UNDERGROUND COAL GASIFICATION (UCG) - II

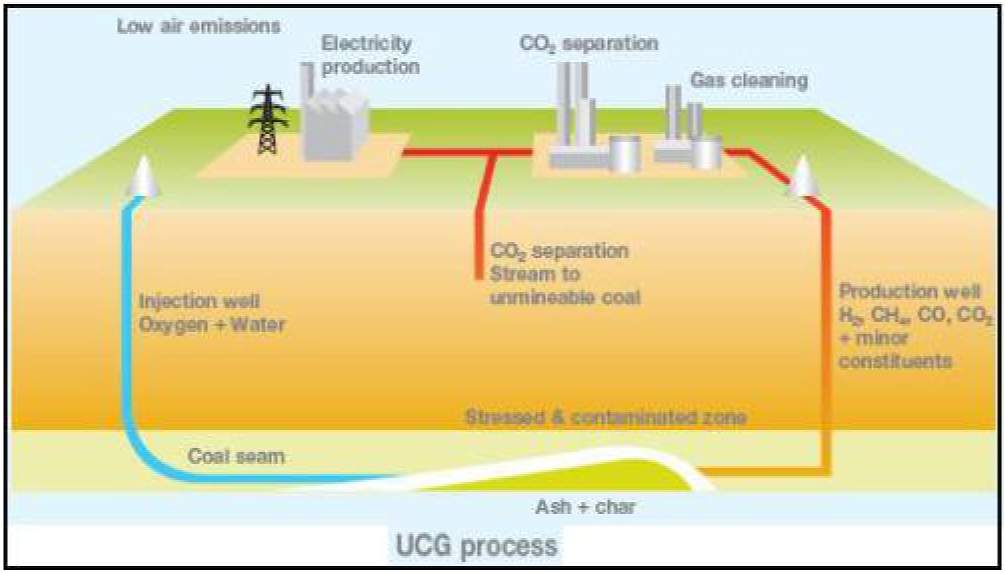
The basic UCG process involves drilling two wells into the coal, one for injection of the oxidants (water/air or water/oxygen mixtures) and another well some distance away to bring the product gas to the surface. Coal is gasified underground by creating a linkage through the coal seam between the injection and production wells and injecting air (or oxygen) and water (or steam) into the underground reaction zone. The injected gases react with coal to form a combustible gas which is brought to the surface in a production well, cleaned and used as a fuel or chemical feedstock. A cavity is formed as the coal burns and the roof collapses. This results in lateral growth and is allowed to continue until the product gas quality deteriorates. The greater the lateral growth, the longer the life of a gasifier and the more cost-effective the operation. When the quality of the product gas falls, fresh coal is ignited further along the injection well. Once the coal within the underground gasifier has been exhausted, new injection and production wells are drilled and the process is repeated.

Injecting oxygen rather than air reduces the nitrogen content and raises the heating value of the produced gas to the ‘medium-Btu’ gas range – of heating value roughly one-fourth of natural gas. If the goal is high-Btu gas (also called as substitute natural gas or SNG), the percentage of methane in the produced gases needs to be boosted. For methane formation in UCG, two additional steps are required. First, some of the carbon monoxide made in the gasification process is reacted with steam to form additional hydrogen. This step, called shift conversion, sets up the proper ratio of gases for the next step called methanation. The hot gas thus produced is allowed to pass through the coal seam to the exit boreholes and is carried to the surface where it is cleaned and upgraded for use. The whole aspect is elaborated in next paragraphs.

In fact, gasification differs from combustion which takes place when coal is burned in excess oxygen to produce carbon dioxide and water. Another important difference between coal combustion and coal gasification is in pollutant formation. The reducing atmosphere in gasification converts sulphur (S) from coal to hydrogen sulphide (H_2S) and nitrogen (N) to ammonia (NH_3), whereas combustion (oxidation) produces sulphur dioxide (SO_2) and oxides of nitrogen (NO_x).

The principal processes can be divided into two stages, namely (i) pyrolysis (also known as carbonisation, devolatilisation or thermal decomposition) and (ii) gasification. During pyrolysis coal is converted to a char releasing tars, oils, low molecular hydrocarbons and other gases. Gasification occurs when water, oxygen, carbon oxide and hydrogen react with the char.

The main gases produced are carbon dioxide, methane (CH4), hydrogen and carbon monoxide (CO) and oxygen. CH4 is essentially a product of pyrolysis, rather than gasification. Its formation is favoured by low temperature and high pressure.



In a theoretical appraisal of the gasification process, the Autothermal Chemical Equilibrium (ACE) condition exists. This is a condition at which the heat value of the product gas and the conversion efficiency of the gasified coal (chemical energy of product gas/chemical energy of gasified coal) is a maximum. At high temperatures and pressures (say 5MPa, 900°C), ACE conditions are approached rapidly but at lower temperatures and pressures the time to attain equilibrium greatly exceed the residence time of the gases in the gasifier and therefore ACE will not be attained.

The basic reactions can be generalised to a simple empirical form:

$C + O_2 \rightarrow CO_2$ (+heat)

$C + CO_2$ (+heat) $\rightarrow 2CO$

$C + H_2O$ (+heat) $\rightarrow H_2 + CO$

$C + 2H_2 \rightarrow CH_4$ (+heat)

During pyrolysis coal, subjected to high temperatures, yields higher heat value gases than ACE gasification products for a relatively small consumption of O_2. Pressure increases the proportion of coal pyrolysed to form methane thus raising the heat value of the product gases. There is also some evidence to suggest that elevated pressures cause pyrolysis processes to penetrate in situ coal, further enhancing the gasifier yield.

4. Gasification circuit and Cavity behaviour: The gasification circuit requires a flow link to be achieved between an injection and a production well. Methods of achieving the link are:

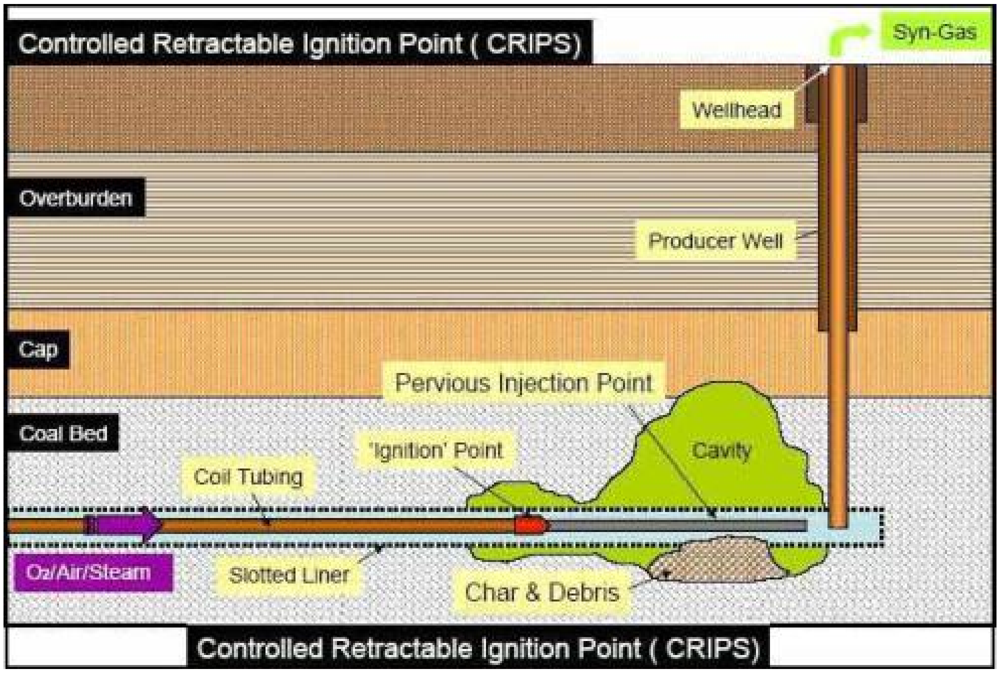
* Accurate drilling assisted by a target device in the vertical well if necessary.

* Reverse combustion, involving ignition at the base of the production well.

Initially, channel created in coal seam using special drilling techniques. As reaction proceeds, channel grows, creating underground ‘cavity’. Volume of cavity increases progressively with progress of reaction.

Installation of well pairs (injection and production wells) is costly and therefore it is desirable to gasify the maximum volume of coal between a well pair. As gasification proceeds, a cavity is formed which will extend until the roof collapses. This roof collapse is important as it aids the lateral growth of the gasifier. Where the roof is strong and fails to break, or where the broken ground is blocky and poorly consolidated, some fluid reactants will by-pass the coal and the reactor efficiency could decline rapidly.

The most successful gasifier or reactor control process, developed in the USA, involves the use of a burner attached to coiled tubing. The device is used to burn through the borehole casing and ignite the coal. The ignition system can be moved to any desired location in the injection well. This ‘controlled retraction of ignition point’ (CRIP) technique enables a new reactor to be started at any chosen upstream location after a declining reactor has been abandoned.



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