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# Low-calorific gasification of underground coal with a higher humidity

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ABSTRACT

The technology of underground coal gasification (UCG) belongs to the group of so called clean coal technologies. It can form a product called syngas, which can serve as a fuel for energy production or can be further processed in the chemical industry. This technology can gasify coal underground which cannot be mined by current methods from economic and technological reasons. Like any technology, UCG also has its limitations. One of them is the high humidity of coal (40%). Article, based on long lasting experimental research, analyzes the possibilities of increasing the UCG efficiency. Especially for lignite with a higher humidity content using only air as an oxidiser. It analyzes the creation of syngas components (CO, $H_2$, $CH_4$), its calorific value during the process in a special laboratory equipment for UCG research. It was demonstrated that the calorific value and syngas quality also depends on the location of sampling point. Based on this knowledge, the principle of a new method, that for the above mentioned conditions (low-calorific coal with a higher humidity), improves the UCG technology from the point of syngas quality and is mentioned in the conclusion.



## 1. Introduction

Approximately out of 18 trillion metric tons of energy resources redound on oil 2.2%, natural gas 2.3% and 95.5% on coal [1]. Worldwide coal reserves are vast, over 10 trillion metric tons, but unless cleaner and cheaper ways can be found to convert coal to gas or liquid fuels. Coal is unlikely to become an acceptable replacement for uncertain supplies of oil and natural gas. From this point of view, underground coal gasification, seems to be the one of possible ways to ensure energetic sufficiency in the world. There are coal deposits in Europe, which are not mined by classic technologies. Coal is possible to transform to gas by "Underground Coal Gasification" (UCG). This technology is developed and improved in the world. Underground coal gasification is a mining method that utilizes injection and production wells drilled from the surface and linked together in the coal seam. Once linked, air and/or oxygen are injected [2]. The coal is then ignited in a controlled manner to produce hot, combustible gases which are captured by the production wells (Fig. 1). This process can be conducted below the water table as water flows into the gasification zone and is utilized in the formation of the gas, known as a syngas [3,4]. The product of UCG is syngas, which mining is safer in comparing to standard coal mining technologies. It is possible to turn syngas into chemical products or use it as a fuel to produce electric energy on a base of well known technologies [5,6].

The utilization of the drilling technique has undergone several changes due to their continuous development. There used all types of wells namely vertical, horizontal and channeled. In this case the underground generators are formed by a system of injection and production wells that are drilled from the surface. Their distance depends

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on the permeability of coal, seam thickness, coal properties, pressure of the gasifying medium, the chosen method of the wells linking and the morphology of the terrain. In the case of commercial production is needed more pairs of wells, resulting in a more underground generators to ensure sufficient volume of gas. In the world there are several known methods of gasification by means of boreholes, whose principle is based on some of the following four basic ways. It is long wall gasification, combining vertical wells, controlled injection point and steeply dipping seams. Selection of the appropriate gasification method is dependent on several factors, but the most important is the depth, thickness and inclination of the coal seam. The first three listed methods are suitable for horizontal bedded coal seam. Necessary condition for the operation of an underground generator is ensuring the effective connection of the injection borehole with production borehole. This connection can be ensured in several ways namely by creating the linked channel with the drilling technique or use one of the following ways: using hydraulic fracturing, backfire, chapping caused by explosion, combustion, electro-carbonization or actuation of the chemical substances.

Long wall gasification – LWG is based on drilling of inclined boreholes at a greater distance from each other (Fig. 2). Gasifying medium is supplied to the pair of wells and by the second pair of the wells; the gas is discharged to the surface. The advantage is the gasification of relatively thin seams specifically from 1.2 to 5 m. Coal seam can be bedded at different depths, but must be extensive and stable. The method requires a minimum of boreholes and despite the greater distance the process is well controllable. This method was modified in China and is well known as Long Tunnel-Large Section-2 stage. Gasification method is based on creation of the channel with a length of more than 200 m, on an area larger than 3.5 $m^2$ and gasification medium is supplied by one borehole in two stages. In the first stage, the air is pushed into the coal seam until the required temperature is not reached and then the steam is used for gasification. There are used directed boreholes.

Linked vertical wells gasification – LVW requires the creation of pairs of wells, among which is the necessary to create an efficient link already mentioned. The disadvantage is that this method requires a larger number of wells, but on the other hand, these are useful as production wells or injection. In the case of termination of gas flow from the production well is possible to inject into the well gasifying medium and thus expand the gasification area. The arrangement of wells may be various. The wells can be arranged in a row, in a circle or square. Fig. 3 shows a diagram of the Hoe Creek site where the wells were linked with the channel created by the drilling technique. For this technology are suitable coal seams with a thickness of 5–15 m.

The method of Controlled Retracting Injection Point – CRIP was developed and firstly verified in the USA concrete in Hoe Creek locality. It is based on linking vertical and inclined borehole, which passes in the seam to the horizontal borehole. Gasification medium is supplied to the seam by inclined borehole that passes through the coal seam to the horizontal borehole and the gas is removed by vertical-production borehole. Ignition point is near the production well, if the quality of produced gas will decrease then the ignition point is shifted. With the shift of the injection point begins to create a new cavity (Fig. 4).

The conception of Steeply dipping bed conception – SDB was developed in the former Soviet Union for gasification of inclined seam with angle greater than 45°. For gasification there are used directed boreholes which the lower ends are linked by seam channel. Injection well is located at the bottom of the coal bed. Production well is drilled at an angle of the seam to ensure the natural flow of resulting gases to the surface. The principle scheme is depicted on Fig. 5. The method was successfully tested on a Rawlins bed in the USA. The results showed that in the steeply dipping seams the produced gas leaks are lower than in the horizontal bedded seams as well as the consumption of gasifying medium is half.

Based on briefly analyzed status of UCG, we found out that despite long-standing and recently growing interest, it is necessary to improve this technology to increase an efficacy of underground coal transformation to energy in the syngas form. As an every coal mining method, also UCG has its possibilities and limits. Using the specific

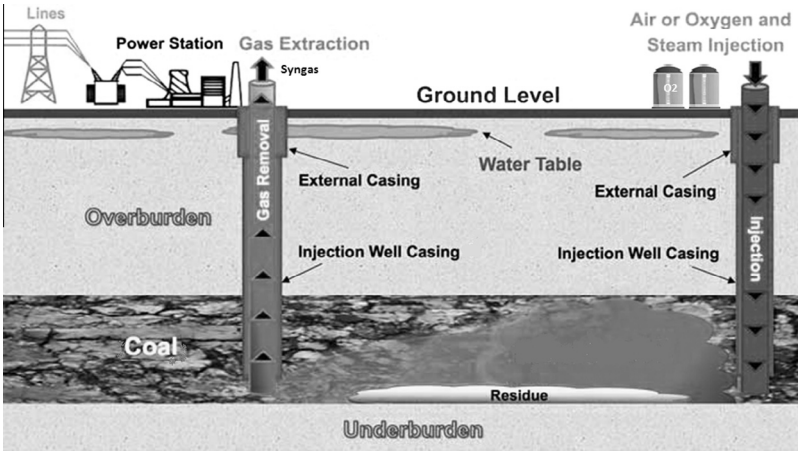


**Fig. 1.** Underground coal gasification.