UDC 622.342

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UNDERGROUND GASIFICATION OF UNCOVENTIONAL FEEDSTOCKS: SHORT REVIEW.

Gasification is a process that converts organic carbonaceous feedstocks into carbon monoxide, carbon dioxide, and hydrogen by reacting the feedstock at high temperatures (800°C), without combustion, with a controlled amount of oxygen and/or steam [1-3].

The resulting gas mixture synthesis gas is called a producer gas and is itself a fuel. The power derived from carbonaceous feedstocks and gasification followed by the combustion of the product gases is considered to be a source of renewable energy if the gaseous products are from a source like a biomass other than a fossil fuel [4, 5].

Gasification processes can accept a variety of feedstocks but the reactor must be selected on the basis of the feedstock properties and behavior in the process, especially when coal and biomass are considered as gasification feedstocks. Furthermore, because of the historical use of coal for gasification purposes, it is the feedstock against which the suitability of all other feedstocks is measured. Therefore, inclusion of coal among the gasification feedstocks in this section is warranted [6-8].

Coal is a combustible organic sedimentary rock (composed primarily of carbon, hydrogen, and oxygen) formed from ancient vegetation and consolidated between other rock strata to form coal seams. The harder forms, such as anthracite coal, can be regarded as organic metamorphic rocks because of a higher degree of maturation [9, 10].

Coal occurs in different forms or types. Variations in the nature of the source material and local or regional variations in the coalification processes caused the vegetal matter to evolve differently. Thus, various classification systems exist to define the different types of coal. Thus, as geological processes increase their effect over time, the coal precursors are transformed over time into: Lignite, Sub-bituminous coal, Bituminous coal, Anthracite.

Biomass includes a wide range of materials that produce a variety of products which are dependent upon the feedstock. For example, typical biomass wastes include wood material (bark, chips, scraps, and saw dust), pulp and paper industry residues, agricultural residues, organic municipal material, sewage, manure, and food processing byproducts. Agricultural residues such as straws, nut shells, fruit shells, fruit seeds, plant stalks and stover, green leaves, and molasses are potential renewable energy resources [11].

Chemically, gasification involves the thermal decomposition of the feedstock and the reaction of the feedstock carbon and other pyrolysis products with oxygen, water, and fuel gases such as methane. Gasification of char in an atmosphere of carbon dioxide can be divided into two stages: (1) pyrolysis and (2) gasification of the pyrolytic char. In the first stage, pyrolysis (removal of moisture content and devolatilization) occurs at a comparatively lower temperature. In the second stage, gasification of the pyrolytic char is achieved by reaction with oxygen/carbon dioxide mixtures at high temperature. In nitrogen and carbon dioxide environments from room temperature to 1000°C, the mass loss rate of pyrolysis in nitrogen may be significantly different (sometimes lower, depending on the feedstock) from mass loss rate in carbon dioxide, which may be due (in part) to the difference in properties of the bulk gases .
In the process, the feedstock undergoes three processes in its conversation to synthesis gas the first two processes, pyrolysis and combustion, occur very rapidly. In pyrolysis, char is produced as the feedstock heats up and volatiles are released. In the combustion process, the volatile products and some of the char reacts with oxygen to produce various products (primarily carbon dioxide and carbon monoxide) and the heat required for subsequent gasification reactions.

Finally, in the gasification process, the feedstock char reacts with steam to produce hydrogen (H_2) and carbon monoxide (CO).

Combustion:

$$2C_{feedstock} + O_2 \rightarrow 2CO + H_2O$$

Gasification:

$$C_{feedstock} + H_2O \rightarrow H_2 + CO$$

$$CO + H_2O \rightarrow H_2 + CO_2$$

Besides fuel and product flexibility, gasification-based systems offer significant environmental advantages over competing technologies, particularly coal-to-electricity combustion systems. Gasification plants can readily capture carbon dioxide, the leading greenhouse gas, much more easily and efficiently than coal-fired power plants. In many instances, this carbon dioxide can be sold, creating additional value from the gasification process.

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