MODULE 1

1. STEAM POWER PLANT:

Two important area of application of thermodynamics are power generation and refrigeration. Both power generation and refrigeration are usually accomplished by a system that operates on a thermodynamics cycle.

Thermodynamics cycles can be divided into two generation categories :

(a) Power Cycles

(b) Refrigeration Cycles

The devices or systems used to produce a net power output are often called engines and the thermodynamics cycles they operate on are called power cycle. The devices or systems use to produce refrigeration are called refrigerator, air conditioners or heat pumps and the cycles they operates on are called refrigeration cycles.

1.1 Thermodynamic cycles can be categorized as :

(a) **Power cycles or Refrigeration cycles**.

(b) **Gas Cycles or Vapor Cycles:** In gas cycles, the working fluid remains in the gaseous phase throughout the entire cycle, where as **in vapor cycles the working fluid exists in the vapor phase during one part of the cycle and in the liquid phase during another part**.

(c) **Closed Cycles or Open Cycles:** In closed cycles, the working fluid is returned to the initial state at the end of the cycle and is re-circulated. In open cycle, the working fluid is renewed at the end of each cycle instead of being re-circulated.

1.1.1 Rankine Cycle: The Ideal Cycle for Vapor Power Cycle

Ideal cycle is made up totally of internally reversible processes. Such a cycle is called an Ideal cycle.

Heat Engines:Heat engines are designed for the purpose of converting other form of energy to work and their performance is expressed as thermal efficiency.

The Idealization and Simplification

(a) The cycle does not involve any friction.

(b) All expansion and compression process take place in a quasi-equilibrium manner.

(c) The pipes connecting the various component of a system are well insulated and heat transfer and pressure drop through them are negligible.

The impracticalities associated with Carnot cycle can be eliminated by superheating the steam in the boiler and condensing it completely in the condenser. This cycle results as the **Rankine cycle, which is the ideal cycle for vapor power plants**. The construct of power plant and T-s diagram is shown in Figures 2.2(a) and (b).

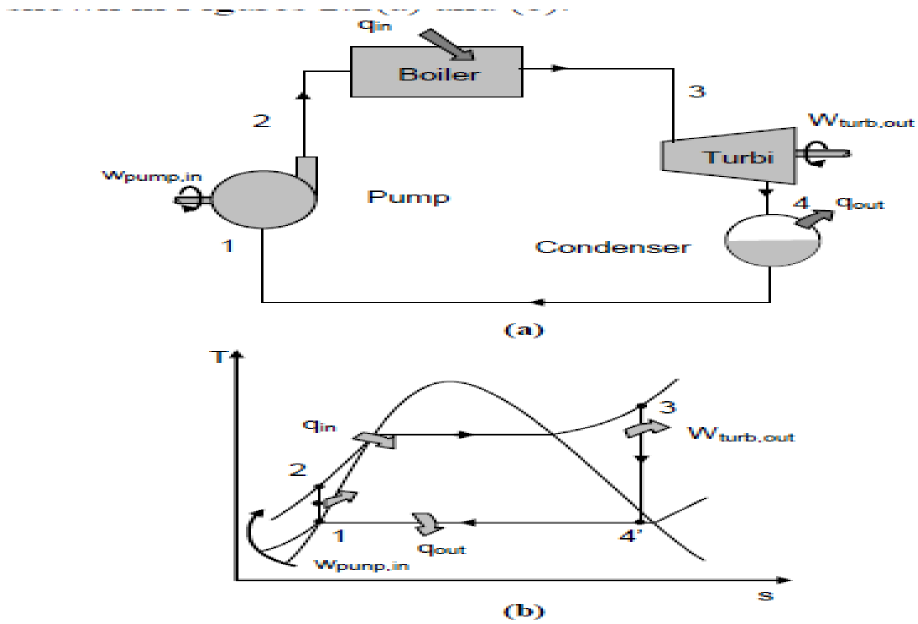


Figure 2.2 : Rankine Cycle

The ideal Rankine cycle dose not involves any internal irreversibilities.

The Rankine cycle consists of the following four processes:

1-2 : Isentropic **compression in pump** (compressors)

2-3 : Constant pressure heat addition in boiler

3-4 : Isentropic **expansion in turbine**

4-1 : Constant pressure **heat rejection in a condenser**

<u>Process 1-2</u>

Water enters the pump at state 1 as saturated liquid **and is compressed isentropically** to the operating pressure of the boiler. The **water temperature increases somewhat during this isentropic compression process due to slight decrease in the specific**

volume of the water. The vertical distance between state 1 and 2 on the T-s diagram is greatly exaggerated for clarity.

<u>Process 2-3</u>

Water enters the boiler as a **compressed liquid at state 2 and leaves as a superheated vapor at state 3**. The **boiler** is basically a large heat exchanger where the **heat** originating from combustion gases**, is transferred to the water essentially at constant pressure**. The boiler together with the section where the steam is superheated (the superheater), is often called the steam generator.

<u>Process 3-4</u>

The **superheated vapor at state 3** enters the turbine, where **it expands isentropically and produces work by rotating the shaft connected to an electric generator.** The **pressure and the temperature of the steam drops during this process to the values at state 4,** where steam enters the condenser

<u>Process 4-1</u>

At this state, the steam is usually a saturated liquid-vapor mixture with a high quality. **Steam is condensed at constant pressure in the condenser which is basically a large heat exchanger, by rejecting heat to a cooling medium** from a lake, or a river. Steam leaves the condenser as saturated liquid and enters the pump, completing the cycle.

1.1.2 Rankine Cycle: Actual Cycle

The cycles encountered in actual devices are difficult to analyze because of the presence of complicating effects, such as friction and the absence of sufficient time for establishment of the equilibrium conditions during the cycle. **The actual vapor power cycle differs from the ideal Rankine cycle, as a result of irreversibilities in various components. Fluid friction and heat loss to the surroundings are the two common sources of irreversibilities.**

Fluid friction causes pressure drop in the boiler, the condenser and the piping between various components. Also the pressure at the turbine inlet is somewhat lower than that at the boiler exit due to the pressure drop in the connecting pipes. To compensate for these pressure drops, the water must be pumped to a sufficiently higher pressure than the ideal cycle. This requires a large pump and larger work input to the pump, are shown in Figures 2.3(a) and (b).

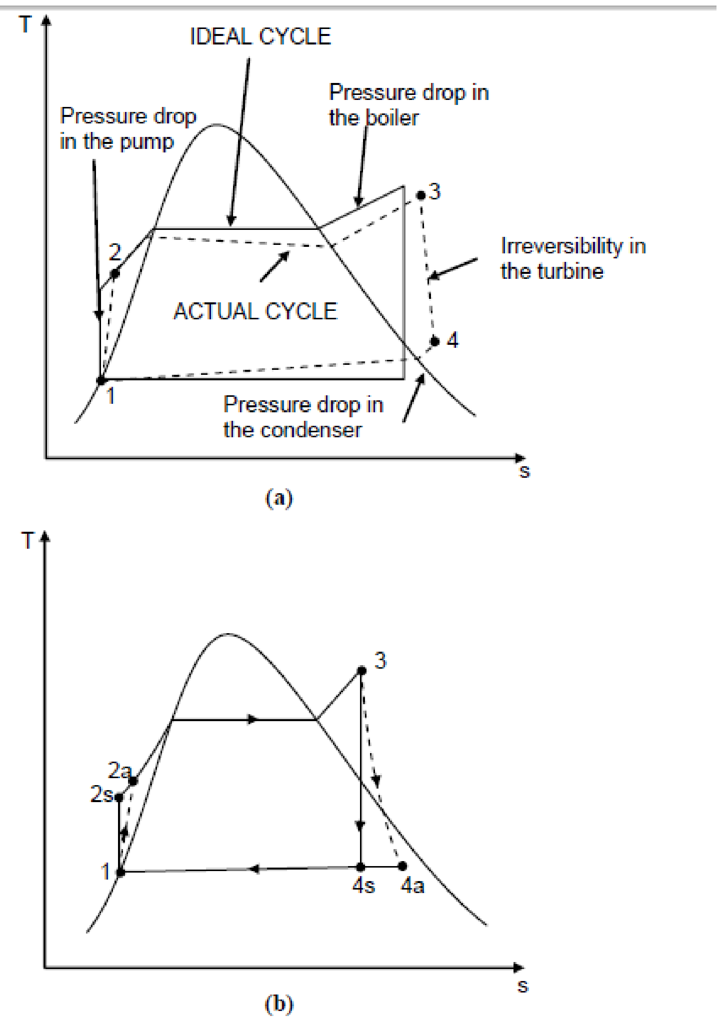


Figure 2.3 : Vapour Power Cycle

The other major source of irreversibility is the **heat loss from the steam to the surrounding** as the steam flows through various components. Particular importance is the irreversibilities occurring within the pump and the turbine. A pump requires a greater work input, and a turbine produces a smaller work output as a result of irreversibilities.

1.1.3 Reheat Rankine Cycle

The efficiency of the Rankine cycle can increase by **expanding the steam in the turbine in two stages, and reheating it in between**. Reheating is a practical solution to the excessive moisture problem in turbines, and it is commonly used in modern steam power plants. The schematic and T-s diagram of the ideal reheat Rankine cycle is shown in Figures 2.7(a) and (b).

The ideal reheat Rankine cycle differs from the simple ideal Rankine cycle in that the expansion process take place in two stages. **In first stage** (the high-pressure turbine), **steam is expanded isentropically to an intermediate pressure and sent back to the boiler where it is reheated at constant pressure**, usually to the inlet temperature of the first turbine stage. **Steam then expands isentropically in the second stage** (low-pressure turbine) **to the condenser pressure**.

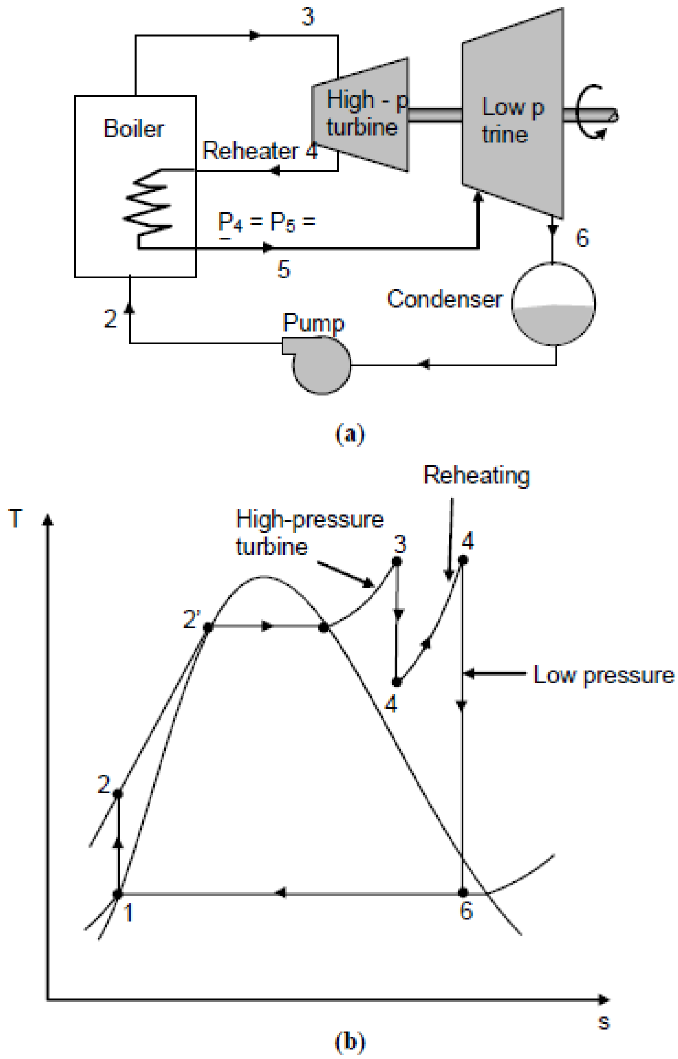


Figure 2.7 : Ideal Reheat Rankine Cycle

As shown in Figure 2.8, T-s diagram for the Rankine cycle shows that heat transferred to the working fluid during process 2-2' at a relatively low temperature. This lowers the average heat-addition temperature and thus the cycle efficiency.

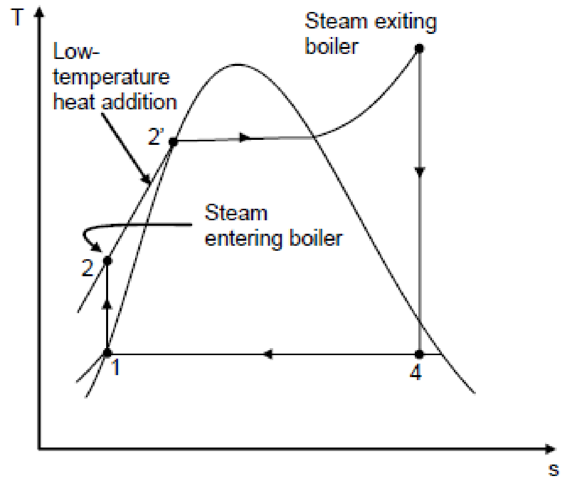


Figure 2.8 : Ideal Regenerative Rankine Cycle

To remedy this shortcoming, the temperature of the liquid leaving the pump (called feedwater) before it enters the boiler need to be increased.

1.2 STEAM POWER PLANT:

Steam is an important medium of producing mechanical energy. Steam has the advantage that, it can be raised from water which is available in abundance it does not react much with the materials of the equipment of power plant and is stable at the temperature required in the plant. Steam is used to drive steam engines, steam turbines etc. Steam power station is most suitable where coal is available in abundance.
Thermal electrical power generation is one of the major methods. Out of total power developed in India about 60% is thermal. For a thermal power plant the range of pressure may vary from 10 kg/cm2 to super critical pressures and the range of temperature may be from 250°C to 650°C.

A steam power plant using steam as working substance works basically on Rankine cycle. Steam is generated in a boiler, expanded in the prime mover and condensed in the condenser and fed into the boiler again.

Thermal generating stations burn COAL, OIL or NATURAL GAS to generate electricity. In the case of a coal-fired generating station, the coal is stored in large coal piles just outside the station. From there, the coal is brought into the station on a conveyor belt where it is fed into large pulverizers that crush the coal into a fine powder. Large fans blow the coal powder into a giant furnace where it is burned giving off vast amounts of heat. The temperature in the furnace can reach over 3,000^{o}C. The furnace is surrounded by tubes filled with water. The immense heat from the burning coal turns the water in the tubes into steam. The steam is then transferred under pressure at high speed through large pipes to a turbine where it pushes the turbine blades causing them to spin. From there, the process is the same as in a nuclear or a hydroelectric generating station; the turbine spins the generator producing electricity. The steam is condensed back to water using cooling water, usually from a nearby lake or river. It is then pumped back into the water tubes surrounding the furnace to continue the process.

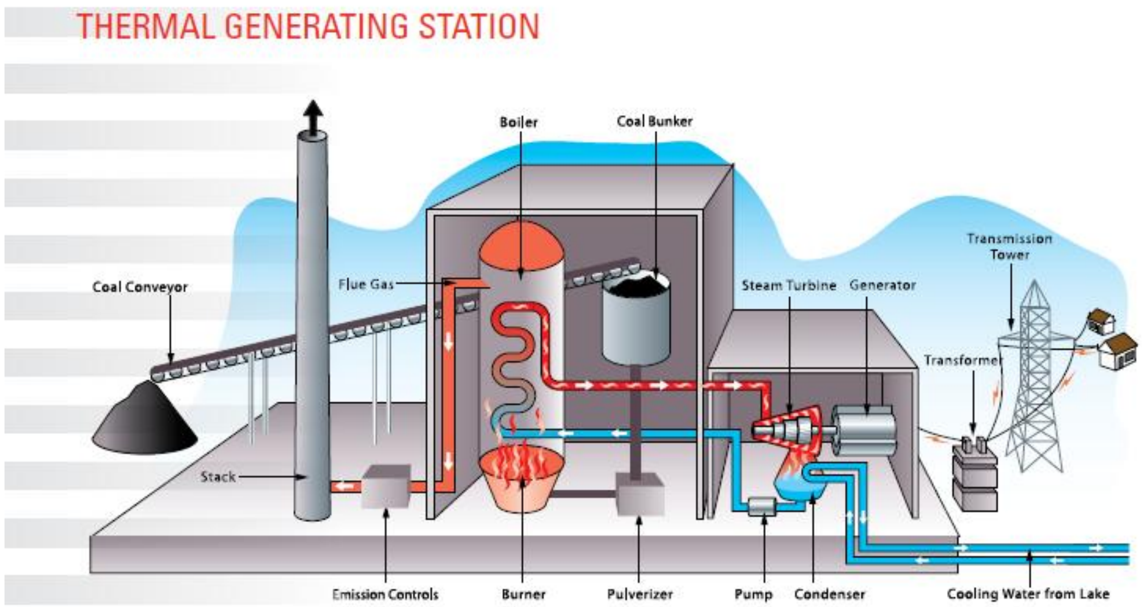


Diagram of a coal-fired generating station.

Thermal plants play an important role because, unlike a nuclear station, they are able to quickly adjust to changes in electricity demand. Their output can be easily increased to help meet periods of peak demand and provide backup for intermittent sources like wind and solar. Burning fossil fuels to generate electricity creates a number of byproducts that impact the environment. These include gases like SULFUR DIOXIDE (SO2) and NITROGEN OXIDES (NOX) which contribute to smog and acid rain.

Another gas that is released when burning fossil fuels is CARBON DIOXIDE (CO2), which is a GREENHOUSE GAS. Greenhouse gases trap heat in the earth's atmosphere and can cause temperatures on the earth's surface to rise. This effect is known as global warming.

1.2.1 Essentials of Steam Power Plant Equipment

A steam power plant must have following equipment:

(a) A furnace to burn the fuel.

(b) Steam generator or boiler containing water. Heat generated in the furnace is utilized to convert water into steam.

(c) Main power unit such as an engine or turbine to use the heat energy of steam and perform work.

(d) Piping system to convey steam and water.

In addition to the above equipment the plant requires various auxiliaries and accessories depending upon the availability of water, fuel and the service for which the plant is intended.

The flow circuit of a thermal power plant consists of the following four main circuits:

(a) Feed water and steam flow circuit.
(b) Coal and ash circuit.
(c) Air and gas circuit.
(d) Cooling water circuit.

The different types of systems and components used in steam power plant are as follows:

1. Coal handling system
2. High pressure boiler
3. Air preheater, economizer, super heater, feed heaters.
4. Pumping system
5. Feed water purification plant
6. Condensers and cooling towers
7. Draught system
8. Prime mover
9. Alternator
10. Ash and dust handling system

1.2.2 Layout of equipment of a steam power station:

Layout of equipment of a steam power station is shown below. Coal received in coal storage yard of power station is transferred in the furnace by coal handling unit. Heat produced due to burning of coal is utilized in converting water contained in boiler drum into steam at suitable pressure and temperature. The steam generated is passed through the superheater. Superheated steam then flows through the turbine. After doing work in the turbine the pressure of steam is reduced. Steam leaving the turbine passes through the condenser which is maintained the low pressure of steam at the exhaust of turbine. Steam pressure in the condenser depends upon flow rate and temperature of cooling water and on effectiveness of air removal equipment. Water circulating through the condenser may be taken from the various sources such as river, lake or sea. If sufficient quantity of water is not available the hot water coming out of the condenser may be cooled in cooling towers and circulated again through the condenser. Bled steam taken from the turbine at suitable extraction points is sent to low pressure and high pressure water heaters.

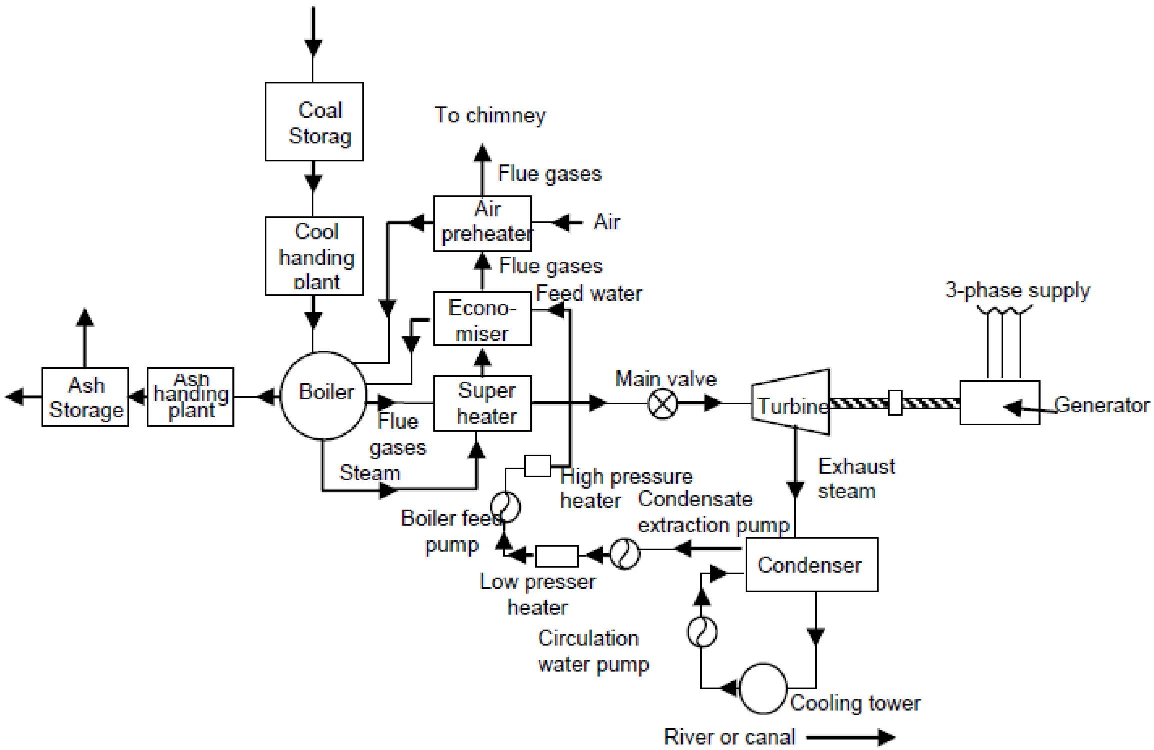


Figure 2.11 : Steam Power Plant

Air taken from the atmosphere is first passed through the air pre-heater, where it is heated by flue gases. The hot air then passes through the furnace. The flue gases after passing over boiler and superheater tubes, flow through the dust collector and then through economiser, air pre-heater and finally they are exhausted to the atmosphere through the chimney.

Steam condensing system consists of the following:

(a) Condenser
(b) Cooling water
(c) Cooling tower
(d) Hot well
(e) Condenser cooling water pump
(f) Condensate air extraction pump

(g) Air extraction pump
(h) Boiler feed pump
(i) Make up water pump.

1.2.3 Major Components and Their Functions

Economizer

The economizer is a feed water heater, deriving heat from the flue gases. The justifiable cost of the economizer depends on the total gain in efficiency. In turn this depends on the flue gas temperature leaving the boiler and the feed water inlet temperature. A typical return bend type economizer is shown in the Figure 2.11.

Air Pre-heater

The flue gases coming out of the economizer is used to preheat the air before supplying it to the combustion chamber. An increase in air temperature of 20 degrees can be achieved by this method. The pre heated air is used for combustion and also to dry the crushed coal before pulverizing.

Soot Blowers

The fuel used in thermal power plants causes soot and this is deposited on the boiler tubes, economizer tubes, air pre heaters, etc. This drastically reduces the amount of heat transfer of the heat exchangers. Soot blowers control the formation of soot and reduce its corrosive effects. The types of soot blowers are fixed type, which may be further classified into lane type and mass type depending upon the type of spray and nozzle used. The other type of soot blower is the retractable soot blower. The advantages are that they are placed far away from the high temperature zone, they concentrate the cleaning through a single large nozzle rather than many small nozzles and there is no concern of nozzle arrangement with respect to the boiler tubes.

Condenser

The use of a condenser in a power plant is to improve the efficiency of the power plant by decreasing the exhaust pressure of the steam below atmosphere. Another advantage of the condenser is that the steam condensed may be recovered to provide a source of good pure feed water to the boiler and reduce the water softening capacity to a considerable extent. A condenser is one of the essential components of a power plant.

Cooling Tower

The importance of the cooling tower is felt when the cooling water from the condenser has to be cooled. The cooling water after condensing the steam becomes hot and it has to

be cooled as it belongs to a closed system. The Cooling towers do the job of decreasing the temperature of the cooling water after condensing the steam in the condenser.
The type of cooling tower used in the Columbia Power Plant was an Inline Induced Draft Cross Flow Tower. This tower provides a horizontal air flow as the water falls down the tower in the form of small droplets. The fan centered at the top of units draws air through two cells that are paired to a suction chamber partitioned beneath the fan. The outstanding feature of this tower is lower air static pressure loss as there is less resistance to air flow. The evaporation and effective cooling of air is greater when the air outside is warmer and dryer than when it is cold and already saturated.

Superheater

The superheater consists of a superheater header and superheater elements. Steam from the main steam pipe arrives at the saturated steam chamber of the superheater header and is fed into the superheater elements. Superheated steam arrives back at the superheated steam chamber of the superheater header and is fed into the steam pipe to the cylinders. Superheated steam is more expansive.

Reheater

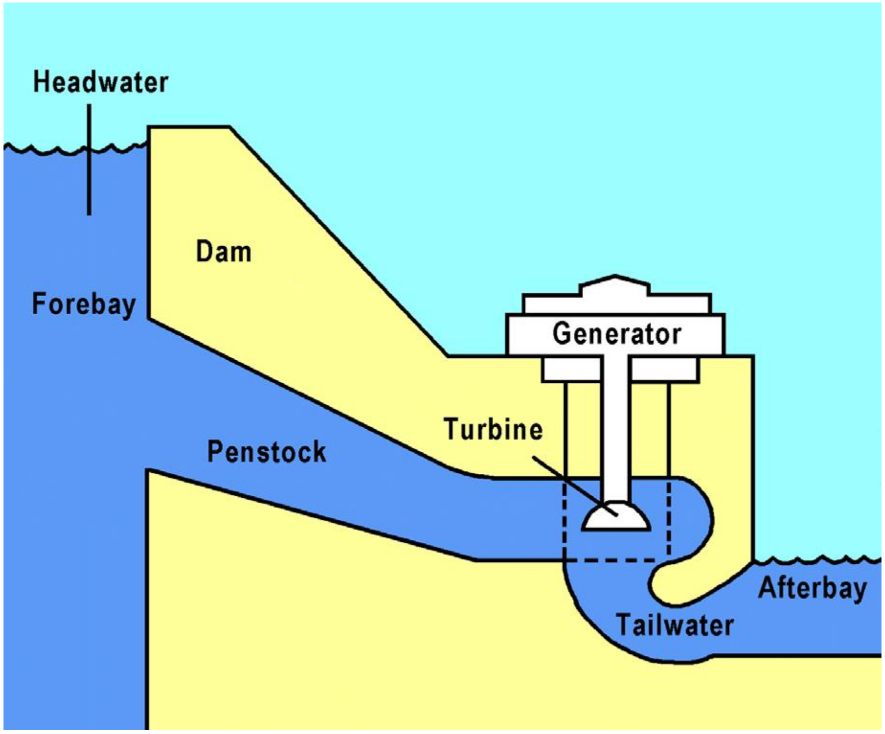
The reheater functions similar to the superheater in that it serves to elevate the steam temperature. Primary steam is supplied to the high pressure turbine. After passing through the high pressure turbine, the steam is returned to the steam generator for reheating (in a reheater) after which it is sent to the low pressure turbine. A second reheat cycle may also be provided.

2. HYDROELECTRIC POWER PLANTS:

To generate electricity, water must be in motion. This is kinetic (moving) energy. When flowing water turns blades in a turbine, the form is changed to mechanical (machine) energy. The turbine turns the generator rotor which then converts this mechanical energy into another energy form electricity. Since water is the initial source of energy, we call this hydroelectric power or hydropower for short.

At facilities called hydroelectric power plants, hydropower is generated. Some power plants are located on rivers, streams, and canals, but for a reliable water supply, dams are needed. Dams store water for later release for such purposes as irrigation, domestic and industrial use, and power generation. The reservoir acts much like a battery, storing water to be released as needed to generate power.

2.1 Layout of hydroelectric power plant:



Water is collected at the top of the dam in called the FOREBAY. From there, the water flows into a pipe called a PENSTOCK which carries it down to a turbine WATER WHEEL. The water pressure increases as it flows down the penstock. The pressure and flow of the falling water drives a turbine which in turn spins a generator. This creates electricity that can be sent across transmission lines to wherever the power is needed.

Hydroelectricity is one of the most economical and environmentally friendly ways of generating electricity. It produces virtually no smog or greenhouse gas emissions and is a renewable energy source – the water can be used again and again.

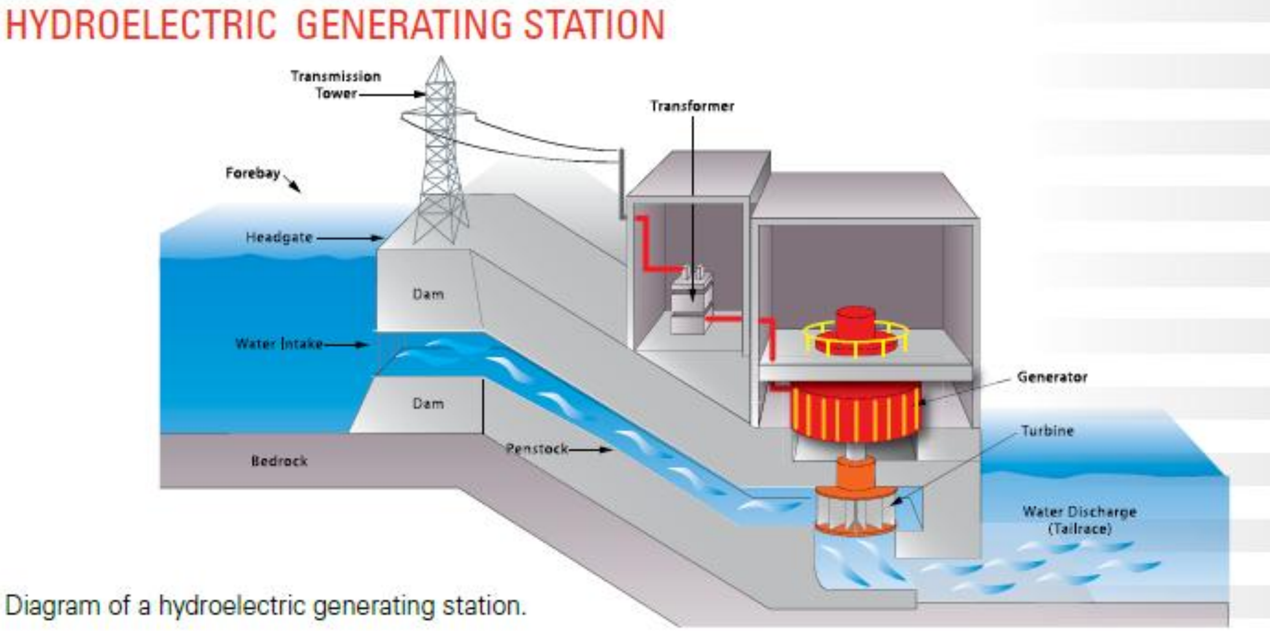


Diagram of a hydroelectric generating station.

The dam creates a head or height from which water flows. A pipe (penstock) carries the water from the reservoir to the turbine. The fast-moving water pushes the turbine blades, something like a pinwheel in the wind. The waters force on the turbine blades turns the rotor, the moving part of the electric generator. When coils of wire on the rotor sweep past the generators stationary coil (stator), electricity is produced.

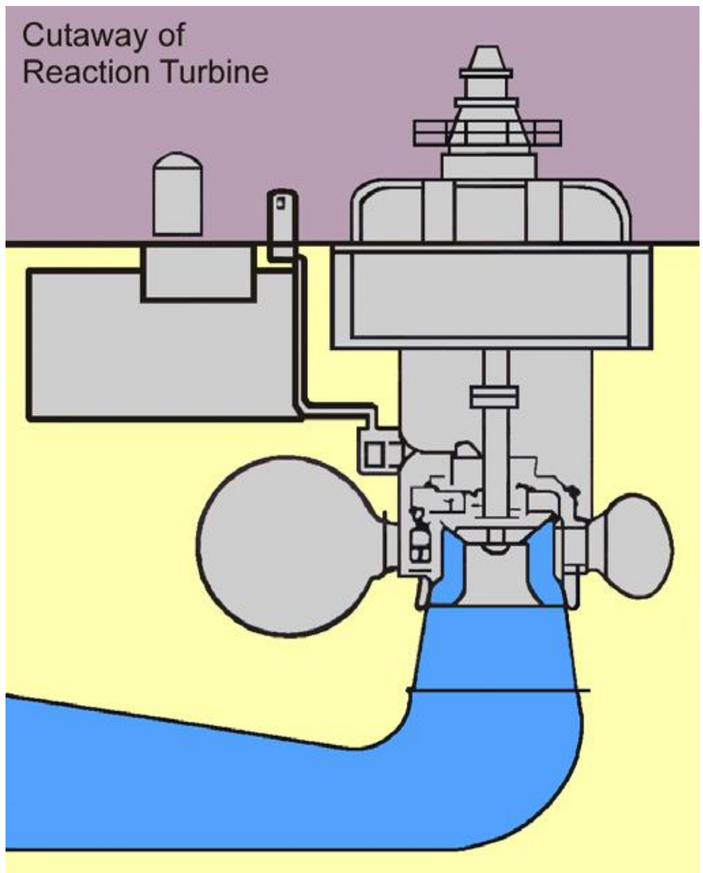
When the water has completed its task, it flows on unchanged to serve other needs.Before a hydroelectric power site is developed, engineers compute how much power can be produced when the facility is complete. The actual output of energy at a dam is determined by the volume of water released (discharge) and the vertical distance the water falls (head). So, a given amount of water falling a given distance will produce a certain amount of energy. The head and the discharge at the power site and the desired rotational speed of the generator determine the type of turbine to be used.
The head produces a pressure (water pressure), and the greater the head, the greater the pressure to drive turbines. This pressure is measured in pounds of force (pounds per square inch). More head or faster flowing water means more power.

2.2 Components of hydroelectric power plant:

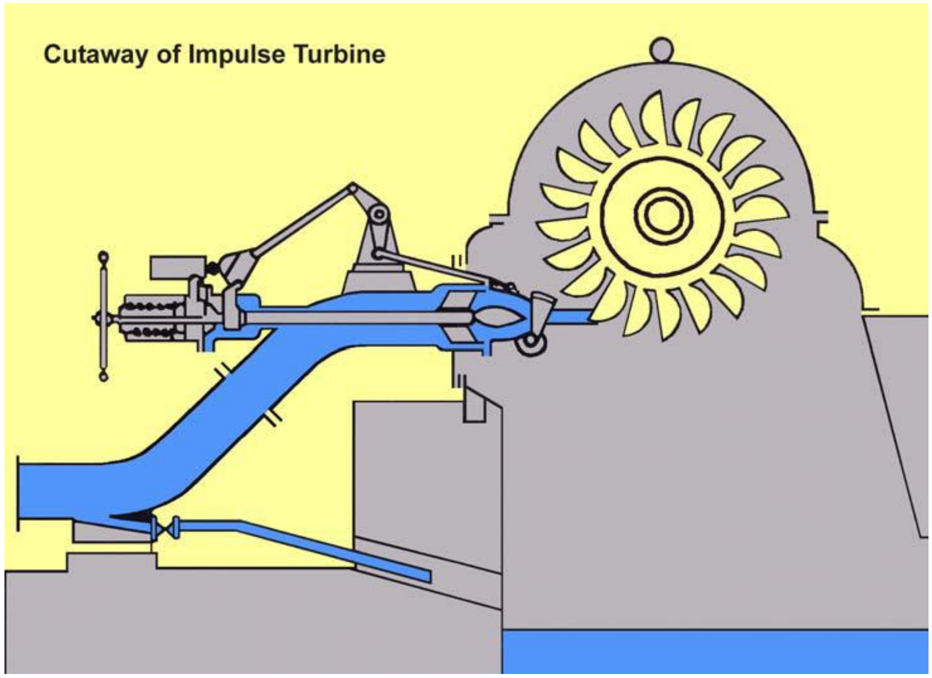
Turbines

There are only two basic types of turbines: impulse and reaction. The specific type of turbine to be used in a power plant is not selected until all operational studies and cost estimates are complete. The turbine selected depends largely on the site conditions.

A **reaction turbine** is a horizontal or vertical wheel that operates with the wheel completely submerged, a feature which reduces turbulence. In theory, the reaction turbine works like a rotating lawn sprinkler where water at a central point is under pressure and escapes from the ends of the blades, causing rotation. Reaction turbines are the type **most widely used.**



An **impulse turbine** is a horizontal or vertical wheel that uses the kinetic energy of water striking its buckets or blades to cause rotation. The wheel is covered by a housing and the buckets or blades are shaped so they turn the flow of water about 170 degrees inside the housing. After turning the blades or buckets, the water falls to the bottom of the wheel housing and flows out.



2.3 Types of dams:

Low-head dams:
A low-head dam is one with a water drop of less than 65 feet and a generating capacity less than 15,000 kW. Small dams drop in elevation along canals where small generating plants could be installed. New low-head dams could be built to increase output as well. The key to the usefulness of such units is their ability to generate power near where it is needed, reducing the power inevitably lost during transmission.

Large, high-head dams:
A high-head dam can produce more power at lower costs than low-head dams, but construction of large dams may be limited by lack of suitable sites, by environmental considerations, or by economic conditions.

3. NUCLEAR POWER PLANT:

Nuclear power plants use URANIUM to generate heat and boil water into steam. Uranium has the largest atoms of the 92 naturally occurring elements on earth, making uranium atoms more likely than other atoms to split.

When subatomic particles called NEUTRONS come in contact with uranium atoms, the atoms split releasing heat energy. This occurs all the time in nature, but at a very slow rate. Nuclear reactors are able to greatly speed up this process by slowing down the neutrons and increasing the chance that the neutrons will hit and split the uranium atoms. When uranium atoms split they also release more neutrons which can then go on and split additional atoms ensuring a chain reaction of atom splitting. This is called NUCLEAR FISSION.

Thousands of fuel bundles are inserted into the core of a nuclear reactor where the uranium atoms split giving off vast amounts of heat. The heat is used to boil water to create steam which then spins a turbine and generator producing electricity. Nuclear power stations are able to produce tremendous amounts of electricity from a very small amount of fuel. A single 2.5 centimeter nuclear fuel pellet can produce the same amount of energy as 807 kilograms of coal, 677 litres of oil, or 476 cubic metres of natural gas.

As well, because nuclear power plants do not burn any fuels, they produce virtually no smog or greenhouse gas emissions. They do however produce nuclear waste which needs to be handled and stored very carefully.

3.1 Layout of nuclear power plant:

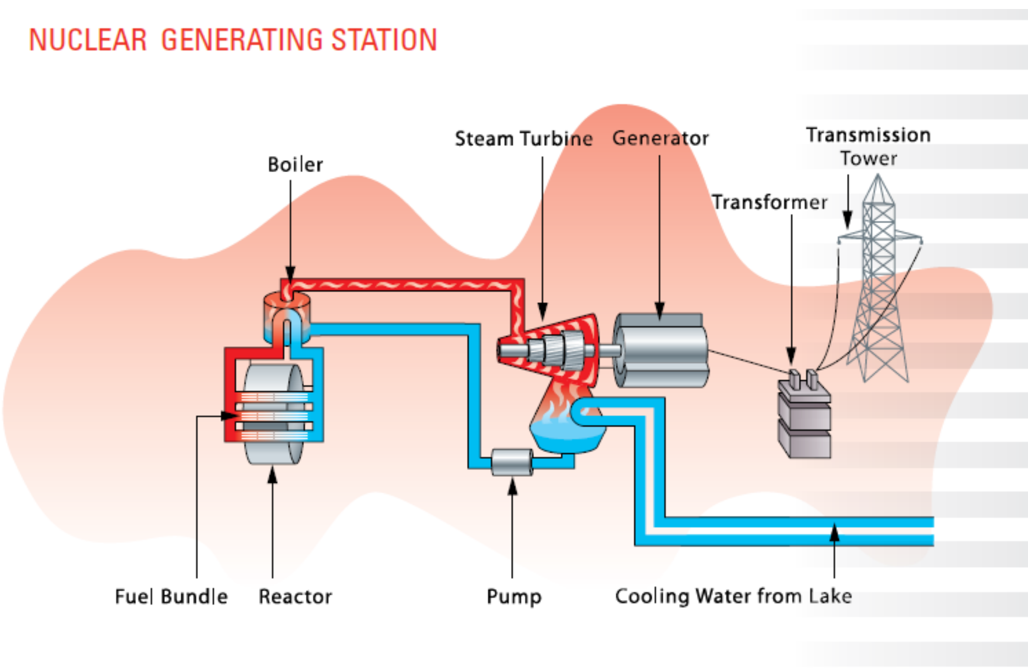


Diagram of a nuclear generating station.

When uranium atoms split they form smaller atoms, called FISSION PRODUCTS. These fission products are highly radioactive. As a result, the fuel bundles that hold the uranium need to be isolated from the environment for an extended period of time once they are removed from a reactor. When they can no longer generate heat efficiently, used fuel bundles are removed from the reactor and placed in WATER-FILLED BAYS to cool down. These water-filled bays are located on the same site as the reactors and are built using reinforced concrete, lined to prevent leaks and designed to withstand earthquakes. The water in the bays helps cool the fuel bundles as well as provide shielding from radiation. The fuel bundles will remain in the bays for approximately 10 years after which time they will have cooled and the radiation they emit will have decreased significantly. The fuel bundles are then removed from the bay and placed in what are called DRY STORAGE CONTAINERS. These containers are made of concrete and steel and provide shielding from radiation. The containers are welded shut and stored in highly secure warehouses located on the same site as the nuclear generating station. Scientists around the world are looking for new and innovative solutions to manage nuclear waste over time.

4. DIESEL ENGINE 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.

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. As the generation cost is considerable due to high price of diesel, therefore, such power stations are only used to produce small power.

Although steam power stations and hydro-electric plants are invariably used to generate bulk power at cheaper costs, yet diesel power stations are finding favour at places where demand of power is less, sufficient quantity of coal and water is not available and the transportation facilities are inadequate.

This plants are also standby sets for continuity of supply to important points such as hospitals, radio stations, cinema houses and telephone exchanges.

Advantages

(a) The design and layout of the plant are quite simple.
(b) It occupies less space as the number and size of the auxiliaries is small.
(c) It can be located at any place.
(d) It can be started quickly and it can pickup load in a short time.
(e) There are no standby losses.
(f) It requires less quantity of water for cooling.

(g) The overall cost is much less than that of steam power station of same capacity.

(h) The thermal efficiency of the plant is higher than that of a steam power station.

(i) It requires less operating staff.

Disadvantages

(a) The plant has high running charges as the fuel (diesel) used is costly.

(b) The plant doesn¡¦t work satisfactorily under overload conditions for a longer period.

(c) The plant can only generate small power.

(d) The cost of lubrication is generally high.

(e) The maintenances charges are generally high

4.1 Essential elements of diesel power plant

Fuel Supply System

It consists of storage tank, strainers, fuel transfer pump and all day fuel tank. The fuel oil is supplied at the plant site by rail or road. The oil is stored in the storage tank. From the storage tank, oil is pumped to smaller all day tank at daily or short intervals. From this tank, fuel oil is passed through strainers to remove suspended impurities. The clean oil is injected into the engine by fuel injection pump.

Air Intake System

This system supplies necessary air to the engine for fuel combustion. It consists of pipes for the supply of fresh air to the engine manifold. Filters are provided to remove dust particles from air which may act as abrasive in the engine cylinder.

Because a diesel engine requires close tolerances to achieve its compression ratio, and because most diesel engines are either turbocharged or supercharged, the air entering the engine must be clean, free of debris, and as cool as possible. Also, to improve a turbocharged or supercharged engine's efficiency, the compressed air must be cooled after being compressed. The air intake system is designed to perform these tasks. Air intake systems are usually one of two types, wet or dry. In a wet filter intake system, as shown in the Figure 4.1, the air is sucked or bubbled through a housing that holds a bath of oil such that the dirt in the air is removed by the oil in the filter. The air then flows through a screen-type material to ensure any entrained oil is removed from the air. In a dry filter system, paper, cloth, or a metal screen material is used to catch and trap dirt before it enters the engine. In addition to cleaning the air, the intake system is usually designed to intake fresh air from as far away from the engine as practicable, usually just

outside of the engine’s building or enclosure. This provides the engine with a supply of air that has not been heated by the engine’s own waste heat. The reason for ensuring that an engine's air supply is as cool as possible is that cool air is denser than hot air. This means that, per unit volume, cool air has more oxygen than hot air.
Thus, cool air provides more oxygen per cylinder charge than less dense, hot air. More oxygen means a more efficient fuel burn and more power.
After being filtered, the air is routed by the intake system into the engine's intake manifold or air box. The manifold or air box is the component that directs the fresh air to each of the engine’s intake valves or ports. If the engine is turbocharged or supercharged, the fresh air will be compressed with a blower and possibly cooled before entering the intake manifold or air box. The intake system also serves to reduce the air flow noise.

Exhaust System

This system leads the engine exhaust gas outside the building and discharges it into atmosphere. A silencer is usually incorporated in the system to reduce the noise level.
The exhaust system of a diesel engine performs three functions. First, the exhaust system routes the spent combustion gasses away from the engine, where they are diluted by the atmosphere. This keeps the area around the engine habitable. Second, the exhaust system confines and routes the gases to the turbocharger, if used. Third, the exhaust system allows mufflers to be used to reduce the engine noise.

Cooling System

The heat released by the burning of fuel in the engine cylinder is partially converted into work. The remainder part of the heat passes through the cylinder wall, piston, rings etc. and may cause damage to system. In order to keep the temperature of the engine parts within the safe operating limits, cooling is provided. The cooling system consists of a water source, pump and cooling towers. The pump circulates water through cylinder and head jacket. The water takes away heat form the engine and it becomes hot. The hot water is cooled by cooling towers and re circulated for cooling.

Lubricating System

The system minimises the wear of rubbing surfaces of the engine. It comprises of lubricating oil tank, pump, filter and oil cooler. The lubrication oil is drawn from the lubricating oil tank by the pump and is passed through filter to remove impurities .The clean lubrication oil is delivered to the points which require lubrication. The oil coolers incorporated in the system keep the temperature of the oil low.
An internal combustion engine would not run for even a few minutes if the moving parts were allowed to make metal-to-metal contact. The heat generated due to the tremendous amounts of friction would melt the metals, leading to the destruction of the engine. To

prevent this, all moving parts ride on a thin film of oil that is pumped between all the moving parts of the engine. The oil serves two purposes. One purpose is to lubricate the bearing surfaces. The other purpose is to cool the bearings by absorbing the friction-generated heat. The flow of oil to the moving parts is accomplished by the engine's internal lubricating system.

Oil is accumulated and stored in the engine's oil pan where one or more oil pumps take suction and pump the oil through one or more oil filters as shown in the figure. The filters clean the oil and remove any metal that the oil has picked up due to wear. The cleaned oil then flows up into the engine's oil galleries. A pressure relief valve(s) maintains oil pressure in the galleries and returns oil to the oil pan upon high pressure. The oil galleries distribute the oil to all the bearing surfaces in the engine. Once the oil has cooled and lubricated the bearing surfaces, it flows out of the bearing and gravity-flows back into the oil pan. In medium to large diesel engines, the oil is also cooled before being distributed into the block. This is accomplished by either internal or external oil cooler. The lubrication system also supplies oil to the engine’s governor.

Engine Starting System

This is an arrangement to rotate the engine initially, while starting, until firing starts and the unit runs with its own power. Small sets are started manually by handles but for larger units, compressed air is used for starting. In the latter case, air at high pressure is admitted to a few of the cylinders, making them to act as reciprocating air motors to turn over the engine shaft. The fuel is admitted to the remaining cylinders which makes the engine to start under its own power.

Starting Circuits

Diesel engines have as many different types of starting circuits as there are types, sizes, and manufacturers of diesel engines. Commonly, they can be started by air motors, electric motors, hydraulic motors, and manually. The start circuit can be a simple manual start pushbutton, or a complex auto-start circuit. But in almost all cases the following events must occur for the starting engine to start.

(a) The start signal is sent to the starting motor. The air, electric, or hydraulic motor, will engage the engine’s flywheel.

(b) The starting motor will crank the engine. The starting motor will spin the engine at a high enough rpm to allow the engine’s compression to ignite the fuel and start the engine running.

(c) The engine will then accelerate to idle speed. When the starter motor is overdriven by the running motor it will disengage the flywheel.

Because a diesel engine relies on compression heat to ignite the fuel, a cold engine can rob enough heat from the gasses that the compressed air falls below the ignition temperature of the fuel. To help overcome this condition, some engines (usually small to medium sized engines) have glow plugs. Glow plugs are located in the cylinder head of the combustion chamber and use electricity to heat up the electrode at the top of the glow plug. The heat added by the glow plug is sufficient to help ignite the fuel in the cold engine. Once the engine is running, the glow plugs are turned off and the heat of combustion is sufficient to heat the block and keep the engine running. Larger engines usually heat the block and/or have powerful starting motors that are able to spin the engine long enough to allow the compression heat to fire the engine. Some large engines use air start manifolds that inject compressed air into the cylinders which rotates the engine during the start sequence.

Fuel injection system

Fuel injection is a system for mixing fuel with air in an internal combustion engine. A fuel injection system is designed and calibrated specifically for the type of fuel it will handle. Most fuel injection systems are for diesel applications. With the advent of electronic fuel injection (EFI), the diesel gasoline hardware has become similar. EFI's programmable firmware has permitted common hardware to be used with different fuels. Carburetors were the predominant method used to meter fuel before the widespread use of fuel injection. A variety of injection systems have existed since the earliest usage of the internal combustion engine.

The primary difference between carburetors and fuel injection is that fuel injection atomizes the fuel by forcibly pumping it through a small nozzle under high pressure, while a carburetor relies on low pressure created by intake air rushing through it to add the fuel to the air stream.

The fuel injector is only a nozzle and a valve: the power to inject the fuel comes from a pump or a pressure container farther back in the fuel supply.

The functional objectives for fuel injection systems can vary. All share the central task of supplying fuel to the combustion process, but it is a design decision how a particular system will be optimized. There are several competing objectives such as :

(a) power output,
(b) fuel efficiency,
(c) emissions performance,
(d) reliability,
(e) smooth operation,

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(a) initial cost,

(b) maintenance cost,
(c) diagnostic capability, and
(d) Range of environmental operation.

Certain combinations of these goals are conflicting, and it is impractical for a single engine control system to fully optimize all criteria simultaneously. In practice, automotive engineers strive to best satisfy a customer's needs competitively. The modern digital electronic fuel injection system is far more capable at optimizing these competing objectives consistently than a carburetor. Carburetors have the potential to atomize fuel better