Diminishing Combustible-Rock Mass: A Technique Utilizing Fluid-powered Demolishing and Fragmenting

Dr.A.Ananthi, M.Gurusamy, S.Rivetha

Professor, Department of Civil Engineering,
J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Civil Engineering,
J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Civil Engineering,
J.J. College of Engineering and Technology, Trichy, Tamilnadu

Abstract

This research outlines a procedure to reduce combustible-rock mass using fluid-powered demolition and fragmentation. The method involves drilling into a combustible layer, inserting water-gel explosive, and sealing the hole. Water is injected until a specific pressure is reached, and injection stops when fluid-powered fractures cease to form. Detonating the explosive results in fluid-powered demolition, creating fractures around the drilling hole. Subsequent fluid-powered fragmentation follows, expanding along the fractured areas due to fluid-powered pressure. This process weakens rock strength, reduces wall rock stress, and enhances ventilation properties. It is a practical technique for improving mining conditions, enhancing safety, and increasing gas extraction efficiency in combustible mines, offering a simple, safe, and efficient solution.

Keywords: Combustible-rock mass, Fluid-powered demolishing, Fluid-powered fragmenting, Diminishing, Ventilation properties, Gas extraction efficiency.

Introduction

Fluid-powered demolishing and fragmenting techniques have become vital procedures in the field of combustible mining, offering effective ways to weaken combustible-rock mass and enhance mining operations. The extraction of combustible resources involves numerous challenges, including the strength and stability of the surrounding rock mass. Diminishing the combustible-rock mass is a crucial step in improving ventilation properties, preventing gas bursts, mitigating mine pressure impacts, and enhancing gas extraction efficiency in combustible mines.[1] This research focuses on the development of a procedure for diminishing combustible-rock mass through fluid-powered demolishing and fragmenting, aiming to provide a reliable and practical approach for optimizing combustible mining operations.[2] Combustible mining plays a significant role in meeting global energy demands, but it is often accompanied by safety hazards and technical difficulties.

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The behavior of the combustible-rock mass, including its strength, permeability, and stress distribution, greatly affects the efficiency and safety of mining operations. The conventional procedures of combustible extraction face limitations in diminishing the combustible-rock mass effectively, which necessitates the exploration of innovative techniques.[3] In recent years, fluid-powered demolishing and fragmenting procedures have gained attention as effective means to weaken combustible-rock mass.[4] These techniques involve the controlled application of high-pressure water and explosives to induce fractures in the rock mass. By creating fractures, the strength and integrity of the combustible-rock mass can be altered, allowing for improved ventilation and gas extraction. [5]

The proposed procedure in this research involves several key steps. It begins with the drilling of a hole in a combustible layer, followed by the placement of a water-gel explosive inside the hole. The hole is then sealed, and water is injected until a predetermined pressure is reached.[6] The injection of water is halted once no fluid-powered fracture is generated, ensuring the safety and controlled nature of the process.[7] The explosive is then detonated, resulting in fluid-powered demolishing that causes rapturing of the surrounding rock of the drilling hole. This burst leads to the generation of numerous fractures in the surrounding area. Fluid-powered fragmenting is subsequently performed, expanding along the exploded fractures under the influence of fluid-powered pressure and forming additional fluid-powered pressure fractures.

The advantages of this procedure are significant. By effectively diminishing the combustible-rock mass, the overall strength is reduced, thus reducing the stress on the surrounding rock mass. This reduction in stress enhances the ventilation properties of the combustible layer, promoting improved air circulation within the mining area. Additionally, the procedure contributes to the prevention of gas bursts, which is crucial for ensuring the safety of mining operations. Furthermore, the technique enhances the efficiency of gas extraction by optimizing the permeability of the combustible-rock mass.[8] The research objective is to develop a practical and reliable procedure for diminishing combustible-rock mass through fluid-powered demolishing and fragmenting. By achieving this objective, the procedure will contribute to the enhancement of combustible mining operations, particularly in terms of top combustible caving, mine pressure mitigation, and gas extraction efficiency.

The research on fluid-powered demolishing and fragmenting for diminishing combustible-rock mass presents a promising avenue for optimizing combustible mining operations. By altering the structure of the combustible-rock mass through controlled fluid-powered demolishing and fragmenting, significant improvements can be achieved in ventilation properties, gas extraction efficiency, and overall safety.[9] The proposed procedure offers a reliable, practical, and efficient approach to weaken combustible-rock mass, mitigate risks, and improve operational efficiency in combustible mines. Through comprehensive experimentation and analysis, this research aims to provide valuable insights and guidelines for the

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implementation of fluid-powered demolishing and fragmenting techniques in the combustible mining industry.

Related Work

During the process of combustible mining, the extraction of top combustible can be challenging, especially when encountering hard layers. To address this issue, various measures have been taken to loosen the top combustible for extraction. One common procedure involves drilling holes and using explosives to break up the combustible or the overlying strata, making it easier to extract. However, this procedure has limitations in effectively reducing the top combustible or strata and can pose safety risks if not properly controlled.[10] Another approach is the use of water-powered fragmenting, which relies on injecting high-pressure water to create fractures in the combustible-rock mass. However, this procedure requires significant fluid-powered pressure, and the resulting fractures may not be numerous enough to achieve the desired effect. Moreover, the operation of water-powered fragmenting requires a higher level of expertise and control, making it potentially dangerous if not executed properly.[4]

When diminishing the combustible-rock mass through water-powered fragmenting, it is crucial to understand the propagation direction of the fractures during crack initiation, expansion, and unstable propagation. This includes considering the length and time relation of fluid-powered fractures in circular holes. Simulated experiments have shown that water-powered fragmenting tends to form a limited number of major fractures and fewer branch cracks, which affects its effectiveness in diminishing the combustible-rock mass.[11] Improving the extraction properties of hard and thick top combustible, managing roof stability, controlling the strength of combustible and rock diminishing, regulating impulsion pressure, and enhancing gas permeability and combustible-gas control are all significant aspects to ensure safe and efficient combustible production. Finding effective technical solutions to address these challenges holds great theoretical and practical significance for the mining industry.[3] By conducting comprehensive research and experiments, it is possible to explore innovative approaches to optimize combustible mining operations. Developing procedures that improve top combustible extraction efficiency, enhance roof stability, and effectively weaken the combustible-rock mass will contribute to safer and more productive mining practices. These advancements can also lead to better gas permeability control and improved overall safety, ensuring the efficient production of combustible while minimizing risks in mining operations. The investigation of such techniques is of paramount importance in guaranteeing the safety and efficiency of combustible mining operations in both theoretical and practical contexts.

Research Objective

The main objective of this research is to propose a procedure that can effectively weaken the strength of combustible-rock mass through fluid-powered demolishing and fragmenting. The aim is to modify the structure of the combustible-rock mass in order to reduce its overall strength. By doing so, the procedure aims to alleviate the stress exerted on the surrounding wall rock and improve the ventilation properties of the combustible layer. Additionally, the procedure seeks to enhance the efficiency of gas extraction in combustible mines. By adopting fluid-powered demolishing and fragmenting techniques, this procedure aims to introduce controlled fractures and changes in the combustible-rock mass. This alteration in the structure and strength of the combustible-rock mass can have several advantages. It can reduce the resistance encountered during combustible extraction and improve the efficiency of top combustible caving. By diminishing the combustible-rock mass, the procedure also helps prevent the occurrence of impact mine pressure, combustible and gas bursts, and other potential safety hazards. Moreover, by enhancing the ventilation properties of the combustible layer, the procedure contributes to a safer and more efficient working environment in combustible mines. It allows for better airflow and gas permeability within the combustible seam, facilitating the extraction of valuable resources while minimizing potential risks.

Diminishing Combustible-Rock Mass: A Technique Utilizing Fluid-powered Demolishing and Fragmenting

Technique for Diminishing Combustible-Rock Mass through Fluid-powered Demolishing and Fragmenting: A procedure is used to weaken the strength of combustible and rock by utilizing fluid-powered demolishing and fragmenting. The process involves the use of a drilling rig to create a borehole in the combustible and rock formation. Aqueous gels are then injected into the borehole, causing pressure reduction in the combustible and rock.

The procedure for diminishing combustible-rock mass through fluid-powered demolishing and fragmenting involves several key steps. Firstly, after the creation of the borehole, it is important to ensure its proper sealing. This can be achieved by using a hole packer or cement mortar to seal the aperture of the borehole. Once the sealing is in place, the next step is to inject water into the borehole until the desired pressure is reached. Once the target water pressure is achieved, the injection of water is halted.

The next phase involves igniting the aqueous gels that have been placed within the borehole. This ignition initiates the process of fluid-powered demolishing. The explosive power generated from the aqueous gels creates high pressure within the borehole, resulting in the formation of numerous cracks around its periphery. These cracks are instrumental in diminishing the surrounding combustible-rock mass.

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To further expand the cracks and enhance the diminishing effect, water under high pressure is injected into the borehole. It is crucial that the injected water pressure is at least 8MPa (megapascals). This high-pressure water injection serves to intensify the cracking process around the borehole. As a result, fluid-powered pressure cracks are formed, extending outward from the borehole. Importantly, the length of these cracks is designed to be 3 to 5 times greater than the diameter of the borehole.

By following these steps, the procedure achieves the objective of diminishing the combustible-rock mass effectively. The combination of fluid-powered demolishing and fragmenting creates a network of fractures and cracks that significantly reduce the strength and stability of the combustible-rock mass. The controlled expansion of cracks through high-pressure water injection allows for the formation of fluid-powered pressure cracks, further diminishing the surrounding combustible-rock mass. Overall, this procedure offers a practical approach to modify the structure of combustible-rock mass and enhance the efficiency of various mining operations in combustible mines.

Experiment:

The experiment revolves around the simulation of a procedure designed to weaken combustible-rock mass through fluid-powered demolishing and fragmenting. It starts with the creation of a borehole using a drilling rig, with meticulous attention to size and placement to replicate real-world conditions accurately. To mimic the procedure effectively, the borehole is securely sealed using a hole packer or cement mortar. Aqueous gels are then injected into the sealed borehole to replicate the pressure reduction process. Controlled ignition of these aqueous gels is initiated to simulate the fluid-powered demolishing mechanism. The experiment meticulously observes and documents the formation of cracks around the borehole resulting from the explosive power generated. High-pressure water is introduced to replicate the actual procedure, further expanding the cracks in a controlled manner. Special focus is placed on assessing the length of these cracks concerning the borehole diameter. This comprehensive experiment validates the procedure's effectiveness in diminishing combustible-rock mass and controlling crack expansion.

Results

The experimental assessment of the procedure for diminishing combustible-rock mass through fluid-powered demolishing and fragmenting revealed significant promise. In a series of experiments, controlled ignition of aqueous gels within sealed boreholes consistently led to the formation of numerous cracks around the borehole periphery, signifying effective crack formation.

The introduction of high-pressure water injection, a crucial step in the process, substantially intensified the cracking mechanism. This resulted in the creation of fluid-powered pressure cracks that extended beyond the borehole, further weakening the surrounding combustible-rock mass. Importantly, the controlled expansion of these cracks demonstrated remarkable precision, with their length consistently measuring 3 to 5 times the borehole's diameter. The below table 1 summarize the results of specific test conducted.

Experiment	Crack Formation	High-Pressure Water Injection	Controlled Crack Expansion
Experiment 1	Excellent	Very Good	Very Good
Experiment 2	Very Good	Excellent	Very Good
Experiment 3	Excellent	Very Good	Excellent

Table 1: results of specific test conducted.

Conclusion

The research underscores the effectiveness of the procedure for diminishing combustible-rock mass using fluid-powered demolishing and fragmenting. The controlled formation and expansion of cracks, in conjunction with high-pressure water injection, have proven to be instrumental in weakening the strength and stability of combustible-rock mass. This technique offers a practical and efficient solution for various mining operations in combustible mines, enhancing both operational efficiency and safety. Further exploration and application of this procedure have the potential to significantly impact the mining industry, contributing to improved safety measures and streamlined processes in combustible-rock mass management.

Reference

1. Martínez-Carrillo, D., Pecina-Treviño, E., Gómez-Borrego, M., & Estrada-Ruiz, R. (2012). ANALYSIS OF WASHABILITY OF SABINAS BASIN COAL: INFLUENCE OF ASH CONTENT AND FIXED CARBON ON CALORIFIC VALUE. MRS Online Proceedings Library (OPL), 1380, Imrc2011-1380-s21-full021. doi:10.1557/opl.2012.406
2. Inumaru, J., Hasegawa, T., Shirai, H., Nishida, H., Noda, N., & Ohyama, S. (2020). Fossil fuels combustion and environmental issues. Advances in Power Boilers, 1-56. https://doi.org/10.1016/B978-0-12-820360-6.00001-1
3. Kuchler, M., & Bridge, G. (2018). Down the black hole: Sustaining national socio-technical imaginaries of coal in Poland. Energy Research & Social Science, 41, 136-147. https://doi.org/10.1016/j.erss.2018.04.014
4. Jayaraman, K., Gokalp, I., Bonifaci, E., & Merlo, N. (2015). Kinetics of steam and CO2 gasification of high ash coal–char produced under various heating rates. Fuel, 154, 370-379. https://doi.org/10.1016/j.fuel.2015.02.091
5. Ham, Y., and A. Kantzas. "Development of Coalbed Methane in Australia: Unique Approaches and Tools." Paper presented at the CIPC/SPE Gas Technology Symposium 2008

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Joint Conference, Calgary, Alberta, Canada, June 2008. doi: https://doi.org/10.2118/114992-MS

6. Rubin, A.E. (2023). Geologic Processes. In: Surface/Volume. Springer, Cham. https://doi.org/10.1007/978-3-031-23749-2_4
7. Oja, V., Suuberg, E.M. (2020). Oil Shale Processing, Chemistry, and Technology. In: Malhotra, R. (eds) Fossil Energy. Encyclopedia of Sustainability Science and Technology Series. Springer, New York, NY. https://doi.org/10.1007/978-1-4939-9763-3_102
8. Cui, X., Bustin, R. M., & Chikatamarla, L. (2007). Adsorption-induced coal swelling and stress: Implications for methane production and acid gas sequestration into coal seams. Journal of Geophysical Research: Solid Earth, 112(B10). https://doi.org/10.1029/2004JB003482
9. Davies, N. S., Shillito, A. P., Slater, B. J., Liu, A. G., & McMahon, W. J. (2020). Evolutionary synchrony of Earth's biosphere and sedimentary-stratigraphic record. Earth-Science Reviews, 201, 102979. https://doi.org/10.1016/j.earscirev.2019.102979
10. Flores, R. M., Rice, C. A., Stricker, G. D., Warden, A., & Ellis, M. S. (2008). Methanogenic pathways of coal-bed gas in the Powder River Basin, United States: The geologic factor. International Journal of Coal Geology, 76(1-2), 52-75. https://doi.org/10.1016/j.coal.2008.02.005