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Extraction Process of Coal Mining using Modern Technologies

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Abstract: This paper represents of a severe and important topic of extraction of coal from mines by using robots through latest technologies by controlling robots through latest technologies by controlling robots through latest technologies by controlling robots through computers, desktop or mobile phones. Here we have tried to suggest development ideas for Indian government by comparing Indian technology with developed countries like United States of America, China, South Africa, Australia and Russia. The topics we have covered in this research paper are Safety precautions and safety statics in coal mining sector, Environmental impacts, Comparison of mining techniques with other countries, effects of coal mining, Diseases and injuries caused during mining process, Advantages and disadvantages of coal mining, Coal demand and availability, world coal resources, Policy and Regulation & Technological Innovations. At the end of this paper we have suggested some ideas for developing coal mining process in India which are fruitful and applicable

Keywords: Extraction, Coal mines , Robots , technology

I. INTRODUCTION

Coal is a combustible black or brownish- black sedimentary rock. Coal is used primarily as a fuel. While coal has been known and used for thousands of years, it's usage was limited untill the Industrial Revolution. With the invention of steam engines coal consumption increased .Coal mining is the process of extracting coal from the ground or from a coal mine. Coal is valued for its energy has been widely used to generate electricity. Steel and cement production. Methods Of Extraction Of Coal :

1. Strip Mining :A thin strip of overlying soil and rock , known as the overburden is removed to expose a seam of coal . This overburden is then placed in a spoil bank , and the mineral is extracted.

2. Contour Mining: A type of coal mining used in mountainous terrain where the coal seam outcrops on the side of a hill or mountain. Removing the overburden to expose the coal seam .Extracting the coal using heavy machinery. Replacing the overburden to restore the original contour of the land.

3. Surface Mining: A type of mining where minerals or coal are extracted from the earth's surface. This can be used to extract a wide range of minerals including coal, iron, copper and gold.

4. Rat Hole Mining : A type of coal mining used in United States of America, particularly in the Appalachian region . The mining process involves

Digging small, narrow tunnels (called rat holes) into the side of a hill or mountain, Extracting coal from tunnels using hand tools or small machinery. Rat Hole Mining is often used in areas where the coal seam is small or irregularly shaped 5. Mountaintop Removal mining : A type of surface mining used in the Appalachian region of United States of America. Removing the top of a mountain or hill to expose a coal seam Extracting the coal using heavy machinery, Replacing the overburden in a nearby valley, Mountaintop Removal mining is highly controversial due to environmental impacts

6. Underground Mining : A type of mining where minerals or coal are extracted from beneath the earth's surface. This can include :

Room and pillar mining, Longwall mining, Sublevel caving Used to extract coal, iron, copper and gold

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ADVANTAGES AND DISADVANTAGES OF COAL MINING

1. Advantages of coal mining:

Economic Benefits : Coal mining provides employment opportunities and simulates local economies, particularly in rural areas where coal mines are often located .

Reliable Energy source : Coal is a reliable and abundant source of energy providing a significant portion of the world's electricity.

Low Cost :Coal is a relatively low-cost fuel compared to other fossil fuels, making it an attractive option for power generation.

Infrastructure Development: Coal mining can lead to the development of infrastructures such as roads, bridges and railways, which can be benefit local communities.

2. Disadvantages of coal mining:

Environmental impacts like Air pollution, water pollution and land degradation.

Health risks like respiratory problems, Injuries and Fatalities.

Community Displacement in areas where mining operations are expanded or new mines are opened

Climate change occursbecause coal is a significant contributor to greenhouse gas emissions due to which natural disasters occurs more frequently and rise in sea level can be observed.

Limited Resources: Coal is a non-renewable resource, meaning that it will eventually run out, making it a limited energy source

Safety precautions and safety statics in coal mining sector

Safety precautions

Personal Protective Equipment (PPE): Providing workers with proper PPE, such as hard hats, safety glasses, earplugs and earplugs, and respiratory, to prevent injuries and illness.

Training and Education: Offering regular training and Education programs to workers on safety procedures, emergency responses and hazard recognition.

Ventilation System: Implementing effective ventilation systems to remove dust, gases and other hazardous substances from mine.

Health Monitoring: Monitoring workers health through regular medical check-ups and providing access to medical care when needed

Safety statistics

Fatalities: According to the International Labour organization (ILO), the coal mining sector has one of the highest fatality rates among all industries, with an estimated 12,000 to 15000 deaths per year.

Injuries: The ILO also reports that coal mining workers are at high risk of injuries, with an estimated 100,000 to 200,000 injuries per year.

Accident Rates : The accident rate in the coal mining sector is significantly higher than in other industries, with an estimated 1000 to 2000 accidents per year per 100,000 workers.

Lost - Time Injuries: The coal mining sector also has a high rate of lost - time injuries per 100 workers per year. Diseases and Injuries Caused During Mining Process

Respiratory Diseases

1) Black Lung Disease / Coal workers Pneumoconiosis : A lung disease caused by inhaling coal dust , which can lead to scarring and inflammation of the lungs

2) Silicosis : It is an incurable lung disease caused by inhaling crystalline sillica dust , which can lead to disability and death.

1) Back Injuries :Back Injuries such as strains and herniated discs , can occur due to heavy lifting, bonding and twisting

2) Joint Injuries: Joint Injuries such as arthritis and brustile can occur due to repetitive motion and heavy lifting.3) Muscle strains :Muscle strains can occur due to overexertion and heavy lifting.

Skin irritation :Skin irritation can occur due to exposure to chemicals and other hazardous substances.

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Eye Injuries: Eye injuries, such as conjunctivitis and corneal ulcers, can occur due to exposure to dust, chemicals and other hazardous substances.

Permanent Hearing Loss: Caused by exposure to loud noises, which can lead to permanent hearing loss. **Tinnitus**: Caused by exposure to loud noises, which can lead to ringing or buzzing in the ears.

1. Skin Cancer: Caused by exposure to UV radiation, which can lead to skin cancer.

- 2. Contact Dermatitis: Caused by exposure to hazardous substances, which can lead to skin irritation and rashes
- 1. Eye Strains: Caused by exposure to bright lights, which can lead to eye fatigue and headaches

2. Eye Infections: Caused by exposure to hazardous substances, which can lead to eye infections and vision loss.

Environmental Impacts Caused by Coal Mining

Air Pollution :1. Particulate Matter: Coal mining releases particulate matter, including dust, smoke, and soot, which can cause respiratory problems and other health issues.

2. Greenhouse Gas Emissions: Coal mining and combustion release greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, contributing to climate change.

3. Acid Rain: Coal mining and combustion release sulfur dioxide and nitrogen oxides, which can combine with water and oxygen to form acid rain, harming ecosystems and infrastructure.

Water Pollution

1.Acid Mine Drainage: Coal mining can lead to acid mine drainage, which occurs when water flows over or through sulfide-bearing materials, forming solutions of net acidity.

2. Heavy Metal Contamination: Coal mining can release heavy metals, such as mercury, lead, and arsenic, into waterways, posing a risk to aquatic life and human health.

3. Sedimentation: Coal mining can lead to sedimentation in waterways, causing erosion and altering habitats.

Land Degradation

1. Deforestation: Coal mining often requires the clearing of land, leading to deforestation and habitat loss.

2. Soil Erosion: Coal mining can cause soil erosion, reducing soil fertility and increasing the risk of landslides.

3. Subsidence: Coal mining can lead to subsidence, or the sinking of the ground surface, causing damage to infrastructure and ecosystems.

Ecosystem Disruption

1. Habitat Destruction: Coal mining can lead to habitat destruction, displacement of wildlife, and loss of biodiversity.

2. Fragmentation: Coal mining can fragment ecosystems, isolating wildlife populations and reducing their ability to adapt to changing environments.

3. **Disruption of Food Chains**: Coal mining can disrupt food chains, affecting the availability of food resources and altering the structure of ecosystem

Economic Impacts

1. Loss of Ecosystem Services: Coal mining can lead to the loss of ecosystem services, including water filtration, soil formation, and climate regulation.

2. Damage to Infrastructure: Coal mining can cause damage to infrastructure, including roads, bridges, and buildings.

3. Economic Costs: Coal mining can impose significant economic costs, including healthcare costs, environmental remediation costs, and lost productivity.

2. **Renewable Energy Transitions**: Transitioning to renewable energy sources, such as solar and wind power, to reduce dependence on coal.

3. Environmental Regulations: Implementing and enforcing environmental regulations to minimize the environmental impacts of coal mining.

4. **Technological Innovations**: Developing and implementing technological innovations to **reduce** the environmental impacts of coal mining, such as more efficient mining methods and pollution control technologies.

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Coal demand and availability

In terms of availability, coal production in India has seen a significant increase, with the country producing 893.19 million tonnes of coal in 2022-23, and 997.83 million tonnes in 2023-24.² The government has also set a target of 1,080 million tonnes of coal production for 2024-25. However, the country still relies heavily on coal imports, with 129.52 million tonnes of coal imported in 2024-25.

Globally, coal demand is expected to peak between 2030-2035, with India's coal demand likely to continue growing due to its increasing energy needs.³

World coal resources

The world's coal resources are estimated to be around 1,139,471,430,000 tons, with proven reserves equivalent to 133.1 times its annual consumption. This means we have about 133 years of coal left at current consumption levels, excluding unproven reserves. The top countries with the most coal reserves are the United States, Russia, Australia, China, and India, with the US having the largest share of around 22.3% of the world's total coal reserves.



In terms of coal consumption, the world uses around 8,561,852,178 tons of coal per year, with the average person consuming around 1,132,737 cubic feet of coal per year. The coal reserves are not evenly distributed, with some countries having significantly more than others. For example, the US has around 254 billion tons of coal reserves, while India has around 107 billion tons. It's worth noting that these numbers are based on 2016 data, and the actual numbers may have changed since then. However, they give us a general idea of the world's coal resources and consumption patterns. 'Comparison between the countries : Methods of extraction of coal mining

Surface mining is a common method used in countries like the United States, where coal seams are near the surface. This method involves removing the topsoil and overburden to expose the coal seam, and it's often used in areas with flat terrain. In contrast, **underground mining** is more prevalent in countries like China, where coal seams are deeper and more complex. In the United States, **longwall mining** is a popular method, accounting for about 50% of underground production. On the other hand, countries like Australia and South Africa use a combination of room and pillar mining and retreat mining to extract coal. India, which is one of the largest coal-producing countries, uses a mix of **opencast mining** and **underground mining**. Opencast mining is used for shallow coal seams, while underground mining is used for deeper seams. In Germany, **lignite mining** is common, with the country being one of the largest producers of lignite in the world. Lignite mining involves extracting brown coal, which is a type of soft coal that's often used for power generation.

Policy and Regulations in the Coal Mining Industry

The coal mining industry is subject to a wide range of policies and regulations that aim to ensure the safe and environmentally responsible extraction of coal. These policies and regulations vary by country and region, but they often include measures to:

1. **Protect the environment**: Regulations may require coal mining companies to conduct environmental impact assessments, obtain permits, and implement measures to minimize pollution and habitat destruction.

2. Ensure worker safety: Policies may require coal mining companies to provide a safe working environment, conduct regular safety inspections, and implement measures to prevent accidents and injuries.

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3. **Promote sustainable development**: Regulations may encourage coal mining companies to adopt sustainable mining practices, such as rehabilitating mined land and minimizing waste. Some examples of policies and regulations in the coal mining industry

- 1. The United States' Surface Mining Control and Reclamation Act(SMCRA)
- 2. The European Union's Mining Waste Directive
- 3. Australia's Environment Protection and Biodiversity Conservation Act
- 4. India's Mines and Minerals (Development and Regulation) ActKey Regulations
- 1. Environmental regulations: Regulations that aim to minimize the environmental impacts of coal mining,
- 2. Safety regulations: Regulations that aim to ensure the safety of coal miners,
- 3. Health regulations: Regulations that aim to protect the health of coal miners and local communities

4. **Reclamation regulations**: Regulations that require coal mining companies to reclaim mined land and restore ecosystems after mining is complete.

Policy Initiatives

1. Clean coal technologies: Initiatives that aim to reduce the environmental impacts of coal mining and combustion, such as carbon capture and storage and advanced coal-fired power generation.

2. **Sustainable mining practices**: Initiatives that aim to promote sustainable mining practices, such as minimizing waste, reducing water usage, and rehabilitating mined land.

3. **Community engagement**: Initiatives that aim to engage with local communities, provide benefits and compensation, and respect indigenous rights.

Technological Innovations in Coal Extraction

The coal extraction industry has undergone significant technological advancements in recent years, aimed at improving efficiency, reducing costs, and minimizing environmental impacts. Some of the key technological innovations in coal extraction include:

1. Automation and Robotics: The use of automated systems and robotics has increased in coal mining, enabling more efficient and safer extraction of coal. Automated systems can monitor and control mining equipment, while robotics can perform tasks such as coal cutting and loading.

1990 : First automated coal mining system introduced in Australia, USA and Germany

2. **Remote-Controlled Mining**: Remote-controlled mining systems allow operators to control mining equipment from a distance, reducing the risk of accidents and improving productivity.

1980 :Australia introduced remote controled systems in coal mining with the first commercial application of remote control mining technology at **Moura coal mine in Queensland**, **Australia**.

3. Advanced Drilling and Blasting: New drilling and blasting technologies have improved the efficiency and accuracy of coal extraction. Advanced drilling systems can drill more accurately and quickly, while blasting systems can optimize the amount of explosives used.

5. Coal Seam Gasification: Coal seam gasification involves extracting gas

6. Underground Coal Gasification: Underground coal gasification involves igniting coal seams underground, which can produce a synthesis gas that can be used to generate electricity or produce chemicals.

7. Advanced Mining Software: Advanced mining software can help optimize coal extraction, improve safety, and reduce costs. Software can be used to simulate mining operations, optimize equipment usage, and monitor environmental impacts.

8. **Drones and Unmanned Aerial Vehicles**: Drones and unmanned aerial vehicles (UAVs) can be used to monitor coal mining operations, inspect equipment, and detect potential safety hazards.

9. Artificial Intelligence and Machine Learning: Artificial intelligence (AI) and machine learning (ML) can be used to analyze data from coal mining operations, optimize equipment usage, and predict potential safety hazards.

10. **Renewable Energy Integration:** Coal mining companies are increasingly integrating renewable energy sources, such as solar and wind power, into their operations to reduce their carbon footprint and improve energy efficiency.

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II. CONCLUSION

The extraction process of coal from mines has undergone significant transformation globally, with the integration of modern technologies playing a crucial role in improving efficiency, safety and productivity. This research paper has explored the current state of coal extraction technologies highlighting the benefits and challenges associated with their adaptation.

Global Trends and Insights

1. **Increased Adoption of Automation:** The use of automated systems, such as remote control mining and robotic equipment, has become more widespread in coal mines worldwide, particularly in countries like Australia, the United States, and China.

2. Growing Focus on Sustainability: Coal mines are under increasing pressure to minimize their environmental footprint, with many adopting technologies and practices that reduce waste, conserve water, and promote responsible resource extraction.

Regional Variations and Challenges

1. **Developed vs. Developing Countries:** The adoption of modern technologies in coal mining varies significantly between developed and developing countries, with the former often having greater access to resources and infrastructure.

2.. Socio-Economic Factors: Coal mining operations must consider socio-economic factors, such as community engagement, labor rights, and economic benefits, when adopting modern technologies.

Future Directions and Recommendations

1. **International Cooperation:** Global cooperation and knowledge sharing are essential for promoting the adoption of modern technologies in coal mining, particularly in developing countries.

2. **Investment in Research and Development**: Ongoing investment in research and development is necessary to address emerging challenges and opportunities in coal mining, such as the integration of renewable energy sources and the development of more efficient extraction technologies.

In conclusion, the extraction process of coal from mines using modern technologies is a complex and multifaceted issue, with varying trends, challenges, and opportunities across different regions and countries. This research paper has highlighted the need for international cooperation, investment in research and development, and a commitment to sustainable and responsible mining practices to ensure a safer, more efficient, and more productive coal mining industry globally.

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