systems and critical data are not compromised during outages.



Applications: Captive and Remote Power Generation

Captive Power

Industries generating their own power to avoid grid tariffs or ensure reliability.

Remote Electrification

Islands, mining sites, and rural communities far from national grid transmission lines.

Mobile/Portable Power

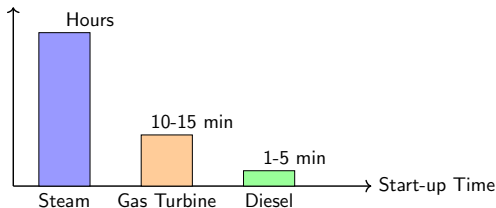
Trailer-mounted generator sets for construction sites, military operations, and disaster relief.

Marine Propulsion

Large scale two-stroke diesel engines serving as the primary power and propulsion for cargo ships.

Advantages of Diesel Power Plants

- **Fast Start-up and Response:** Can pick up full load within minutes from a cold start.
- **No Standby Losses:** Fuel is consumed only when the engine is running, unlike steam boilers that must be kept hot.
- **High Efficiency:** Higher thermal efficiency than small steam plants, maintaining good efficiency even at part loads.
- **Simple and Compact Design:** Requires significantly less floor space and land volume than a comparable steam or hydro plant.

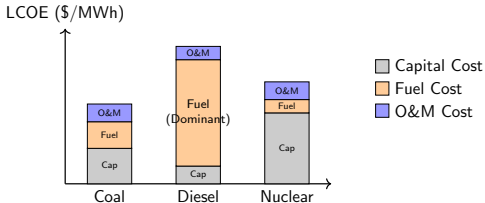


Further Advantages

- **Lower Initial Capital Cost:** Economical to install for small to medium capacities (up to ~ 50 MW).
- **Less Cooling Water Required:** Radiator cooling or small closed-loop towers suffice, unlike massive condensers in thermal plants.
- **Siting Flexibility:** Can be located close to the load center, reducing transmission and distribution (T&D) losses.
- **Easy Handling of Fuel:** Liquid diesel is easier to transport, store, and handle automatically compared to coal or nuclear material.

Limitations of Diesel Power Plants

- **High Operating Cost:** Diesel fuel is significantly more expensive per unit of energy than coal or uranium.
- **High Lubrication Cost:** Requires expensive lubricating oils consumed continuously to manage reciprocating wear.
- **Capacity Constraints:** Impractical for massive grid-scale base load generation. Single unit sizes rarely exceed 50-60 MW.
- **Shorter Lifespan:** High friction and reciprocating forces lead to a shorter operational life compared to rotary steam turbines.



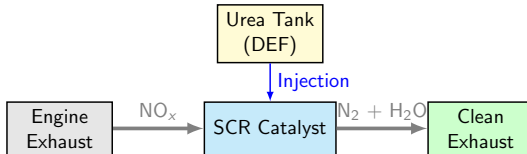
Environmental and Operational Limitations

Maintenance and Operational Issues

- **High Maintenance:** Frequent overhauls, filter changes, and part replacements due to wear and tear of moving parts.
- **Noise and Vibration:** Produces severe low-frequency noise and vibration; requires massive foundations and acoustic enclosures.

Environmental Impact

- **Emissions:** High emissions of Nitrogen Oxides (NO_x), Sulfur Oxides (SO_x), and Particulate Matter (PM).
- Requires expensive exhaust after-treatment (like SCR - Selective Catalytic Reduction) to meet modern environmental norms.



Summary

- Diesel power plants use IC engines to drive generators, providing high thermal efficiency and rapid start capabilities.
- They are best suited for peak load shaving, emergency backup, and remote off-grid power generation.
- Key advantages include low initial cost, compactness, no standby losses, and low cooling water requirements.
- Major limitations are the high cost of diesel fuel, restricted total plant capacity, frequent maintenance, and significant exhaust emissions.

Next Lecture Preview

Deep Dive into Diesel Plant Auxiliary Systems

- Fuel Injection and Storage Systems
- Engine Cooling and Lubrication Circuits
- Starting Mechanisms (Compressed Air and Battery Systems)