## Lecture: 05

# Fuels & Energy

**Prepared by**

**Dr. Bhupendra Suryawanshi**

**Dharmsinh Desai University, Nadiad**
**Gujarat - India**

# Water Gas

- Water Gas is a medium calorific value (about 2800 kcal/$Nm^3$) comprising mainly of CO and H2.

- It is prepared by the action of Superheated steam on a bed of hot COKE/COAL at about 1000 °C as per the reaction.

$$C + H_2O = CO + H_2, \quad \Delta H = +28 \text{ kcal/kmol}$$

- As the above reaction is endothermic, the coal cools down after a few minutes and the reaction proceeds in a different way to form CO2 and H2 instead of water gas (CO+H2).

$$C + 2H_2O = CO_2 + 2H_2, \quad \Delta H = +19000 \text{ kcal/kmol}$$

- In order to avoid the above undesirable reaction, the current of steam in intermittently replaced by a blast of air.

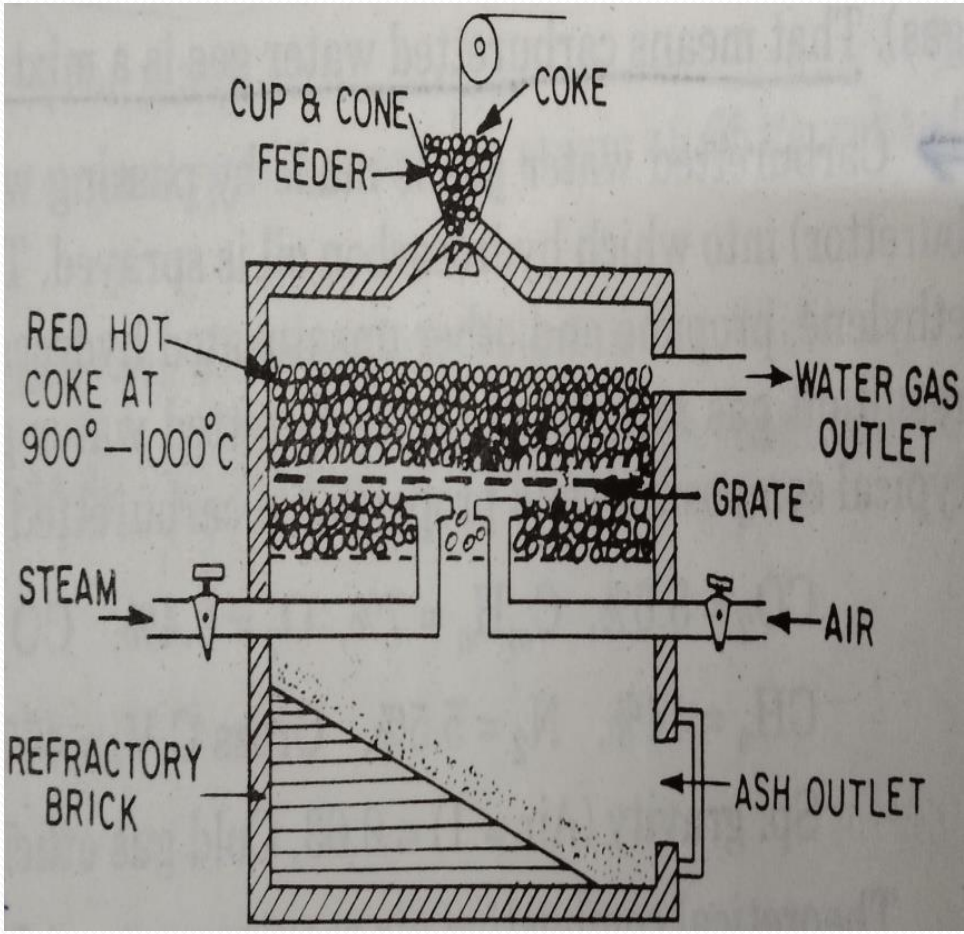
$$C + O_2 = CO_2, \quad \Delta H = -97000 \text{ kcal/kmol}$$

$$2C + O_2 = 2CO, \quad \Delta H = -29000 \text{ kcal/kmol}$$

**Note:** Due to exothermic reaction the temperature of carbon again rises and when the temperature increases to 1000 °C air entry stopped and steam is again passed.

- In modern gas plants steam and air are blown alternatively.
- The period of Steam blow (cold blow) is usually for 4 minutes while the period of Air blow (hot blow) is very short about 1-2 minutes.
- The duration of these periods are adjusted in such a way that the maximum yield of water gas is obtained.

- A water gas generator is a cylindrical vessel made of steel. It is about 4-5 m in height and 2-3 m in diameter.
- At the top, it is provided with a hopper for adding coke.
- Water gas outlet is provided near the top. It has two separate inlets for blowing steam and air.
- At the bottom, it is provided with an arrangement for taking out ash formed.
- During the steam blow, water gas is produced. This is led out through the water gas outlet.



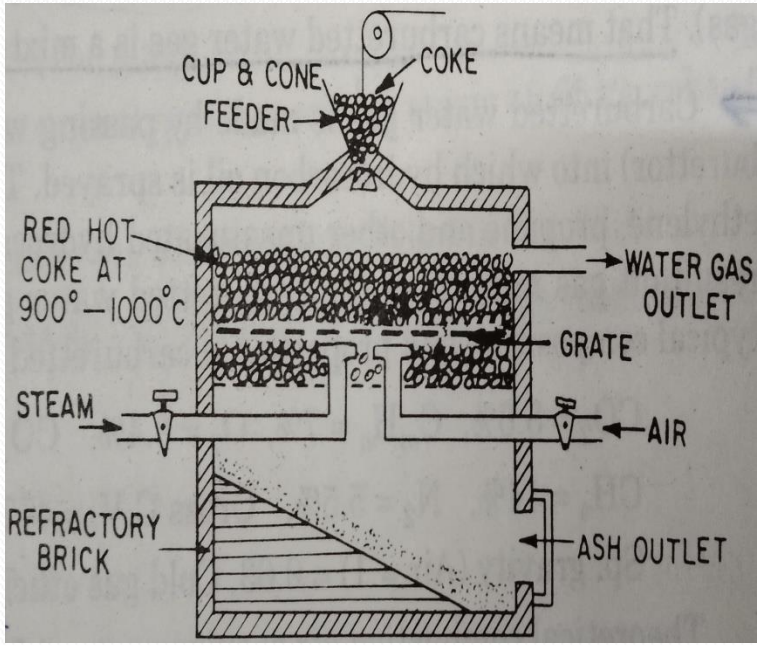

- On the other hand, nitrogen, carbon dioxide and carbon monoxide are formed during the air blow. These are allowed to escape in the atmosphere. Thus the manufacture of water gas is intermittent.

- The typical composition of water gas is:

| $H_2$ | CO | $CH_4$ | $CO_2$ | $N_2$ |
|---|---|---|---|---|
| 48-51% | 40-42% | 0.1-0.5% | 3-5% | 3-6% |

- Theoretical combustion air requirement
  = 2-2.5 $Nm^3/Nm^3$ gas

- C.V. = 2500-2800 kcal/$Nm^3$.




- **Uses of water gas:** It is used as fuel in furnaces, Normally, it is enriched by adding hydrocarbon gas (oil gas) and the mixture is called CARBURETTED WATER GAS which has high C.V.
- It is also used as a source of Hydrogen for ammonia synthesis in fertiliser plant.

**Note:** When water gas is specifically produced for Ammonia synthesis, a portion of air is added to the steam so as to get a mixture of $H_2$, CO, $CO_2$ and $N_2$. This is called 'SEMI WATER GAS'.

Major engineering problems

(a) Designing suitable ash removal systems for various grades of coal in continuous processing

(b) Optimizing cycle for regenerative process

# Carburetted Water Gas

- The C.V. of water gas is too low for being an effective gaseous fuel in town gas distribution system.

- It can be enriched to make 'CARBURETTED WATER GAS' by mixing Hydrocarbon oil vapour (having high C.V. of 10000-13000 kcal/Nm3).

- The process of making Carburetted Water Gas involves both gasification of coal as well as oil and then mixing them (oil gas+coal gas).

- Means CARBURETTED WATER GAS is a mixture of water gas and oil gas.

| $H_2$ | CO | $CH_4$ | $CO_2$ | $N_2$ | $C_mH_n$ | $O_2$ |
|---|---|---|---|---|---|---|
| 37.0% | 30.5% | 14.0% | 5.6% | 5.5% | 7% | 0.4 |

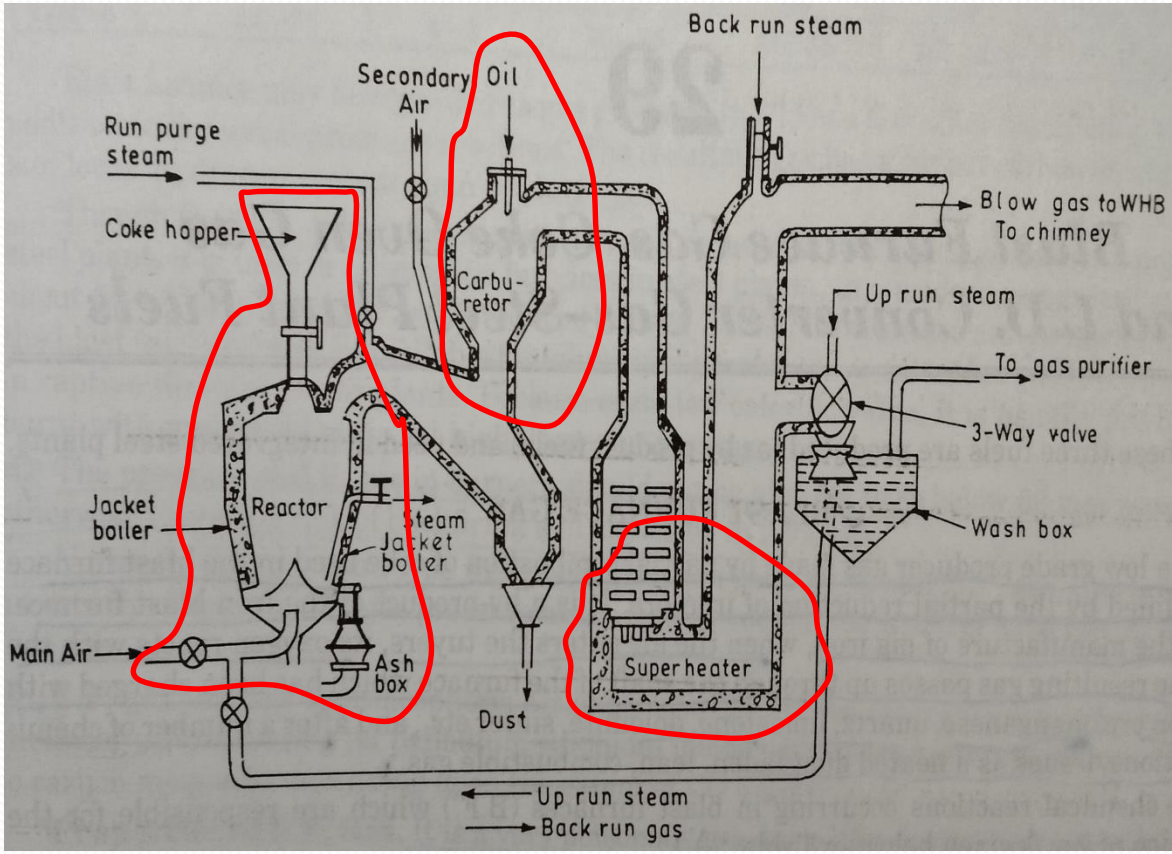
- Gross C.V. = 4770 kacl/Nm3

❑ Carburetted Water Gas is made by passing water gas through a hot chamber (called Carburettor) into which Hydrocarbon Oil is sprayed. The oil cracks and produces ***Methane, Ethane, Ethylene, Propane and other unsaturated hydrocarbons which have high C.V.'s.***

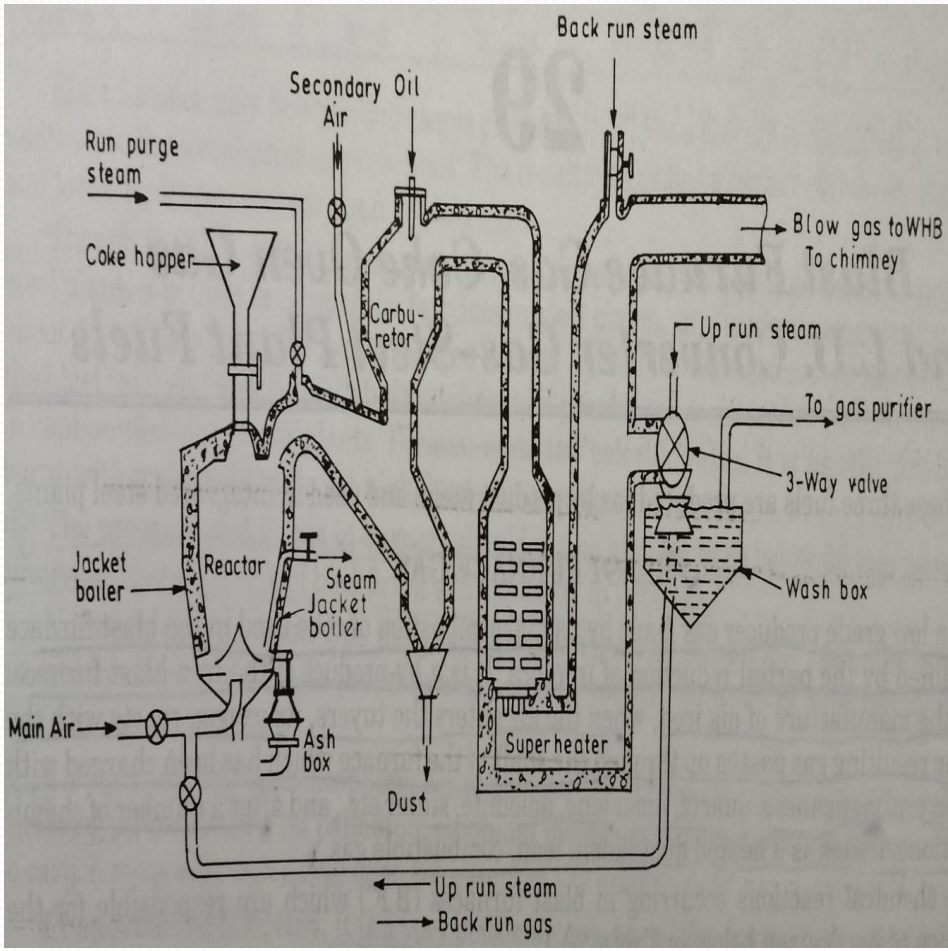
❑ A Carburettor Water Gas plant involves:

1. Water gas generator.
2. Carburettor.
3. Super heater.

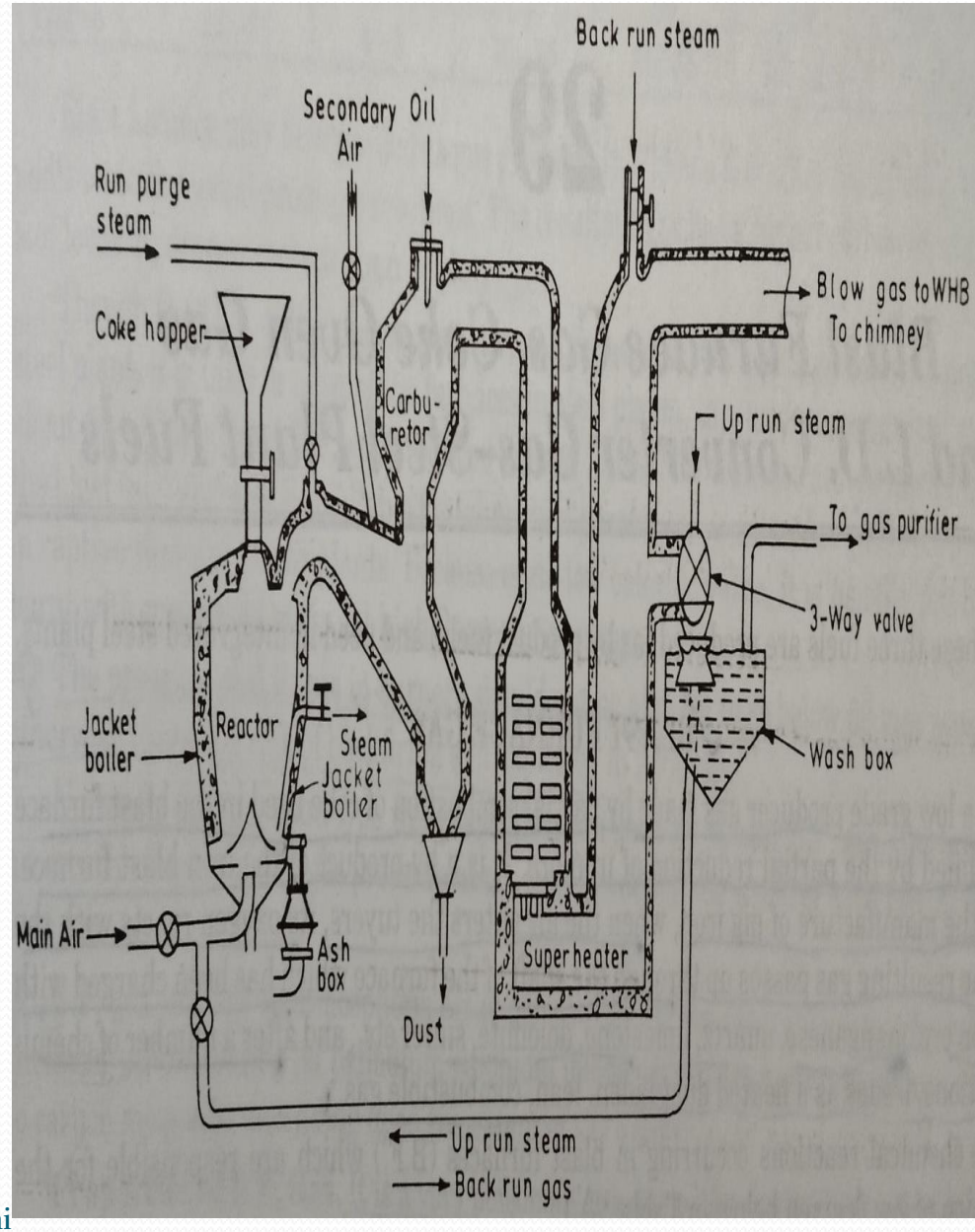
❑ The oil used in carburetting is a light petroleum fraction (boiling between 200 to 300 °C) comprising mainly of paraffins.



- Carburettor and super heater are filled with chequered bricks.
- The gas produced during the blow period (blow gas) is burned in the carburettor and then the combustion is completed in super heater.
- The flue gases are routed through a waste heat boiler (to generate steam) and finally leave through the chimney.
- During the run period, oil is sprayed into the chequer of carburettor and the water gas is passed through the chamber.
- Endothermic oil cracking process is completed in the super heater which results in the fall in the brickwork temperature which are again heated up during the blow period.



- The cyclic process of carburetting water gas is synchronised with the parent water gas generation process. And the resultant gas is passed out of the plant through a wash box.
- Part of the heat produced by blow gas in carburettor and superheater is fed back to the fuel bed by carrying out back run.
- Steam is blown through superheater and carburettor into the top of the fuel bed.
- Oil is sprayed into the steam which cracks on passage through the fuel bed. This back-run increases the thermal efficiency of the plant.



**Use of Carburetted Water Gas:** Carburetted water gas is mainly used as an ingredient of town gas and as substitute of coal gas to meet peak loads of gas supply.