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Modern Conceptualization of the Most Important Chemical Reactions Taking Place during Underground Coal Gasification

Underground Coal Gasification (UCG) is a process by which coal is converted in-situ to a combustible gas. UCG can provide energy from coal seams where traditional mining methods are either impossible or uneconomical.

In order to implement this technology we need two boreholes. One of them is an injection well, the other one is a production. Boreholes are bored towards the coal seam. It is so called an in-seam directional drilling.

UCG gases can be used for industrial heating, power generation, hydrogen production and chemicals like sodium, ammonia, char and other raw materials, because coal is a source of rare chemical elements. From coal we can also produce petroleum in the large volumes.

«Gasification» is a general term used for various reactions, besides combustion, that result primarily in a gaseous mixture of CO, H_2 and CH_4. In both conventional and underground gasification processes, the chemical and physical changes are similar; however, the in-situ coal naturally has higher methane and moisture contents.

The main chemical processes occurring during coal gasification are drying, pyrolysis, combustion and gasification of the solid hydro-carbon. The combustion gases generated from in-situ coal under specific conditions and according to the following reactions:

Drying :	Wet Coal → Dry Coal + H_2O + 394 kJ/mol	
Pyrolysis:	Dry Coal → Char + Volatile matter	~ 0 kJ/mol
COMBUSTION	1). $C + O_2 = CO_2$	+ 394 kJ/mol
	2). $2C + O_2 = 2CO$	+ 221 kJ/mol
GASIFICATION	3). $CO_2 + C = 2CO$	– 173 kJ/mol
	4). $H_2O + C = CO + H_2$	– 130 kJ/mol
	5). $2H_2O + C = CO_2 + H_2$	– 80 kJ/mol
	6). $CO + 3H_2 = CH_4 + H_2O$	+ 205 kJ/mol
	7). $C + 2H_2 = CH_4$	+75 kJ/mol

The water-gas reaction is the most important for generating the gas fuel mixture of mainly H_2 and CO, known also as ‘water-gas’ product. It should be noted that the enthalpy of reaction is positive, that means that this reaction is endothermic. As a result, the preparation of the water-gas reaction typically involves alternating blasts of steam and either oxygen or air through a heated coal seam. The exothermic reactions between coal and oxygen to produce CO and CO_2 provide enough energy to drive the reaction between steam and coal. Additional steam in the injection blast generally lowers the temperature of the reaction zones and thus improves the efficiency of the gasification. Too much steam, however, can stop the gasification process, than it is need to provide a new coal ignition.