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POTENTIAL AND CHALLENGES OF UNDERGROUND COAL GASIFICATION IN INDIA: A SUSTAINABLE APPROACH TO COAL UTILIZATION

Anshul Avinash Dhoble, B.Tech., Dept. of Mining Engineering, MATS University, Raipur, Chhattisgarh, India
Dr. Ghanshyam Shakar, Assistant Professor, Dept. of Mining Engineering, MATS University, Raipur, Chhattisgarh, India
Gopal Singh, Uttam Vishwakarma, Assistant Professor, Dept. of Mining Engineering, Shri Rawatpura Sarkar University, Raipur, Chhattisgarh, India

ABSTRACT :
India has a great chance to use Underground Coal Gasification (UCG) to more effectively and sustainably use its enormous coal reserves. This study highlights UCG's capacity to access deep and unmineable coal seams while examining its potential as a more cost-effective and environmentally friendly alternative to traditional coal mining and combustion. The study looks at the benefits of UCG for the environment, economy, and technology in India. It also tackles issues including community acceptance, environmental dangers, regulatory frameworks, and geological suitability. This paper offers strategic ideas for incorporating UCG into India's energy portfolio to improve energy security and lower carbon emissions by examining international case studies and the Indian context.
Keywords: Underground Coal Gasification, Sustainable coal utilization, environmental impact, Green mining technology, technical feasibility, economic viability.

INTRODUCTION :

Mining is valuable and beneficial industry in the 21st century as it provides the raw material to other industries as well as coal supplier in huge amount **[1].**Various mining methods are used for the extraction of coal from underground and surface mining methods but due to the extraction of coal faces many environment problems, such as the emission of high rate of CO_2. To reduced environmental problems by adopting underground coal gasification technique. Underground coal Gasification is a clean-coal production technology that offers a prospect to be one of the solutions to such challenges, as it safely harness the energy by utilizing deep coal deposits and covert the coal into the synthetic gas **[2].** By using the UCG method to utilized coal reserve likelihood of increasing the efficiency of fossil fuels usages and mitigate the problem of emission of CO2 and other harmful gases. The underground coal gasification process involves the reactions of oxygen, air or steam with coal carbon and other pyrolysis products producing a syngas which is mainly composed of methane, hydrogen, carbon monoxide, carbon di-oxide and steam. The produced methane-rich syngas is compatible with natural gases and can be used as a synthetic natural gas (SNG) for power generation, as raw material in industry, or for conversion into other fuels and chemicals **[2]**.

Underground coal gasification can support extraction of so far unmineable coal reserve, where its technical and economical feasibility has been investigated by means of numerous interdisciplinary studies in the past decades. In order to implement the UGC process, the target coal seam is developed by vertical and deviated wells, which are linked to establish by the injection of gasification (Fig. 1). UCG produces a high-calorific synthetic gas, application for different end- use options, e.g., provision of chemical raw material, liquid fuels, fertilizer’s or electricity **[3].**

The aim of this paper is to examine the potential of UCG. In India; regularly growing a large population so it’s our duty to provide clean and unambiguous environment from various mining activities by adopting underground coal gasification technique and mitigate environmental pollution which is produced during mining.

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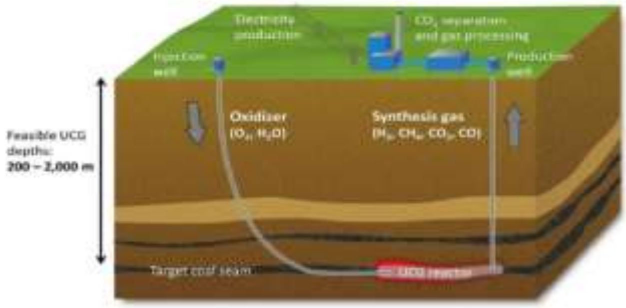

Fig.1 Schematic of UCG process with gasification agent injection as well as synthesis gas production **[3]**

OVERVIEW OF UNDERGROUND COAL GASIFICATION (UCG) :

Under UCG, the gasification process is started and maintained by boring wells into a coal seam and injecting an oxidant, like air or oxygen. Different production wells are used to extract the generated syngas, which can then be processed for a number of purposes. UCG has a number of benefits, two of which are its comparatively smaller environmental impact and its capacity to access coal that is too thin, deep, or otherwise unfeasible to mine using traditional techniques. However, geological, environmental, and technical factors must be carefully taken into account for UCG implementation to be successful.Underground coal gasification convert coal in-situ into synthesis gas or “syngas” through the same chemical reaction that occur in surface gasifies. Partial heat of combustion drives the key gasification reactions which converts subsurface coal into a synthesis gas at elevated pressures and temperatures. The first experiment in underground coal gasification was tried in 1912, followed by large research problems in power, hydrogen and chemical feed stocks, mostly in FSU and China [4].At present there are two active pre-commercial pilots of UCG. The first, Eskorm’s Majuba project in South Africa, began January 2007. It produces 100 kW of electricity from 5000 m^3/hr. production. However, the success of this pilot. Led by Ergo energy, has led to an announced 2100 MW new IGCC plant to be run entirely on UCG syngas at 375,000 m3/hr. production rate. The other pilot, ENN’s pilot in Inner Mongolia, China, ignited October 2007. Result this pilot show sustained production of syngas in terms of rate and composition over 5 months. New pilots have been announced in India, Canada, New Zealand, Wyoming, China, and Australia to commence in 2009-2010 as a prelude to commercial projects to procedure hydrogen, power, liquid fuels and chemicals. In all cases coal resources will be exploited that could not be mined due to depth, overburden characteristics, geologic complexity, or land use restrictions. As such, UCG is pursued as a complement to conventional mining and transportation **[4]**.

POTENTIAL OF UCG IN INDIA :

Coal Reserves and Energy Demand:

The fifth-largest coal reserves in the world are found in India, yet a sizable fraction of these deposits cannot be extracted because to environmental restrictions, geological conditions, or depth. A chance to effectively access these reserves is provided by UCG. UCG could be essential in helping India satisfy its energy needs while lowering its reliance on foreign fuels, as the country's energy demand is predicted to increase significantly over the next few decades **[5].**

Technological Feasibility:

Technological development in gas processing, reservoir management and drilling have increased the viability of UCG. India is well-Positioned to implement the technology due to its diversified geology, which includes large coal seams that are appropriate for UCG. UCG is a competitive option since it may improve operational safety and efficiency via the use of digital and remote monitoring systems **[6].**

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Environmental Benefits:

Compare to traditional coal mining and combustion, UCG has a number of environmental benefits. It considerably lessens water pollution, soil degradation, and surface disturbance. In order to help mitigate greenhouse gas emissions, the process can also be made to traditional underground mining **[7].**

Coal gasification is a clear, less-polluting method of processing coal. It emits less carbon upon burning, and other polluting gases like CO2 can be easily separated, captured, and put to other uses. The syngas derived from coal gasification can also be further treated to create fuels like gasoline and diesel **[8].**

CHALLENGES OF UCG IN INDIA :

Geological and Technical Challenges

Not every coal seam is a suitable for Underground coal gasification. Certain geological conditions are necessary for the technology to function, including sufficient seam thickness, depth and permeability. Some Indian coalfields have complex geological formations and faults and fault lines that could make implementing underground coal gasification difficult. Furthermore, there are important technology issues that must be resolved, such as managing any groundwater contamination or subsidence and controlling the subterranean gasification process **[12].**

Economic Viability

The costs associated with drilling, producing, and purifying syngas, as well as the demands for syngas and its derivatives in the Indian market, all affect how economically viable UCG is. Although UCG may provide economic benefits by providing access to coal that would access to coal that would otherwise be unmineable, startup and operating expenditures may be sustainability of UCG projects by changes I national and international energy costs as well as legislative changes [**13].**

Regulatory and Policy Framework

The safe and log-term development of underground coal gasification depends on a well-defined regulatory framework. There are currently no comprehensive laws in India that expressly cover land-use rights, environmental protection, or Underground coal gasification operation; instead, the legal environment for this industry is still developing. For UCG to be used successfully, a strong regulatory framework comprising operational instructions, safety standards, and environmental impact evaluations must be established [**14].**

Environmental and Safety concerns

The key words green mining, ecological mines recycling economy, industrial ecology, site characterization for remediation of abandoned mine lands and life cycle assessment were proposed by environmentalists, economists and scholars working in the field of mining science. The core ways to solve mine environmental problems may fall into two types. One is the taking of measures to lessen the impact of mining on the environment mining. The other is taking measures to clean or remediate or restore or reclaim the environment post mining as shown in fig. 2 **[9].**

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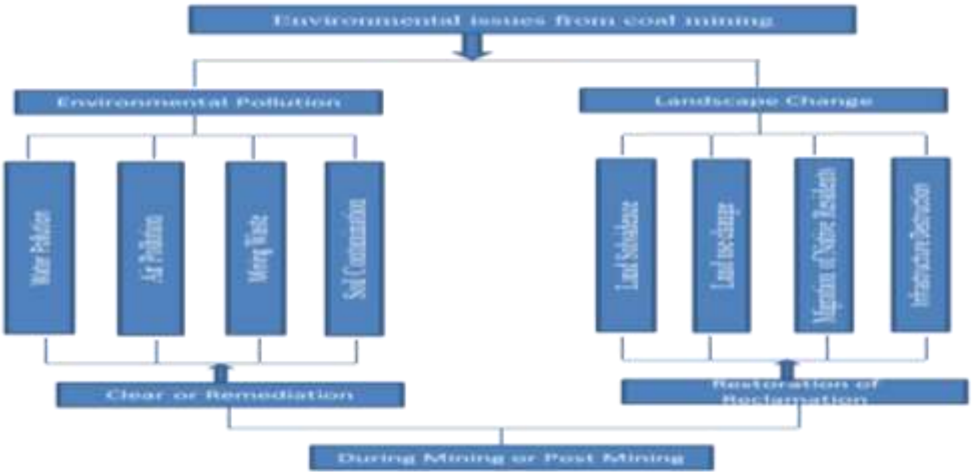

Fig.2 A strategic Approach to Addressing Environmental Challenges in Mining Operation

Green mining as poses by professor Qian, a Chinese Engineering Academician, is one of many ideas proposed to solve the environmental issues. The foundation of these ideas is the distribution behaviour of joints, fractures and bed separations and the seepage flow of methane and water through broken rock strata caused by mining. Green mining techniques under development include water-preserved-mining, coal mi9ning under infrastructure, grouting into the space between separated rock layers to reduce surface subsidence, partial extraction and backfill mining simultaneous extraction of coal-bed methane, underground roadway support, underground discharge of partial mining wastes and underground coal gasification. The principles of industrial ecology and mining science also should promote the rational utilization of natural resources by reducing waste, reusing waste and recycling waste. A reduction in the mining waste produced by excavating roadways along coal seams and other innovative mining methods are one approach to this. Using coal mining waste as fuel for thermal electric plants is a god example of reusing mining wastes. Recycling of mining waste is a more environmental friendly technique. For example, after mining waste is burned in an electric plant the fly ash can bemused as raw material for cement production. Or rather that just conveying fly ash into cement some such fuel elements of the fly ash, such as refractions, can first be extracted **[9]**

Case Studies of UCG Globally and Lessons for:

India may learn a lot from the analysis of successful underground coal gasification initiatives in nations like South Africa, China, and Australia. The significance of site selection, technical innovation, legal frameworks, and community engagement in the successful implementation of underground coal gasification is underscored by these case studies. Learning from these nations can assist India in formulating a well-thought-out plan for implementing underground coal gasification technology **[10]**.

Strategic Implications for India's Energy security:

Energy security might be improved by incorporating underground coal gasification into India's energy mix since it would lessen dependency on imported fuels and make better use of the country's coal reserves underground coal gasification concurs with India's resolve to lower carbon and methane (CH_4) emissions and switch to environmentally friendly energy sources. To fully achieve UCG's potential; however research and development spending along with strategic planning are needed to overcome the obstacles in the way **[11].**

Conclusion and Recommendations:

In India, UCG offers a viable option for the sustainable use of coal. Notwithstanding the many advantages-such as the ability to tap deep coal reserves, lessen environmental effect, and improve energy security- a number of issues must be resolved. Geological suitability, economic feasibility, legal framework, and safety and environmental issues are a few of them. In order to advance and increase capacity in underground coal gasification technology, India should fund pilot projects, provide a thorough regulatory framework and encourage public private collaborations. By resolving these issues, underground coal gasification may be essential to India's energy future.

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