

Research Paper

Utilisation of coal gasification in addition of bord and pillar method in underground coal mine

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Abstract— Underground coal gasification is an example of a modern, innovative technology that is used to extract the coal for underground as a product of methane gas or syngas. The board and pillar method is a traditional approach. Using the board and pillar method, a non-negotiable amount of coal is lost in the goaf area. We propose to use underground coal gasification in addition to bord and pillar for a working or closed unstowing coal mine as a solution for the previously mentioned problem and for optimal production with minimal cost, time, and labor..

Keywords— Underground mine, Coal ,Bord and pillar method, Underground coal gasification, Goaf , methane, Injection well, Production well.

1. Introduction

Underground coal mining is done by bord and pillar, longwall, shortwall, and underground coal gasification methods.

Bord and Pillar method:

Bord and Pillar method, by which the coal seam is extracted by making intersecting headings that provide coal pillars as a natural support for the development stage and gallery after the pillar has been extracted [1].

Longwall :

It is a mechanized method of underground coal mining. A shearer is a coal cutting machine that is placed in the longwall face supported by power support and interconnected by the main gate and tail gate; an AFC (Armoured Face Conveyor) a BSL (Bridge Stage Loader) and conveyor belts are used for the extracted coal transfer[2].

Sort-well mining:

Sort-well is a combined method of bord and pillar and longwall mining underground coal mines[3].

Underground coal gasification (UCG):

It is a process in which coal is converted to useful gases internally without requiring a mining operation. The gases can subsequently be used to produce heat, generate power, or synthesise a variety of chemical products. UCG is realised through circulating gasification agents (air or oxygen, and water) into a coal seam [4].

Major Problem with Conventional Bord and Pillar Mining Method:

The most valid problem in conventional block and pillar mining is coal loss, such as

- a. Coal losses in Goaf: huge amounts of coal are lost in Goaf in terms of rib pillar, barrier pillar etc. Also in the process of depillaring to temporarily support the roof, we have to leave a the coal pillars.

b.

- b. Coal Loss in Closed Mines: The ultimate outcome of coal loss in goaf areas and unplanned development results in a completely closed mine, which still won a huge amount of coal.

Hence, the accountable lose of coal is became approximately 40% [5].

Proposed solution:

If we use gasification in addition to the bord and pillar method in an underground coal mine, the previously mentioned problem can be solved.

2. Related Work

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3. Theory of the Procedure

A. Applicability:

This method may be used in

I. In a completely extracted closed underground coal mine by applying the bord and pillar method and not stowing, where coal left during depillaring;

II. In a goaf area of a working underground coal mine using the bord and pillar method, we may use development and depillaring by gasification simultaneously or individually in a completely developed panel (depillaring using coal gasification after completely developing the panel).

B. Procedure:

For a closed mine:

I. Preparation

a. Underground preparation:






The whole mine was divided into grids of walls to shape panel like arrangement, the size of the grids (panel) depending on the non-effective width of the mine area.

Description of wall: The wall is made of cement and bricks or concrete and steel rod as per the strata condition of the mine. The width of the wall is 25 cm, and two pairs of such walls sit side by side with a gap of 50 cm in between two walls, which is fulfilled by white sand stone from a surface borehole , because sand stone will not transfer heat from one wall to another and It is working as a thermo-flux. The wall extended and grooved around 2m into the roof , floor and wall of the mine.



Figure 1. Preparation for closed unstowing underground coal mine ; grid panel

Table 1. Index

	country rock
	Floor of the mine
	Coal
	Send stone
	Separation wall

b. Surface preparation:

- i. Making borehole for - the input connection of the underground gas generator, the output connection for the surface plant to receive the gas and process it for use in the power station, stowing, collecting survey data, and others.
- ii. Surface structures such as processing and power stations

For a working underground coal mine:

For the working underground coal mine, all the procedures are the same as those followed in closed mines, but here we have to use two sets of pair walls to separate the working zone from the goaf area, and with the advancement of the goaf, the gasification area tends to be expanded either simultaneously with development or individually after development.

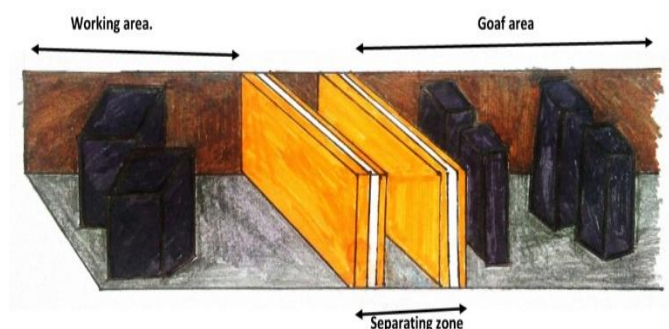


Figure 2. Preparation for underground coal mine

II. Production:

After the preparation is done gasification is introduced .

The steps are following [6] :

- After proper allocation of goaf area with proper support of wall ,the bore holes are drilled from the surface into goaf.
- Among these bore holes one of the bore which is properly seal at the neck, used for injection well and other one for production well.
- In the of beginning underground coal gasification, exact amount oxygen/air is injected into the cavity of the panel
- This will provide sufficiently large volume underground cavity at high temperature is required.
- Once the suitable environment for UCG like - size of cavity and stable temperature field is increased, a mixture of oxygen/air, along with steam, is injected through bore holes.
- The inter mixing of gases react with coal which are in the goaf of the panel through combustion and gasification reactions.
- The product gases are a mixture of carbon monoxide, carbon dioxide, hydrogen, water vapours, and methane along with nitrogen. The composition of the product mix varies depending on the coal, the oxidant used, reactor temperature and pressure, and gas residence time.

Reaction :-

- $C + H_2O = H_2 + CO$
- $C + 1/2O_2 = CO$
- $C + O_2 = CO_2$
- $C + CO_2 = 2CO$
- $CO + H_2O = H_2 + CO_2$
- $CO + 3H_2 = CH_4 + H_2O$
- $C + 2H_2 = CH_4$

- At the time of initial injection of steam can be decided on the basis of the moisture content in the coal. After some extent, the cavity grows in all three dimensions as a result of heterogeneous reactions which is called spalling.

- Spalling simple means a thermo- mechanical failure of coal which causes fall of coal/ char particles from the roof of the cavity at specific temperature.
- When one is come to end then next grid panel is introduced for underground coal gasification , but the working principle must be same as previous one.
- An another bore hole also introduce accordingly to exhaust the produce gases.

III. Termination:

At the end, when the coal from the amine is completely extracted with gasification, we have to shut down the mine as a precaution. For the termination of the mine, we may use

- Stowing[7] : Using a surface borehole, the mine may be stowed with sand or other suitable material.
- Caving[8] : The drilling of a blast hole for the surface to destroy the wall or induce caving can be done. If we do caving, then after that we have to do reclamation.
- Other economic aspects: We may use those mines as underground bunkers, storage facilities, underground homes, etc.

4. Results and Discussion

Discussion:

For use of this method, there are two major problems. The first is to build a wall in the goaf area of a working underground coal mine and also in a closed mine, and the second is ground water, which reduces the efficiency of the gasification.

Result:

As the procedure is theoretical, its possible practical outcome is inconspicuous.

5. Conclusion and Future Scope

It is said that Indian coal mines lose around 40% of their coal in depillaring panels, which can be extracted by this gasification method, and the pollution caused by coal burning in the open air will be reduced. This method also helpful for economical aspects and extraction time period is less, less manpower is required, thus probable risk and hazard is less.

Data Availability

None.

Conflict of Interest

We do not have any conflict of interest.

Funding Source

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Authors' Contributions

If it has to be considered the contribution of authors for integral the research paper , it will be 50%–50%.

Author 1 (SK Asrafal Karim) researched literature and wrote the first draft of the manuscript.

Author 2 (Soumyadip Biswas) involved conceived the study and analysis required data .

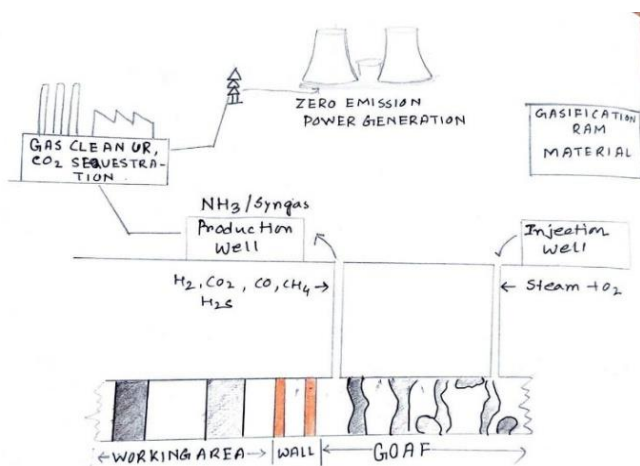


Figure 3. Underground coal gasification processing arrangements

All authors draw the figures, reviewed and edited the manuscript and approved the final version of the manuscript.

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The authors truly appreciate his belief in their abilities and the opportunities he has provided for their academic growth.
- ii. To every project that tries or practices their idea with slight modifications that ensure their idea is practical.

With their little knowledge, they mention some notable work that partially implements their idea.

- a. Cougar Energy and Linc Energy conducted pilot projects in Queensland, Australia based on UCG technology provided by Ergo Exergy until their activities were banned in 2016
- b. In South Africa, Eskom (with Ergo Exergy as technology provider) is operating a demonstration plant in preparation for supplying commercial quantities of syngas for commercial production of electricity
- c. ENN has operated a successful pilot project in China
- d. The first pilot project of underground coal gasification (UCG) in India was carried out in the Vastan mine block, Surat, Gujarat by ONGC (Oil & Natural Gas Corporation Limited) in collaboration with Gujarat Industries Power Company Ltd (GIPCL) in 2010. ONGC took up the Vastan Mine block site belonging to GIPCL in Nani naroli, Surat district,
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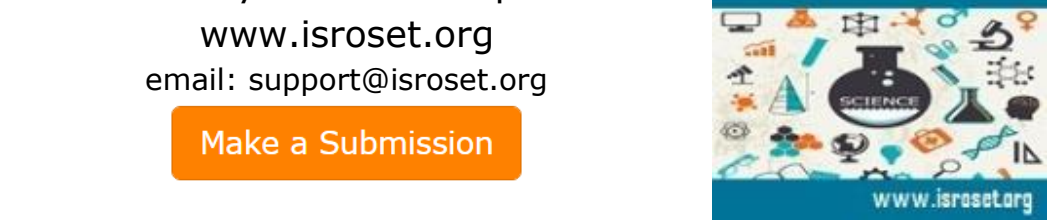
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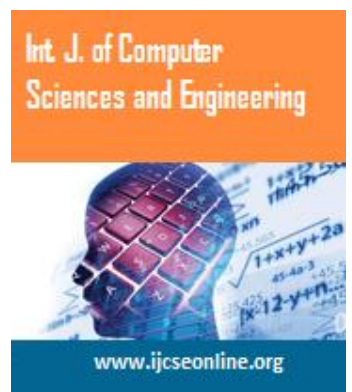
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