

Module 4: Gaseous Fuel

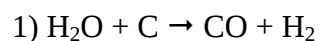
Lecture 28: Water Gas

Keywords: Coal gasification, steam blast, blast saturation temperature, gas generator

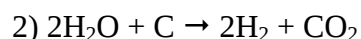
4.3 Water gas

Water gas is a gaseous fuel generated in the similar way as producer gas, by gasifying incandescent bed of solid fuel with superheated steam. The gas is mainly composed of an equal proportion mixture of carbon monoxide and hydrogen. It is a low calorific value fuel; the calorific value is around 2800 kcal/Nm³. The gas emits blue flame when ignited due to high content of carbon monoxide, hence, it is named as blue water gas.

The reactions involved when steam is passed through the burning bed of coal or coke above 1000°C are,

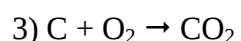


This reaction is strongly exothermic and temperature falls below 1000°C gradually with the progress of the reaction. At lower temperature steam starts to react with carbon to form carbon dioxide, according to the following reaction,

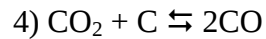


As carbon dioxide does not contribute to the calorific value of water gas, the above reaction is undesirable. To prevent the formation of carbon dioxide and to lower the cost of the process by not supplying heat from outside to the fuel bed, the whole process of water gas generation is divided into two stages,

a) Blasting period, when fuel bed is heated up by passing air through it by the exothermic reaction,



Carbon dioxide formed in this reaction is converted into carbon monoxide by the reaction with the carbon of the solid fuel as the temperature of the fuel bed rises.



b) Run or gas-making period, when blue water gas is produced by passing steam through the incandescent bed of coal. At this period, along with the reactions 1) and 2), other reactions such as water gas shift reaction and methanation reaction also occur.

The objective of the blast period is to accomplish only reaction 1) to produce maximum possible heat by this exothermic reaction and the objective of run period is to produce carbon monoxide as much quantity as possible by utilizing maximum amount of steam. Both these objectives keeping in consideration, a fuel bed with moderate thickness is used, with enough contact time of steam with the bed. In practice, the rate of decomposition of steam and the formation of water gas are controlled by alternate blast and run period. As soon as temperature falls below 1000°C , steam blast i.e, run period is stopped and air blast period is started to raise the temperature of the fuel up to 1400°C . When this temperature is attained, the air blast is stopped and steam blast is again resumed. In this way, the process alternated. After the air blast period is over, the bed is purged with steam for 2 seconds to remove the carbon dioxide formed in the blast period and this way CO_2 is prevented to mix with the blue gas. This steam is called purge steam. On the other hand, after the run period, a 2 second air purging is done to remove last trace of water gas present in the generator, before the blast period is started. The period for which air is passed through the fuel bed is called hot blow. The run period is carried out for 3 min and this period is also called cold blow. The hot blow is done for about 1 min. In the modern period, it is aimed to decrease hot blow period and to increase the run period.

Gas generator

The gas generator consists of a refractory brick lined steel cylinder with approximately 3 m dia and 5 m height. The solid fuel, coal or coke is introduced at the top of generator through an opening, provided with a door. Two inlet pipes with valves are fitted at the left side of the generator, where, one pipe is below the top and the other is above the bottom. Air blast is introduced through these pipes. Steam is passed through two sets of steam pipes, one set is located at the upper region and another set is at the lower region of the generator. The cyclic operation runs according to the following:

- a) Up-stream period: At this period, steam is blown through the lower set of steam pipes and passed upward through the hot fuel bed to generate water gas. This period is carried out for 1.5 min. Water gas produced goes out from the generator by an outlet pipe located at the top.
- b) Down-stream period: This period also takes 1.5 min. Steam is blown downward through the upper set of steam pipes to the fuel bed. The water gas produced leaves the generator through a pipe at the base. This pipe is connected to a vertical pipe which is again attached to the outlet pipe. So, water gas formed goes out of the generator through the outlet pipe.
- c) The three minute run period (up-stream + down-stream) is followed by one minute purge with air to remove the remaining water gas and send that to the gas holders.
- d) After the air purging, air blast is sent through the bed to increase its temperature up to 1400°C . This operation takes about 2 min. Carbon dioxide formed at this stage passed out through the top valve and thrown as waste.

Carbureted water gas

Water gas is a low calorific value fuel gas. To increase its calorific value, water gas is carbureted by adding gaseous hydrocarbons obtained by cracking petroleum oils. In addition to the gas generator, a carburetor, a superheater with purifiers, scrubbers and condensers are used to produce carbureted water gas. Carburetor and superheaters are the two big steel vessels, lined with refractory checker bricks to provide intensive heat transfer surface. The gas produced at the air blast period contains large amount of heat which is passed through these vessels to heat the top and side walls and then escape through a chimney to waste heat boiler for raising steam. Water gas produced during the run period in the gas generator is passed to the carburetor at the top and hydrocarbon oil is sprayed through atomizer into the red hot fire brick. The sprayed oil in the carburetor is cracked. The products of cracking and the water gas pass down the carburetor and enter the superheater at its bottom. The gas mixture rises up through the superheater and the cracking process is completed at this stage. Some tar produced during cracking is separated in a separator. The gas then passed through a series of pipes cooled by water spray. After cooling, the gases are led to the purifiers and finally to the gas holders. In purifiers, hydrated ferric oxide and lime impregnated wood shavings are placed which remove hydrogen sulfide as iron sulfide. The calorific value of carbureted water gas is approximately 4500 kcal/Nm^3 .

The composition of carbureted water gas is as follows:

H₂: 34-38%, CO: 23-28%, saturated hydrocarbons: 17-21%, unsaturated hydrocarbons: 13-16%, CO₂: 0.2-2.2% and N₂: 2.5-5%.

Water gas is used as a source of industrial hydrogen in the manufacture of methyl alcohol and carbureted water gas is used for welding purpose, and illuminating purposes.

Reference

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