MODULE-5

Incineration can be defined as the controlled combustion process for burning of solid, liquid waste to residue containing non-combustible materials.

Incineration is one of the chemical process used to reduce the volume of the solid waste .This process is also called as chemical volume reduction. At present it is one of the common method used to reduce the volume of waste chemically. chemical process such as pyrolysis. hydrolysis and chemical conversion are also effective in reducing the volume of waste.

Normally all the combustible matters such as garbage rubbish and dead animals are burnt and the incombustible matters like chinaware. glass. metals etc are left unburnt or separated out for recycling and reuse before the burning of solid wastes.

Advantages

1. Incineration causes a significant reduction in the volume of waste. The reduction in the original volume and weight 95% and 75% respectively.
2. It helps providing a renewable source and conserving valuable raw materials.
3. Bottom ash can be reused as secondary aggregates for parking lots, paved roads etc.
4. Due to incineration, a large proportion of the organic compounds including putresible and hazardous waste is destroyed. So there is a net reduction in the quantity of toxicity.
5. Incineration does not does not generate methane gas and reduces methane from landfills.
6. It provides better control over odour and noise.
7. It occupies small land.

Disadvantages of Incineration

The disadvantages of incineration are as follows.

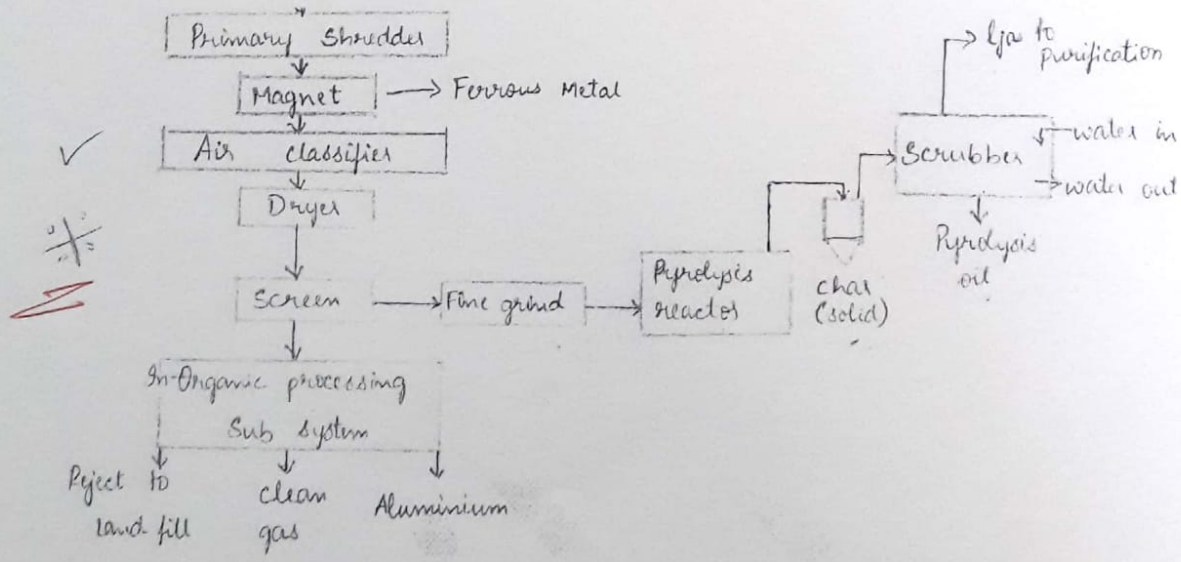
1. It causes atmospheric pollution if incinerators are not ell maintained.
2. Incinerators are costly to construct. operate and regulate. Stringent emission for incinerators increase the cost of construction. operation and maintenance.
3. It lacks system flexibility. The demand for recycled and recovered material for different treatment methods is likely to change overtime.
4. Incineration process produces ash and waste water from pollution control devices.

5. A huge amount of money required to purchase a foreign made incinerator.
6. Low income countries often lacks of adequately trained labor to operate and maintain incinerator systems.

Factors affecting Incineration process

- **Pressure:** Incineration operations are designed to operate at slightly -ve pressure to reduce unwanted gases.
- **Air supply:** Incineration operation involves the reaction of combustible components with air. Air provides oxygen for the incineration process. Typical incineration process requires sufficient oxygen to ensure complete combustion.
- **Use of refractory materials:** The thermal destruction system must be insulated with refractory materials to effectively operate at high temperature. The main purpose of refractory materials is to contain within the unit the heat released from the incineration process, proper containment of this energy is desirable for optimal vaporization & combustion of waste.
- **Materials of construction:** Normally ordinary steel or alloys are used as materials of construction for incinerators. Required temperature can be maintained in the incinerators by the proper selection of materials of construction

PYROLYSIS



Pyrolysis is the thermal process of converting the solid waste into gaseous, liquid & solid fractions, thus a combination of thermal cracking & condensation reaction.

Pyrolysis is widely used as an industrial process for the production of charcoal from wood coke & coke gas from coal, fuel gas from heavy petroleum fractions.

The three major components resulting from pyrolysis process are

- Gas stream consisting primarily of hydrogen, methane, carbon monoxide, carbon dioxide and various other gases depending on the organic characteristics of materials.
- Liquid fraction consisting of tar/oil stream contains acetic acid, acetone, methanol & complex hydrocarbon
- Solid fraction - Pure char consisting of almost pure carbon and any inert materials originally present in the solid waste.

This system employs stages of shredding, air classification, drying to produce a very fine organic fraction. Inorganic fraction is rejected to landfill site. Ferrous metals, aluminum & glass are recovered by magnetic separation. The pyrolysis portion consists of several interconnected loops. The end products are pyrolytic oil, gases, char & ash.

Limitations

- Inherent complexity of the system.
- Lack of appreciation by system designers of the difficulties of producing a consistent feed stock from municipal solid waste.
- They never produce design and operational data that can be used by future designs.

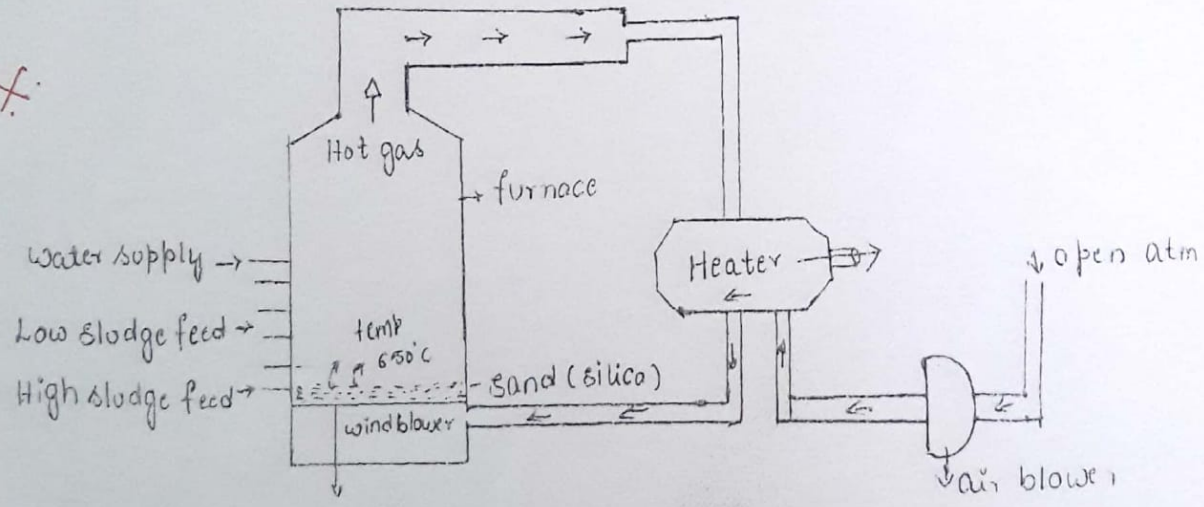
TYPES OF INCINERATORS

FLUIDIZED BED INCINERATOR

In this system, generally the source separation is carried out because glass and metals do not fare well in these systems and also they can successfully burn wastes of widely varying moisture and heat content, so that the inclusion of paper and wood, which are both recyclable and burnable.

The system is comparatively of modern origin & consists of furnace or reactor having silica sand filled in its bottom portion.

- Fluidized system consist of vertical steel cylinder usually refractory lined with a sand bed a supporting and air injection nozzle known as tuyeres.
- This structure has a series of layer which allow the passage of air upward towards the sand bed.
- The sand bed is kept in fluid condition by creating turbulence by upward flow of air to be passed under a pressure of about 25 to 35kpa
- The sand bed is also preheated to approximately 650°c by using fuel oil or gas.
- The depth of sand bed in a fluid bed incinerator may usually vary from 0.6 to .4m.
- High sludge solid waste followed by low sludge waste is burnt in the incinerator.
- Water is supplied in the incinerator for the combustion process.
- Hot air is then passed into the heater where in particulate matters are removed from the air and some part of the air is again recycled into the incinerator and rest is left into the



open atmosphere

MERITS

- This is the most hygienic method since it ensures complete destruction of pathogens.
- There is no odor trouble or dust sense. The heat generated can be used for generation of stream power.
- Adverse weather conditions have no effect on the Incinerators.

DEMERITS

- It is very costly method & requires technical person to handle the instruments.
- Improper operation result in air pollution problem& in complete reduction of the waste materials.
- Disposal of remaining residue is required.

* Types of Incinerators

1. Rotary Kiln Incinerator :-

Solid waste as well as liquid waste generated by industry are destroyed by on site and commercial site Rotary Kiln incinerator system.

- The Rotary Kiln is a cylindrical refractory-lined shell that is rotated to provide tumbling and lifting action to the solid waste materials.

- Rotary Kiln incinerator like other types, are designed with i) A primary chamber where the waste is heated and Volatilized
ii) A Secondary chamber, where combustion of the Volatile fraction is completed.

- The primary chamber consist of slightly inclined, in which waste materials migrate from the feed end to the ash discharge end.

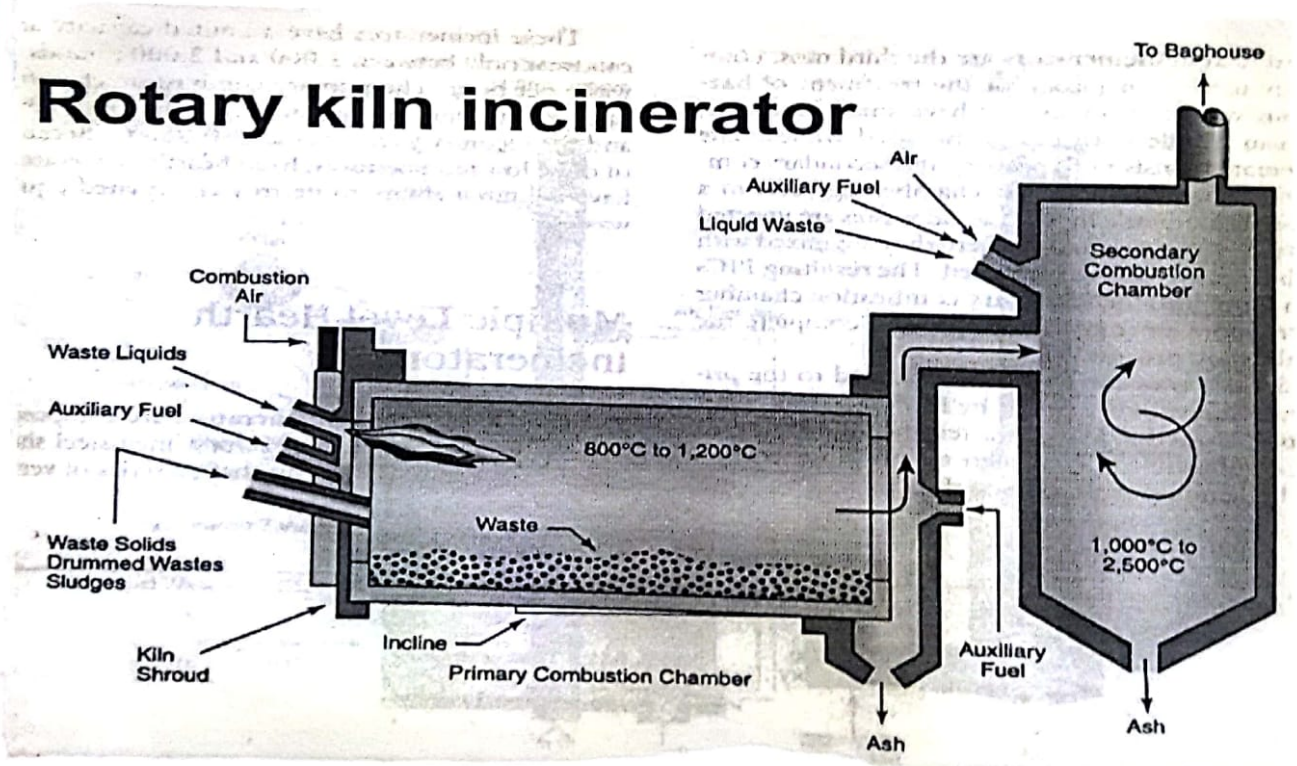
Nozzles/

- Openings are provided to input solid & liquid waste, fuel & air for burning of waste.
Flames are generated over the surface of waste solids exposed to the heat & incoming air.
Temperature for burning Varies from 1,300 to 2400°F, in which the wastes are Volatized and oxidized in primary chamber.

- The unburnt Volatiles enter the Secondary chamber along with the hot products of combustion. where additional oxygen is introduced and

ignitable liquid waste or fuel can be burned.

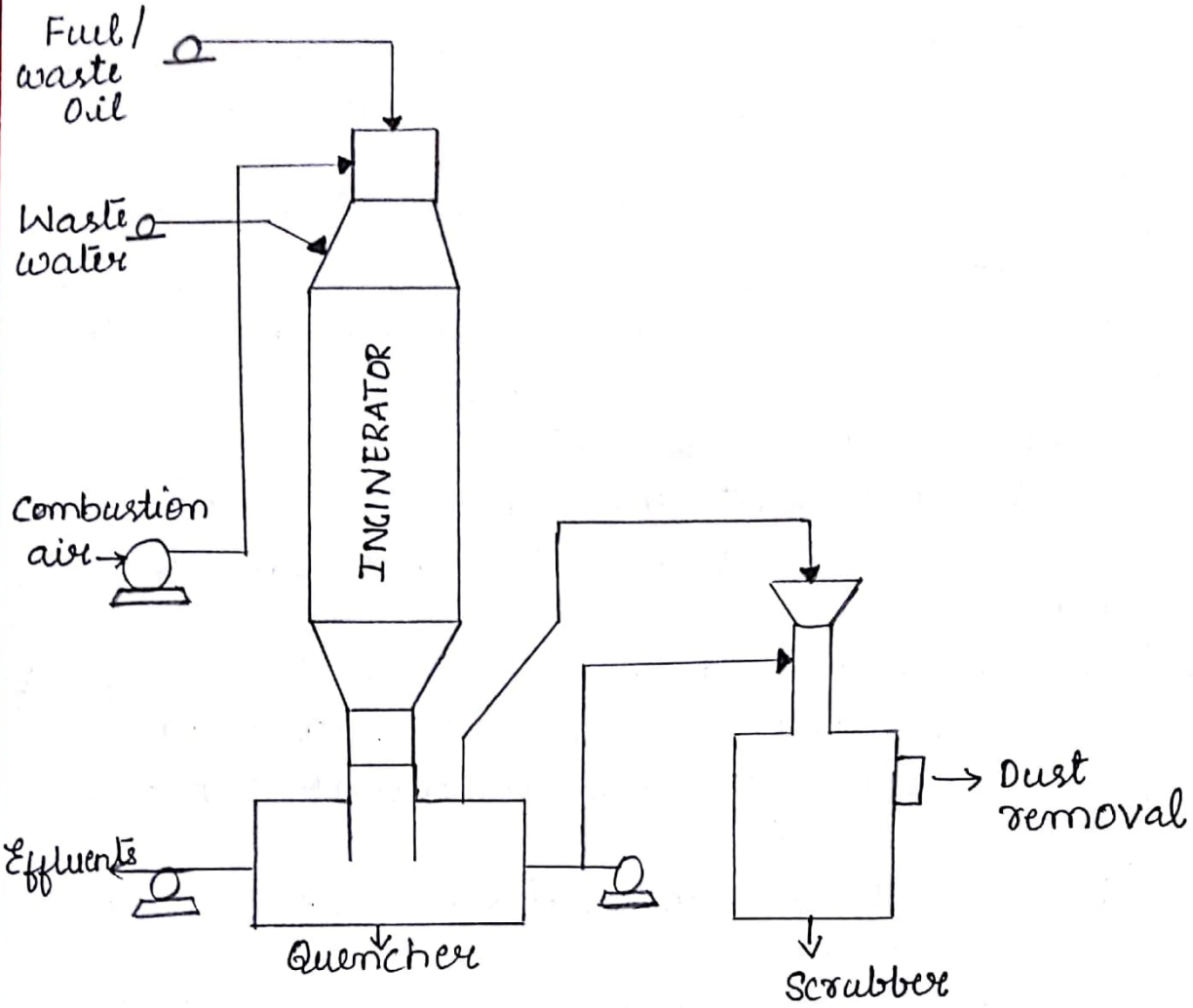
- Ashes from the primary & secondary chamber is discharged out. The temp of the ash discharged by the kiln is lower. This creates less issues with slagging and is therefore more reliable and less complex. No need of water bath for cooling slag and discharge. Metal recovery from the ashes is also possible.



* Liquid Injection Incinerator :-

It is used primarily in chemical Industry to destroy the liquid waste that contains organic toxins.

- It is commonly used system that relies on high pressure to prepare liquid wastes for incineration
- This Incinerator furnace is lined inside with firebrick & temperature of usually 1000°C & higher is maintained.
- Wastes are sent through nozzles, along with wastes, fuel is added to reach the desired temperature.
- Liquid sent into the nozzle will be exposed to burner flames & is atomized into small droplets to allow for the greatest possible mixing with air.
- The operating temperature varies from 1200-3000F.
- Can completely combust non combustibles like contaminated water, along with Organic combustible materials.
- Toxic liquid waste gets oxidized to produce CO_2, H_2O, O_2, N_2 & acid gases.
- Acid gases must be cleaned from exhaust stream by using wet scrubbers.



* Catalytic Incineratore :-

Catalytic Incineratore is a oxidation process which oxidizes volatile organic compounds by using catalyst to promote the combustion process. Catalytic Incineratore require lower temperatures, thus saving fuel & other costs.

- Catalytic Incineratore are used to destroy gaseous pollutants in Volatile Organic compounds. Catalyst used may be platium, oxides of copper in the form of porous, honeycomb or wire mesh.

A catalytic Incineratore may consist of the following components :-

1. A preheater section
2. A burnere
3. A mixing chamber
4. A catalyst bed
5. A blower

Process :-

1. An incoming pollutant gas stream may be preheated prior to feeding the same into the mixing chamber.
2. In mixing chamber, the gas stream gets mixed with the hot flue gas from the burner so that the mixture may attain the temperature at which catalytic oxidation would takes place.
3. The purpose of the burnere would be to produce the heat required to maintain in mixing chamber and the catalyst bed. The fuel may be either gas or an oil.

- The catalyst bed is arranged in such a fashion that the influent stream admixed with hot flue gas has to pass through the bed & no portion may bypass the bed.
It should be so fitted to the combustion chamber that the same may be easily taken out for reactivating or replacement.

- Complete destruction of the pollutants present in a waste gas stream is difficult to achieve in an incinerator.
98-99% destruction may bring down the pollutant concentration to permissible limit.
Most of the Volatile organic compound on complete combustion produce CO_2 & H_2O
Some of the pollutants like SO_2, SO_3, halogens are also obtained.

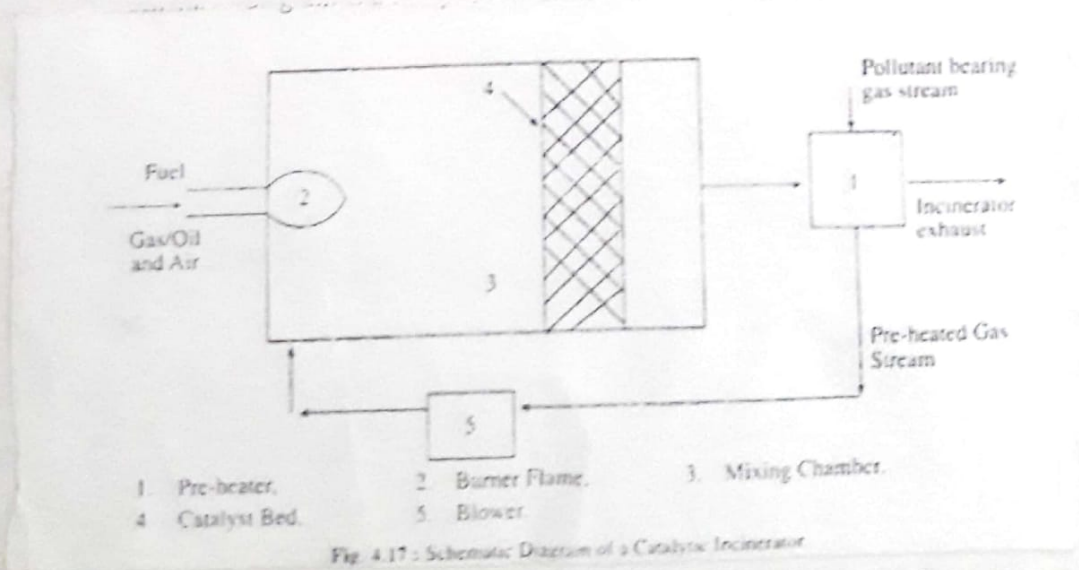


Fig. 4.17 : Schematic Diagram of a Catalytic Incinerator

* Multiple hearth Incinerator :-

- The multiple hearth incinerator is a flexible unit that has been utilized to dispose of sewage sludge, solids and liquid combustible waste.
- A multiple hearth furnace includes a refractory lined steel shell, a central shaft that rotates, a series of solid flat hearths, a series of rabble arms with teeth for each hearth, a combustion air blower, fuel burners mounted on the walls, a ash removal system and a waste feed system.
- In vertically oriented, cylindrical style multi hearth furnaces, ~~dewatered~~ water sludge is fed into the perimeter of the top of hearth.
- Due to gravity and rabble arms more the sludge progressively downwards through the hearths towards an ash discharge below the last hearth.
- Multiple hearths furnaces can typically be considered to consist of three zones.
  The upper hearth comprise the drying zone where most of the moisture in the sludge is evaporated. The temperature in the drying zone is typically between 425°C - 760°C
- Sludge combustion occurs in middle hearths (Second zone) as the temperature is increased to about 925°C.

- The combustion zone can be further sub-divided into middle hearths, where volatile gases & upper solids are burned & lower middle hearths, where most of the fixed carbon is burned.
- The third zone, made up of lower hearths is the cooling zone. In this zone, the ash is cooled as its heat is transferred to the incoming combustion air.

* Disadvantages:-

- Due to the longer residence times of the waste materials, temperature response throughout the incinerator when the burners are adjusted is usually very slow.
- It is difficult to control the firing of supplemental fuel as a result of this slow response.
- Maintainence cost is high.
- This device is not suitable for wastes containing fusible ash, waste that require extremely high temperature for distruction or irregular bulky solids.

* Energy Recovery Operations

Once the Solid waste has been converted to thermal energy in the form of steam by combustion or to chemical energy in the form of gases or liquid by pyrolysis or gasification, it can be converted to mechanical or Electrical energy.

- Steam can be used to produce mechanical or electrical energy by a steam Engine/turbine
- Gases & liquid produced from solid waste by both thermal and biological processes can be used in fuel boilers to produce steam.

The purpose of Energy Recovery Operation is as follows

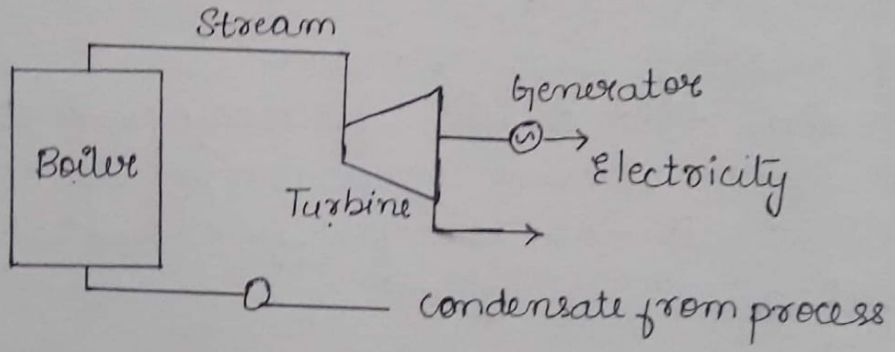
- To present basic flow diagram available for accomplishing these conversions.
- To present data on the efficiency of components used in the various conversion process.
- To illustrate the use of efficiency data in computing energy outputs.

* Energy Recovery Flow diagram:- - Recovery Techniques

The principle components used for energy recovery are boilers for steam production, Steam turbines, gas turbines and reciprocating engines as prime movers for mechanical energy. Electric generators for the conversion of mechanical energy into Electricity.

* Stream Turbine System :-

- The most common energy recovery system for the production of electricity is the Stream turbine system.
- Stream is produced in a boiler by burning of municipal solid waste.
- Stream is used to drive a stream turbine and then condensed back into boiler feed system.
- The stream turbines drives an Electrical generator, which supplies on site power and excess power for export.

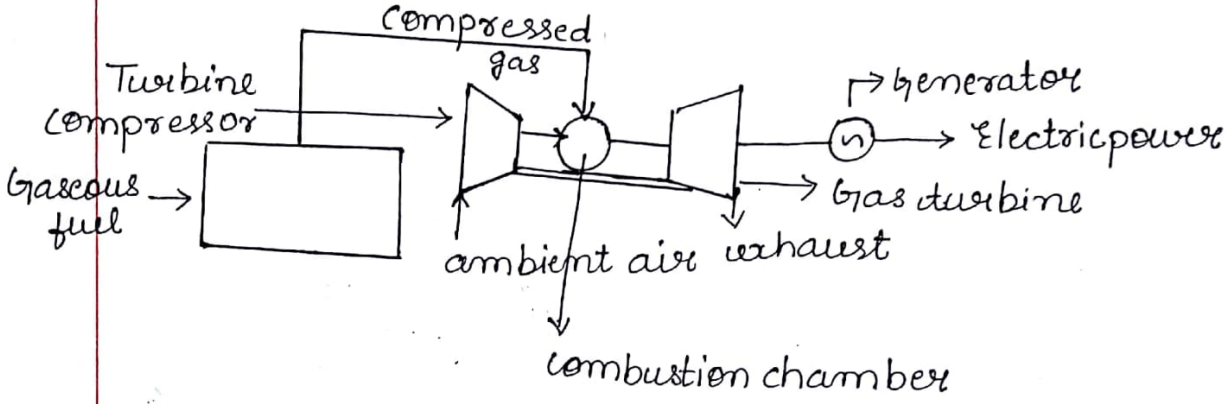


* Gas Turbine Generator system

Gas turbines requires gaseous or liquid fuel.

- These fuel can be supplied by biological processes such as landfill gas or by the anaerobic process or by pyrolysis.
- A gas turbine is similar to a jet Engine.
- In that it consist of a compressor section to increase the density of gas/air mixture, a combustor and a turbine section to convert the hot combustion gases to mechanical energy.

- An electrical generator is connected directly to the output shaft of the gas turbine.
- Gas turbines are efficient and compact & are widely used in Landfill gas system.



* ~~Internal combustion Engine system.~~

* Co-generation System :-

Cogeneration refers to combined production of steam and electricity & can occur in two ways.

- Cogeneration systems are widely used in industries to generate electricity & process or building heat at the same time.
- In cogeneration, high pressure steam is used first to generate electricity, the steam leaving the turbine is then used to serve the steam users.
- Solid waste is combusted in Incinerator. The end products obtained after the combustion process is Ash residue & Flue gases. Ash residue is then sent to sanitary landfill for further treatment.
- Flue gas is then diverted into boiler for the production of steam. Then the steam is sent into Extraction steam turbine, from turbine to electric generator for the production of electricity.

- Cogeneration System for producing Electricity & steam