GASEOUS FUELS

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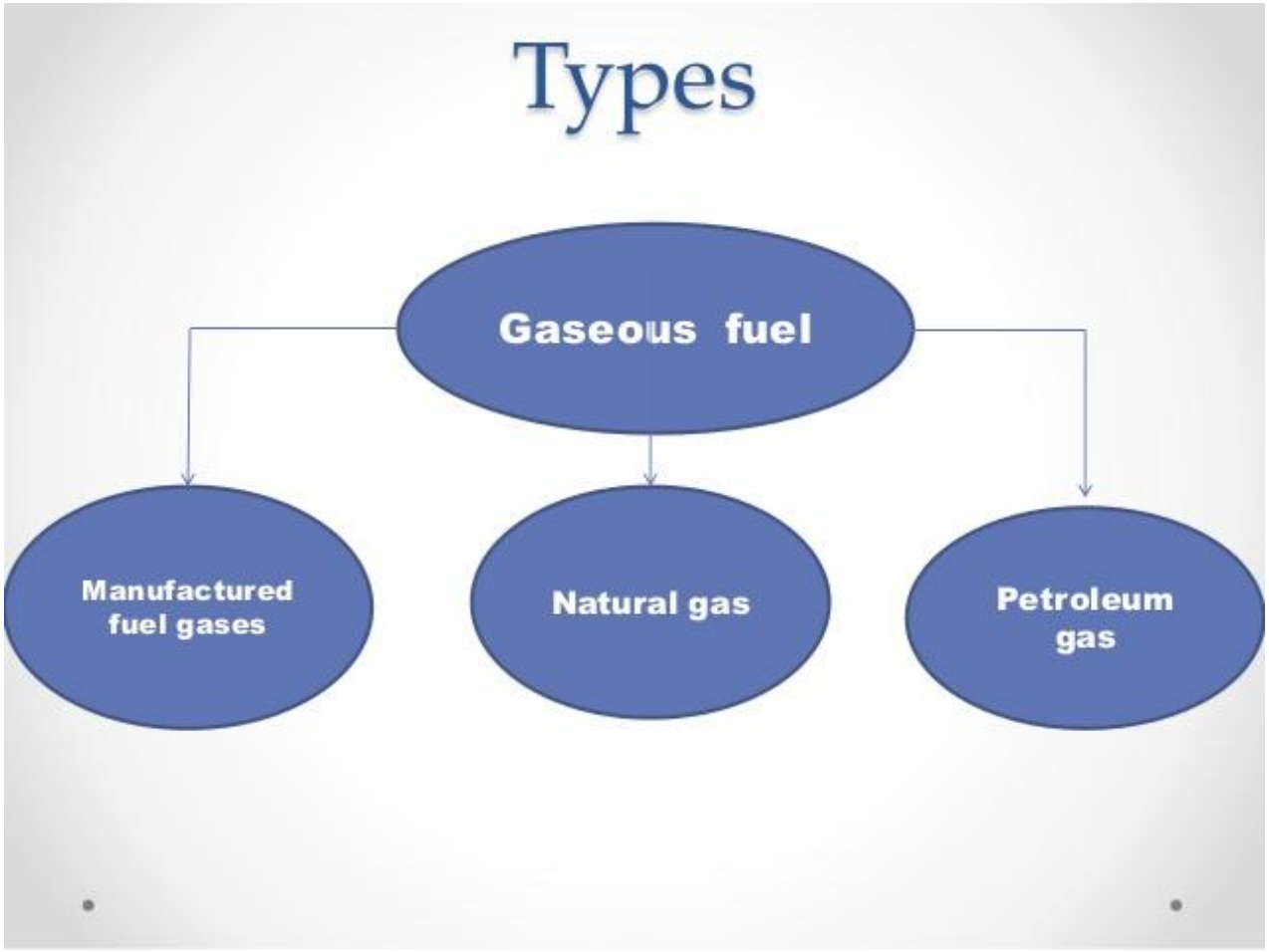
GASEOUS FUEL

- Gaseous fuels are obtained either naturally or by the treatment of solid or liquid fuel.
- Among the naturally occurring gaseous fuels, natural gas and liquefied petroleum gas are most important.
- These gases have high calorific value.
- The calorific value (CV) and specific gravity (Sp. gr.) of a gaseous fuel determine the thermal output of a heating appliance.

Gas v/s Fuel

- Gaseous fuels have lower energy content than liquid fuels such as, petrol or diesel.
- Gaseous fuels are potentially more deserved fuel as they produce very low greenhouse gas upon burning and hence air quality benefits are obtained compared to conventional and petrol and diesel products.


Types
Gaseous fuel
Manufactured fuel gases
Natural gas
Petroleum gas

COAL GAS

- Coal gas is a mixture of CH4 (50%) and H2 (30%).
- Coal gas is obtained when coal is carbonized or heated in absence of air at a pressure little more than atmospheric pressure at about 1300oC in coke ovens or gas retorts.
- Coal □ Coke + Coal gas
  (Residue in retorts)

Manufacturing Process

1. Powdered coal is fed into the top of large, vertical silica retorts maintained at a temperature of 1300oC by producer gas burners.
2. The coal gas obtained contains large number of useful impurities like ammonia, tar, organic nitrogen compounds and sulphur compounds.

Manufacturing Process (contd..)

- These are removed from the coal gas by passing it into hydraulic main which contains water.
- Here, some of the tar and water soluble products such as ammonia are removed. Further separation of tar and ammonical liquid occurs in condensers.
- The gas after scrubbing with water is passed through a chamber containing moist ferric oxide to remove traces of H2S and HCN.

Manufacturing Process (contd..)

- **Chemical Reactions:**
- $NH_3 + H_2O \rightarrow NH_4OH$
- $3H_2S + Fe_2O_3 \rightarrow Fe_2S_3 + 3H_2O$
- $2Fe_2S_3 + 3O_2 \rightarrow 2Fe_2S_3 + 6H_2O$
- $6HCN + Fe_2O_3 \rightarrow 2Fe(CN)_3 + 3H_2O$

Manufacturing Process (contd..)

3. The purified gas is finally stored over water in gas holder and is distributed as town through pipelines.

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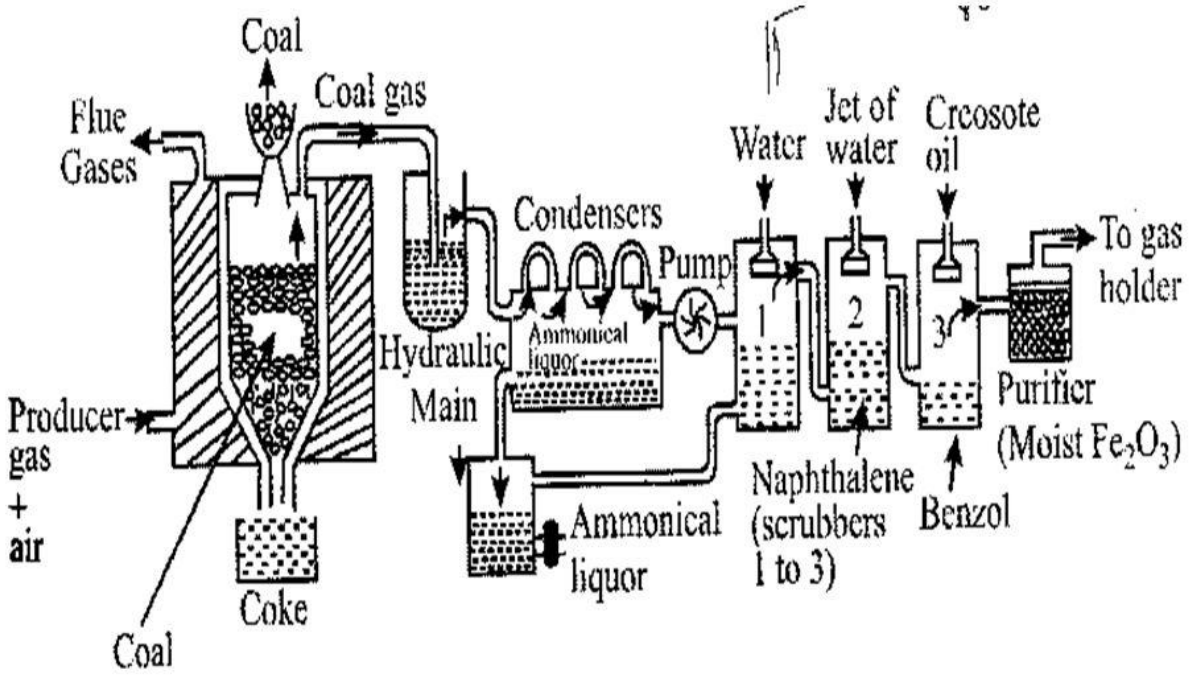

Manufacture of Coal Gas

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Properties of Coal Gas:

- Coal gas is colorless gas having characteristics smell.
- It is lighter than air and burns with a non smoky flame.
- Calorific value: about 4900 kcal/m^3.

Average Composition:

- CH_4=32%, N_2=8%, CO=7%, CO_2=1%, C_2H_2=2%, H_2=30%, C_2H_4=3%, other hydrocarbons=4%

Uses of Coal Gas

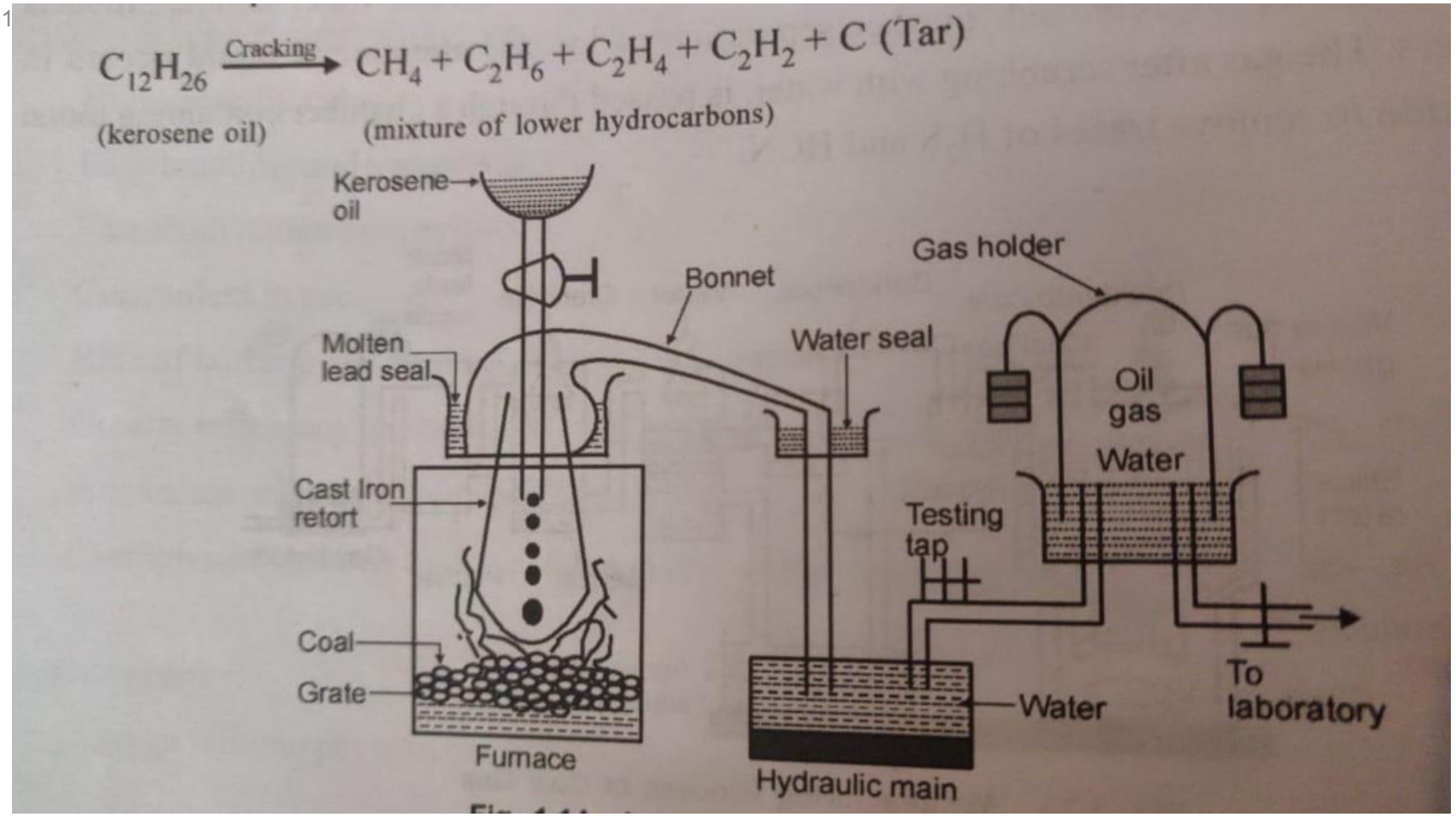
- It is used as domestic fuel for heating purposes and also as an illuminant
- It is also used to provide a reducing atmosphere in metallurgical processes.

OIL GAS

- Oil gas is mainly mixture of hydrogen and lower hydrocarbons. It is obtained by cracking or thermal decomposition of kerosene oil.

$$C_{12}H_{26} \xrightarrow{\text{Cracking}} CH_4 + C_2H_6 + C_2H_4 + C_2H_2 + C\ (\text{Tar})$$

(kerosene oil) (mixture of lower hydrocarbons)



Manufacturing Process:

(i) Kerosene oil is fed into a strong iron retort which is enclosed in a coal fired furnace.

(ii) At the mouth of the retort, a bonnet is fixed through a molten lead seal.

(iii) This bonnet is then attached to a hydraulic main from where a pipe leads to the gas holder.

(iv) The kerosene oil which is fed into the red hot retort immediately gets cracked into a number of lower gaseous hydrocarbons.

(v) The gas so formed rises up and goes to the hydraulic main through the bonnet where tar gets condensed.

(vi) Pure gas is then collected over the gas holder.

(vii) The proper cracking of the oil is assessed from the colour of the gas produced which should have a golden colour.

(viii) Finally, the gas is mixed with air and supplied to the place of burning.

Composition of Oil gas:

CH_4 = 25–30%, H_2 = 50–55%, CO = 10–15%, CO_2 = 3%

Properties of Oil Gas:

- Oil gas burns with a smoky flame.
- It has a characteristic odour.
- Calorific values about 4500-5400 kcal/m^3.
- **Uses:**
- It is mainly used as a laboratory gas.

Junker's Gas Calorimeter

1. History:

- The junker’s gas calorimeter was named by Antoine Lavoisier.
- In 1870, he used guinea pig with this device to measure heat production in his experiments. The heat produced by the pig melted the snow around the calorimeter.
- This shows that respiratory is the combustion similar to burning of candle.
- The junker’s gas calorimeter is almost similar to bomb calorimeter in respect that heat evolved by burning gas is taken away by water.

Junker's Gas Calorimeter (contd..)

- **Description:**
- The junker’s gas calorimeter is used to determine the calorific value of the gaseous fuels.
- **Construction:**
- The junker’s gas calorimeter is a device used to measure the calorific value of the gaseous fuels.

Junker's Gas Calorimeter (contd..)

- The device is essentially a Bunsen burner with a cooling jacket.
- The jacket is cylindrical in shape with water in it.
- The burner is inside the cylinder.
- The calorimeter allows the user to measure the temperature of water flowing in and flowing out.

Junker's Gas Calorimeter (contd..)

- Once steady state is reached, the water flowing through is collected for a specified period of time.
- Measuring the mass of the water and the temperature rise in the water, the operator can calculate the number of joules which went into the water to heat it.

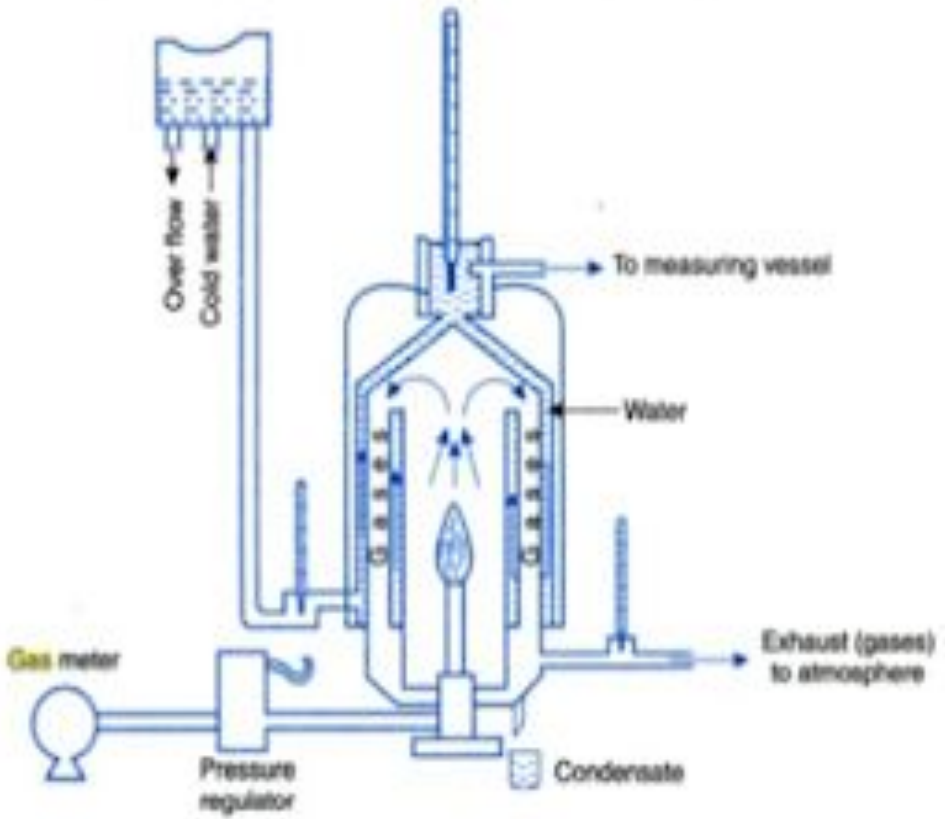
Junker's Gas Calorimeter (contd..)

- There is a flow meter on the fuel gas, so the operator can also calculate the volume of gas that was burned in the same time period.
- The amount of energy, in J, available per litre of gas can then be calculated.
- A Junkers calorimeter is a flow calorimeter, with heat transfer happening continuously, as opposed to a batch calorimeter.

Junker's Gas Calorimeter (contd..)

- The device consists of a cylindrical shell and two paths for water are there which have copper coil arranged in it.
- One path is the inlet and the other is outlet. Water pass through the copper coils.
- There is pressure regulator in the path of water flow which is further connected with gas flow meter.
- Gas flow meter is used to measure the flow rate of gas.
- Temperature sensors are used in the device to measure the inlet and outlet water temperature and also for the flue gases.

Junker's Gas Calorimeter



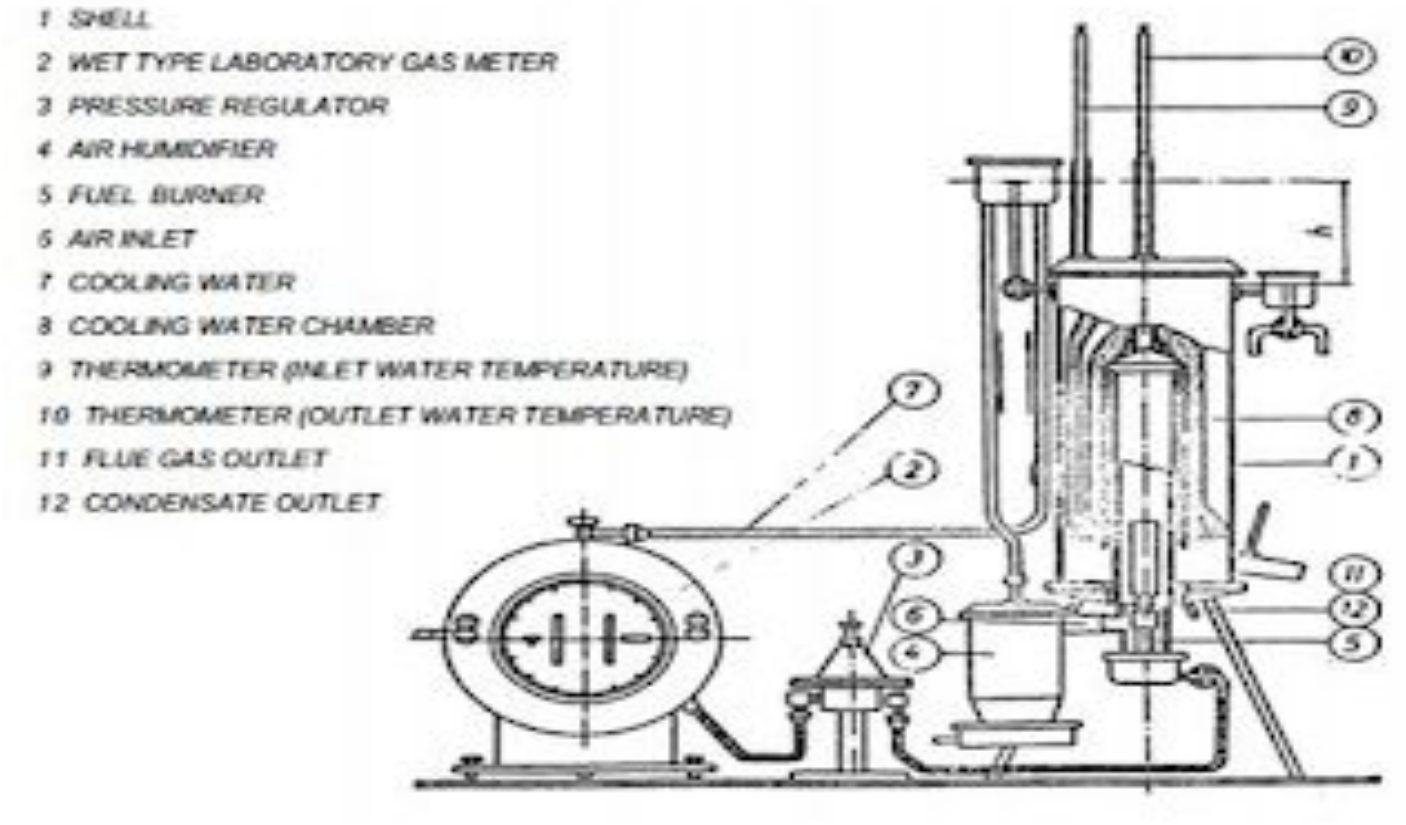
Junker's Gas Calorimeter (contd..)

- **Main Parts:**
- 1. SHELL
- 2. WET TYPE LABORATORY GAS METER
- 3. PRESSURE REGULATOR
- 4. AIR HUMIDIFIER
- 5. FUEL BURNER
- 6. AIR INLET

Junker's Gas Calorimeter (contd..)

- 7. COOLING WATER
- 8. COOLING WATER CHAMBER
- 9. THERMOMETER (INLET WATER TEMPERATURE)
- 10. THERMOMETER (OUTLET WATER TEMPERATURE)
- 11. FLUE GAS OUTLET

Junker's Gas Calorimeter (contd..) - Condensate Outlet



Junker's Gas Calorimeter (contd..)

- Working:
- The junker’s gas calorimeter works on the principle of burning of a gas whose volume is known.
- The temperature of water and gas is measured along with flow rate of gas to measure the calorific value.
- The formula is: Calorific Value of Gas X Volume of Gas = Volume of water X Rise in Temperature, is then used to determine the Calorific Value of the Gas (assuming that heat capacity of water is unity).

Junker's Gas Calorimeter (contd..)

- A measured quantity of gas whose calorific value is required supplied to a gas meter which measures the volume of gas and after it the gas pass through the pressure regulator which measures the pressure of gas using the manometer.
- When the gas inside the chamber is burned, the products produced in the combustion rise into the chamber and then move downward where it is extracted as gas flues.

Junker's Gas Calorimeter (contd..)

- After this gas finally escapes to the atmosphere.
- There is thermometer at the end of the outlet which measures the temperature of the escaping gas.
- This temperature should be near room temperature so that whole heat is absorbed by the water.

Junker's Gas Calorimeter (contd..)

- Cold water enters the calorimeter near the bottom of device and leaves from top.
- Water that was formed by condensation is collected in a pot.
- The quantity of gas in te process is measured accurately and the temperature of ingoing and outgoing gas is also measured.
- By using above collected data we can measure the calorific value from formula as mentioned earlier.

Numerical

Example 2.13 : The following data were obtained in Junker's calorimeter experiment.

Volume of gas used = 0.1m^3 at NTP = 0.1 Nm^3

Weight of water heated = 25 kg

Temperature of inlet water = 20 °C

Temperature of outlet water = 33 °C

Weight of steam condensed = 0.025 kg

Calculate higher and lower calorific value per m^3 at NTP assuming that the latent heat of condensation of steam = 580 kcal/kg.

Solution :

$V = 0.1\ Nm^3$ $\quad W' = 0.025$ kg

$W = 25$ kg $\quad t_2 - t_1 = 13$ °C

Latent heat of steam $= 580$ kcal/kg

Now higher calorific value (HCV) $= \dfrac{W(t_2 - t_1)}{V}$

Numerical (contd..)

Now higher calorific value (HCV) $= \dfrac{W(t_2 - t_1)}{V}$

$= \dfrac{25 \times 13}{0.1} = 3250\,\text{kcal/Nm}^3$

Lower calorific value $= \text{HCV} - \dfrac{W' \times \text{Latent heat of steam}}{V}$

$= 3250 - \dfrac{0.025 \times 580}{1}$

$= 3250 - 145 = \mathbf{3105\ kcal/Nm^3}$

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Thank you!