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Prof.(Dr.) S. Jayanthu

Persons in the News

Shri Pankaj Kumar Sharma selected as the next Director (Production) of NALCO. Currently he is working as Chief General Manager (CGM) at NMDC.

Shri Ajit Kumar Saxena presently Director (Operations), Rashtriya Ispat Nigam Limited (RINL), has been selected for the post of Chairman & Managind Director, MOIL Limited. He had taken charge as the Director (Operations) on October 17, 2019. Prior to this assignment, he had worked as Chief General Manager, Mills, IISCO, Burnpur, Steel Authority of India Ltd. Shri Saxena started his career as a Management Trainee (Technical) in 1986. He worked in various assignments in SAIL starting with Bhilai Steel Plant and worked in various positions during his long tenure of 33 years in SAIL. Saxena holds a B Tech degree from the Institute of Technology, Banaras Hindu University in Metallurgy and later also acquired an MBA. He is also a proud holder of the "Young Metallurgist of the Year Award " for the year 2000 given away by the Ministry of Steel.

Shri Ashok Das assumed the charge as Director (HR) of Oil India Limited (OIL). Shri Das was the Executive Director (HR) at OIL prior to taking over as Director (HR) of the company. A Graduate in Political Science and Masters in Business Administration (MBA), Shri Das began his career as an Executive Trainee with OIL in 1989 and over the span of more than three decades, he played a pivotal role in shaping OIL's Human Resource functions like Talent Acquisition, Performance Management, Compensation Management, Employee Relations, Wage Negotiations, Training & Development, HRIS, Employee Engagement etc. Known for his performance-focused people-centric leadership style, Shri Das has successfully managed HR functions in OIL and has taken several progressive HR initiatives like introduction of IT-enabled HR practices, streamlining of HR systems & policies to enhance transparency, objectivity & fairness. He led the HR team in designing and implementing Online Performance Management System. Shri Das has also led several Corporate Social Responsibility initiatives at OIL and is instrumental in setting up of the Skill Development Institute in Guwahati, a first of its kind institute in Northeast India. An alumnus of Cotton College and Gauhati University, Shri Das is a former national level footballer and a theatre artiste with several awards & accolades.

Indian Coal Sector: Diversifying Use of Coal for Sustainability and Supporting Atmanirbhar Bharat Abhiyan

Peeyush Kumar*

ABSTRACT

Energy is one of the basic requirements for growth of any country and becomes very important for developing countries such as India. Coal accounts for about 55% of energy requirement of the country and India has the fifth largest deposit of coal in the world. The other major source of energy in the country is oil and gas and the country depends on imports to meet the need of these resources. With environment concerns and development of renewable energy, diversification of coal for its sustainable use is inevitable. Coal gasification technology primarily used in China helps in producing methanol, ethanol etc can be used as mix for energy fuel, DME as substitute for LPG. Syn Gas produced from Coal contains hydrogen and through water gas shift reactions, pure hydrogen can be produced from coal which is future fuel meeting energy demand. Hydrogen produced from Coal is cheapest as compared to hydrogen produced from Natural gas or Green Hydrogen from electrolysis. Syn Gas is also used in gas based DRI for production of steel and production of ammonia and ammonium nitrate and fertiliser such as Urea. Considering the import dependency of country on Oil and Gas, coal and coal gasification can be a better substitute of these imported fuels and varied use of coal will be in line with the Government Policy of Make in India and Atmanirbhar Bharat.

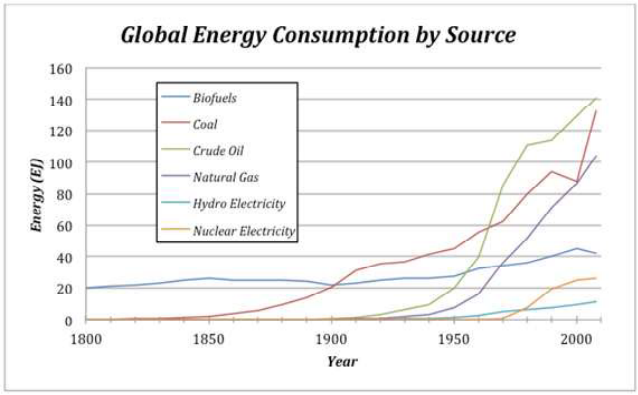
Keywords: sustainability, coal mining, coal use, gasification, grey hydrogen, CCUS

SOURCES OF PRIMARY ENERGY SUPPLIES: COAL SECTOR IN INDIA

Sources of Primary energy supplies across world can be grouped as non-renewable and renewable source of energy supplies. Fossil fuels such as coal, crude oil and Natural Gas and nuclear energy using uranium can be considered under non-renewable energy source whereas energy extracted using biomass, geothermal, hydropower, solar, tidal, wave, wind etc. are considered as renewable energy sources.

Initially the major source of energy was biofuels. However, with exploration and identification of energy resources in earth crust, Crude oil and coal took an important share in energy supplies.

Fossil fuels such as crude oil, Natural Gas and Coal plays an important role in meeting energy requirement of world. However, the availability of these energy minerals is not uniform across world, and this result in import and export of energy mineral across. India is rich in coal deposits but lack crude oil and natural gas resources. Coal account for about 55% of energy requirement of country whereas contribution of crude oil and natural gas is 29% and 8% respectively. (Source: BP Statistical review 2014).Most of the requirement of crude oil and natural gas is met with imports and as such number of efforts are being made to produce Syn-gas from coal gasification process to produce ammonia for fertiliser replacing Natural Gas requirement and to produce ethanol and methanol as energy fuel to be blended with gasoline resulting in lower imports for these sources of energy.



Source: Data from International Energy Agency (iea.org) (https://www.e-education.psu.edu/earth104/node/1345)

Figure 1.1: Trend in energy source in last 2 centuries

**Officer on Special Duty, Ministry of Coal, Government Of India, E303, Prateek Stylome, Sector 45, Noida, UP 201303*

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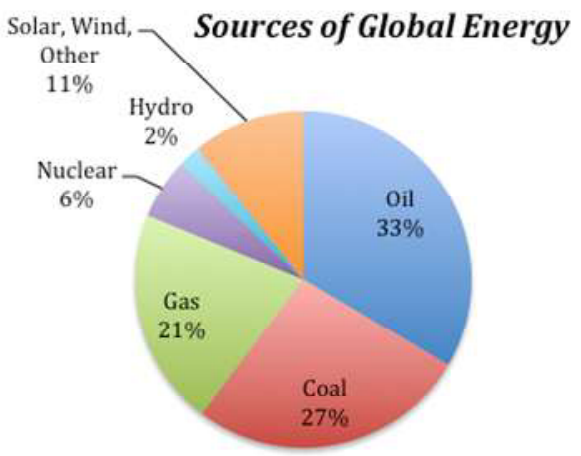
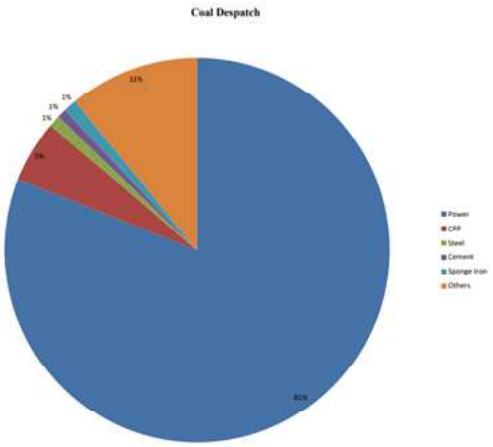


Source: Data from International Energy Agency (iea.org) (https://www.e-education.psu.edu/earth104/node/1345)

Figure 1.2: Source wise contribution to global energy in 2021

As per the reports prepared by Geological surveys of India, as on 1.4.2021, the estimated coal resources in the country are 352 billion tonnes including 177 billion tonnes of measured resources. (Source: Indian Coal and Lignite Resources 2021, Natural Energy Resources Mission II B, GSI). About 720 million tonnes of coal is produced every year and it has been planned to scale up the domestic production to 1.3 billion tonnes by 2023-24. With the planned quantity of coal production, Indian coal is sufficient to meet the energy demand of the country for at least 100 years. At present about 81% coal produced in India is used in power generation and the balance is used in steel, fertiliser, cement, captive purposes.



Source: Coal Statistics, March 2021, CCO, Ministry of Coal

Figure 2.3: Sector wise offtake of coal in India 2020-21

DIVERSIFYING USE OF COAL: COAL GASIFICATION

India has a huge reserve of coal and with the current rate of consumption; it is expected to last for more than 5 decades. About 80% coal is used in thermal power plants. With environment concerns and development of renewable energy, diversification of coal for its sustainable use is inevitable. Coal gasification is considered as cleaner option as compared to burning of coal and has diversified use of coal such as production of Synthetic Natural Gas (SNG), energy fuel (methanol), production of urea for fertilisers and production of Chemicals such as Acetic Acid, Methyl Acetate, Acetic Anhydride, DME, Ethylene and Propylene, Oxo chemicals and Poly Olefins.

Coal gasification offers a practical means of utilizing coal for meeting stringent environmental control requirements. In the gasification process, sulphur present in the coal is converted to Hydrogen Sulphide (H_2S) and minor amounts of Carbonyl Sulphide (COS). These Sulphur compounds can be easily and economically removed from gas streams by a wide variety of commercially available processes (i.e., acid gas removal systems). The separated acid gas is further processed to recover elemental sulphur. After the acid gas removal treatment, only few ppm of Sulphur remains in the coal gas. Nitrogen oxides (NO_x) are not formed to any appreciable extent in the reducing atmosphere of coal gasification. The particulate content in the fuel gas after gasification is negligible since the gas cleaning steps (hot cyclones, water scrubbing or hot gas cleaning) capture almost all the particulate. Except for hot gas clean up, other two systems are commercially established and practiced. Most part of the wash water is recycled and the residual waste waters from gasification plants can be effectively treated. The coal gasification plants do not produce any scrubber sludge which need careful and costly disposal. Though ash handling is an issue while using high ash Indian coals, the coal ash from gasifier is not hazardous and its leaching effect is very low.

Coal gasification process has several other advantages besides minimum environmental impacts. A broad range of coals with varying ash content, coal fines, middling and washery rejects can be successfully gasified. Coal can be fed to the gasifier in the form of crushed coal of 5 to 50 mm size, coal fines, pulverized coal or coal water slurry depending upon the generic type of gasification process (i.e., moving bed, fluidized bed and entrained bed). Oxygen enriched Air or oxygen can be used as gasification medium.

If oxygen is used in a coal gasifier instead of air, carbon dioxide is emitted as a concentrated gas stream. In this form, it can be captured more easily and at lower costs for ultimate disposition in various sequestration approaches. By contrast, when coal burns or is reacted in air, 80 percent of which is nitrogen, the resulting carbon dioxide is much more diluted and is costlier to separate from the much larger mass of gases flowing from the combustor or gasifier. Carbon conversion efficiency of as high as 99% can be attained in the gasification process. The major advantage of gasification is that coal is converted into a gaseous fuel which is easy to handle and is a clean form of energy. In the gaseous form, it enables to substitute petroleum products and natural gas. The synthesis gas has wide range of applications. It can be used in Integrated Gasification Combined Cycle (IGCC) system for efficient and clean generation of electric power. It is suitable for the manufacturing of hydrogen and basic chemicals such as ammonia, methanol, substitute natural gas, CTL (coal to liquid), as reduction gas in steel industry etc. It can be used in complex of plants for the simultaneous production of electric power, chemicals/ fertilizers, reduction gas and fuels which also improve the economics of coal gasification.

Different Surface Coal Gasification process technologies broadly categorized on the basis of type of gasifiers in use are as follows:

(i) **Moving Bed or Fixed bed Dry bottom:** Moving bed type gasifier operates with a counter current flow of oxidant through a series of reaction zones – gradually changing from coal-coke-tar-ash. The moving bed reactor requires sized coal, generally in the range of 5-50 mm with a limitation on the fines content (-6 mm) in the feed. Air blown gasifiers do not exceed ash melting point whereas oxygen blown moving bed gasifiers can be either dry ash or slagging. Dry ash gasifier uses considerable excess process-steam, required to control the bed temperatures below the ash fusion point to avoid formation of clinkers. Highest bed temperature is generally maintained below the ash fusion point. Dry- ash Removal System is highly suitable for High-ash Indian Coals having High Ash Fusion Temperatures.

(ii) Fluidized Bed: Fluidized bed gasifier is fed with 5 to 50 mm size coal as well as pulverized coal which is fluidized and gasified by the oxidant gas either oxygen or air. The reactor operates around 30 kg/cm^2 pressure and at a temperature well below the ash fusion temperature of coal, typically ranging from 800 to 1050^{O}C depending on the feedstock characteristic. As a result of maintaining constant low temperature, clinker formation and possible defluidisation of the bed is prevented. Low temperature operation makes fluidized bed gasifiers ideal for reactive coals. Due to the restricted flow of oxidant most of coal particles do not burn completely but form char particles which are entrained the raw gas exit gasifier. This necessitates separation and recycle of substantial quantity of char particles

(iii) Entrained Bed: In this fine coal feed and oxidant are fed co-currently. As a result, oxidant and steam is entraining the coal particles. This results in high throughput and high carbon conversion efficiencies. Entrained flow type gasification is the cleanest and efficient type of coal gasification. The entrained flow gasifiers are widely used abroad. It is ideal for coal with low ash content. If ash content of coal fed in entrained flow gasifier is high, considerable part of energy will be consumed in melting & slagging the ash content of high ash coal resulting in lower gasification energy.

Coal to Liquids is an upcoming industry which can play a vital role in India's chemical and petrochemical industry as majority of chemicals and petrochemicals are derived from products which are derived from crude oil and natural gas. Coal can be used to make the following products:

(i) Methanol: BIS has notified M15 fuel for automobile sector wherein 15% methanol can be blended with Gasoline requiring additional demand of 5-7 Million tonnes of methanol considering 30 million Ton gasoline consumption. Further, in Pharma Sector, Methanol acts as solvent for many of the bulk drugs and there is a need to identify the potential requirement of methanol by 2030.

(ii) Ethanol: under the national policy on bio fuels 2018, Government of India with effect from 01.01.2003 resolved to supply 5% ethanol blended petrol under its First-Generation Ethanol blended petrol(EBP). Government of India has also advanced the target for 20% ethanol blending in petrol (also called E20) to 2025 from 2030. Ministry of Petroleum and Natural Gas is in the process of modifying National Policy on Bio fuels 2018, to include production of ethanol also from coal gasification route. Primary discussions with licensors such as Synata Bio (USA) revealed that ethanol can be produced in a cost-effective manner from Syn Gas. Oil companies have also shown

interest to buy cost effective ethanol and this will help in reducing imports. Ethanol is envisaged for being a downstream product from syngas obtained by coal gasification. Opinions were voiced regarding fermentation of syngas to meet the demand of ethanol blending projected by 2025-26. India's net import of petroleum stood at 185 million T putting the cost at 55 billion USD, which is used primarily for products in the transportation sector. NITI Aayog has laid out a roadmap for ethanol blending preponing the target from the earlier 2030 to 2025. Additionally, ethanol has medical applications as an antiseptic and disinfectant. It is also used as a chemical solvent and in the synthesis of organic compounds.

(iii) Olefins are currently produced from natural gas and naphtha. Natural gas is a scarce natural resource in India as it imports almost 45% of its requirement. Moreover, Naphtha is derived from crude oil which is again an imported commodity as India imports around 82% of its crude requirement. Therefore, coal to methanol and then further production of olefins would help India to substitute the use of imported products to produce olefins. The production of olefins is about 9 MT in India from crude oil however economics of product is to be examined for setting up plant since about 3 tons of Methanol are required to produced 1 ton of olefins.

(iv) DME, Acetic Acid and Formaldehyde: Production of DME in India is insignificant, whereas approximately 0.16 MT of Acetic Acid is produced. DME can be blended with LPG and India currently imports 50% of its LPG requirement of around 21 MT per year. A 20% DME blend with LPG is feasible and can open an opportunity to substitute LPG imports by DME which is produced from domestic coal. Therefore, 2 MT of DME would be required assuming a 20% blend for around 10 MT of LPG imported. 1.4 units of methanol are required to produce 1 unit of DME. Acetic Acid (CH*f* COOH), popularly known as Vinegar, is a clear liquid with a pungent odour, sharp taste and is widely used as a food preservative. The most common route for its production is the carbonylation of methanol. GNFC is the only producer in India using methanol to acetic acid route – therefore, low cost of methanol is imperative to make acetic acid competitive. Formaldehyde is the simplest form of aldehyde (HCHO) which is a colourless gas with a pungent odour. Formaldehyde is used in the production of household products, building materials, glues and adhesives, resins etc. It is commonly produced through the dehydrogenation of Methanol, so Methanol to Formaldehyde is a common route. Like Acetic Acid, availability of low-cost Methanol becomes important to competitively produce Formaldehyde.

(v) Fertilisers and NH3 based products: Hydrogen available in Syn Gas can be utilised for manufacturing ammonia (NH3) which is a feed stock to Urea, Ammonium nitrate and there are many other applications of ammonia.

COAL TO HYDROGEN: GREY AND BLUE HYDROGEN

Hydrogen is a clean fuel. It is an energy carrier that can be used for a broad range of applications. Also, it could serve as a possible substitute to liquid and fossil fuels. At standard temperature and pressure, hydrogen is a nontoxic, non-metallic, odourless, tasteless, colourless, and highly combustible diatomic gas. It is also the most abundant element in the universe, making up more than 90% of all known matter. The abundance of hydrogen on earth, minimal environmental consequences of its use and the need to replace fossil fuels, makes it the ideal fuel of the future. Hydrogen energy involves the use of hydrogen and/ or hydrogen-containing compounds to generate energy to be supplied to all practical uses needed with high energy efficiency, overwhelming environmental and social benefits, as well as economic competitiveness.

The production of hydrogen requires utilizing one of the primary energy sources – fossil fuels, nuclear, solar, wind, biomass, hydro, geothermal and urban waste resources. Once hydrogen is produced, it can be reacted with oxygen in a manner similar to gasoline combustion in an engine or used in a fuel cell to generate electric power. The electricity produced by a fuel cell can then be used to power electrical devices such as computers or an electric car. An important benefit is that, using hydrogen does not produce carbon monoxide or carbon dioxide. This makes it attractive because no greenhouse gases are produced To produce hydrogen, it must be separated from the other elements in the molecules where it occurs. Hydrogen can be produced via thermochemical pathway, which uses a fossil fuel feedstock to produce hydrogen. This process must be paired with carbon capture and storage (CCS) to produce clean hydrogen. Steam methane reforming (SMR), which relies on natural gas as an input, and coal gasification, are the mature technologies of this pathway. Syngas derived from gasification processes contains a significant amount of hydrogen (H_2), which can be increased through water gas shift (WGS) and be readily separated

into a pure H_2 product meeting industry product quality standards.

There are several conventional H_2 separation processes, but modern installations preferentially choose pressure swing adsorption (PSA), which is a well-proven technology offering high availability and low cost. PSA has the ability to produce high purity (99.9%) hydrogen at near feed pressure; however, relatively high H_2 concentration in feed gases is required for its economics to remain favourable. New technologies are being developed to increase the efficiency and reduce the costs associated with H_2 production from coal gasification. Although most hydrogen is produced by steam reforming of natural gas (95% of world totals), hydrogen production or co-production from syngas generated by liquid or solid gasification is commercially practiced as well. This is mainly based on gasification of residuals, heavy oil or pet-coke from refinery operations, with the hydrogen helping to satisfy the in-house demand for hydro treating, hydro desulfurization, hydrogenation, and hydrocracking. In our country any studies and coal gasification pilot plants for producing syn-gas have been completed, but there is currently no commercial coal gasification plant producing H_2 as a final product, though RIL has large units based on Pet-coke. Indian scenario in which the high cost of natural gas including import dependence occur concurrently with the low cost of domestic coal provide the impetus for the production of hydrogen from coal feedstock. Moreover, H_2 production technologies are gaining attention because hydrogen is predicted by some to be the energy carrier of the future, as it is extremely clean when reacted with oxygen (producing water) and has a high energy density by mass. Hydrogen can be used to feed fuel cells or combusted in a hydrogen turbine to generate electricity. Hydrogen could also power fuel cell vehicles. Although there are technical challenges to overcome, a clean coal gasifier to produce H_2 would be a key component of a hydrogen economy and hydrogen-based power generation as envisioned.

STEEL MAKING

As per National Steel Policy, India is expected to build a capacity of 300 million tonnes of steel per annum to cater to demand of around 255 mtpa by 2031. To support this demand and the necessary production process, the requirement of coal would be to the tune of 300 mtpa of which around 165 mt would be coking coal, 35 mtpa coal for PCI (pulverized coal injection) and around 100 mt would be non-coking coal for DRI (direct reduced iron or sponge iron prod). Coke is an essential input for production of steel and currently about 0.9 Tonne of coke is required to produce 1.0 Hot Metal (HM) through blast furnace route. Indian coking coals are inferior to imported coking coals in terms of ash and other properties. At present, SAIL & TATA use about 90% of imported coking coal in the blend and rest 10% through indigenous sources. CO and H_2 of Syn gas are important reducing agent for steel making and are environment friendly method of steel making through DRI route. The technology has already been proven by JSPL at its Angul Plant and greater use of Syn Gas will help in reducing demand of coking coal for steel making.

CONCLUSION

As per the study conducted during Vision 2047, Coal will continue to play a dominant role in meeting energy demand of country by 2047. However, with development of indigenous technology in coal gasification specially for high ash coal, various products from Syn gas will help in reducing import dependence in energy fuel as well as imports in chemical and pharmaceutical industries. Requirement of coking coal for steel making through blast furnace route is also expected to go down with implementation of Syn Gas based DRI plants and availability of huge coal reserves will definitely help in import dependency in Power, Steel and Chemical and fertilizer sector.

A Digitalization Model (Input-Output Model Based Approach) for Improving Productivity of Open Pit Coal Mines Vis-a-Vis IOT Based Monitoring of Energy Consumption

Vislavath Suresh* Siddharth Agarwal** Yoginder P. Chugh***

ABSTRACT

The project proposes to develop a standard uniform method that has cheap, portable, remotely controlled sensor technology to capture real-time data of energy consumption as cloud storage and decision analytics built upon artificial intelligence. Thus, this proposal hopes to push the horizon with big data, data management, data visualization and business intelligence making it a truly smart, safer and sustainable mining experience. The coal industry also needs an integrated mine nerve center (IMNC) for hourly, daily and monthly reporting through dashboards on different screens. This can also help in getting updated yearly and audited. The project is one of its kind in integrating the state-of-art intelligent monitoring and analysis techniques, tools and gadgets to make Indian coal mining industry very contemporary with the global mining industry. The overall idea is to calculate for each equipment type and each mining unit operation the current energy consumption, best practice energy consumption, and previous consumption.

Key words: energy consumption, emissions, input-output-process

INTRODUCTION

Background

Mining is one of the most energy-intensive industries worldwide. It is also a major source of raw materials for manufacturing, transportation, construction, and energy sectors. Total electricity consumption industrial sector is 42.69% of total in India Electricity Consumption. That is currently 551362 Gwh = 1.984903e+9 giga joules, where1 Gigawatt hour (GWh) = 3,600.00 gigajoules (GJ). Out of this 10 % is consumption of total mining industry in India which is again equivalent to 440 Metric Tons of CO_2 released into the atmosphere. India has pledged a 33-35% reduction in the "emissions intensity" of its economy by 2030, compared to 2005 levels. India emits about 3 gigatonnes (Gt) CO_2 eq of greenhouse gases each year currently as of 2019 large portion comes from coal mining. Reducing emissions from mining could help in achieving India's commitment to Paris Agreement as well as save money. Due to the remoteness of mining industry, mining is heavily dependent on fossil fuels such as diesel, heavy oil and coal for onsite generation. The calculation of carbon emissions generated by the consumption of fossil fuels has been treated as a key governmental task and is the concern of international scientific communities. The IPCC (Intergovernmental Panel on Climate Change) affirms that greenhouse gases (GHG), in particular carbon emissions, from human activities has been the dominant reason for the observed global warming since the mid-20th century. With growing climate change disasters top 50 global mining companies have committed to a target of zero net emissions by 2050 or significantly reduce them by 2030. This includes companies' giants like BHP Billiton, Rio Tinto, Barrick Gold etc. Similarly, they have invested billions of dollars in automation of energy usage for improving their equipment availability, production performance and calculating their carbon footprint. Indian coal mining industry is not only one of the largest sources of GHG emitters but also a huge energy consumer. Since India will be using coal and other fossil fuels for a long time (production will peak in 2040) (by 2025 target 1 billion tonne, by 2030 target is 1.5 Bt) based on current projections by Niti Ayog and IEA.

Hence the impacts of this study will be far reaching to India. This would be a landmark project in terms of implementing industry 4.0 standards in the Indian surface coal mining context using industrial internet of things (IIoT). The project proposes to use smart, portable, remotely controlled sensor technology to capture real-time emissions data along with GPS location, cloud storage

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and decision analytics built upon artificial intelligence. Digitization and Digitalization is one of the core areas of research as suggested by the ministry of coal in India.

Digital initiatives at the leading mining companies

Mining Project	Implementation Partner	Technology	Results/Benefits
Ability™ Ventilation Optimizer Mine ventilation on demand (VOD)	ABB	the mine is equipped with a number of sensors that send real-time data to the control system operator for analysis on the air quality, diesel vehicle use, and personnel.	Reduce ventilation costs, increase the lifespan of your ventilation system, and provide a long-lasting, secure workplace.
Unmanned Aerial Vehicles (UAV) Applications in Mining	HATCH	Photogrammetry from a Drone	Visual Inspections ? Ore Pass, vent raise, stopes, hazardous areas, confine spaces, stockpiles
Hindustan Zinc's Sindesar Khurd (SK) mine - India	INFOSYS, Newtrax MET integrated with the Sandvik OptiMine	IOT based digital platform to track and receive data from the entire underground operation	Improve overall efficiency including drills, loaders, trucks and other equipment.
Vedanta digital fleet Center solution	Siemens		Reduce unplanned outages, optimize costs and improve efficiency.
Smart Underground Monitoring & Integrated Technologies (SUMIT)	Government of Canada, Centre for Excellence in Mining Innovation (CEMI)	underground lasers to track subtle changes in the rock face and computer software to predict how rock might react to specific mining activities	Deep mine monitoring of rockmass behavior changes, mining induced and triggered seismicity, enhanced mine development
Connected Mine solution	Accenture and Avanade	Accenture Connected Platforms as a Service (CPaaS) on Microsoft Azure, mobile, cloud and analytics	prevent productivity and safety risks before they become a problem
Enterprise-wide analytics hub and Interactive data rooms	Barrick and CISCO	Data Visualization, Data Simulation and analytics	Barrick's leaders to make decisions more quickly, precisely, and productively; to better assess and reduce risk; and to give partners more transparency

state of the art

This proposal aims to establish and develop an integrated industry 4.0 driven model for calculating total energy consumption and total GHGE across loading and hauling mining process based on KATRAS AKWMC surface coal mines of BCCL, JHARKHAND, India. To install and deploy the state-of-the-art technology for data collection. Capturing real time data with multiple sensors such as fuel, electricity and Air Quality.

Develop a baseline or benchmark for Indian surface coal mines in terms of energy consumption per ton of coal produced/ or sold and amount of GHG emitted /per ton of coal produced based on loading and hauling operations. In addition, it is proposed to build an AI/ machine learning driven Dashboards. This will help Mining Managers and Supervisors visualize key performance indicators such as total energy use per unit increase in production or sales, consumption of fuel & electricity or emission of various gases as daily, weekly or monthly trends and show forecasts. This will be done by systematic collection of real-time spatial and temporal GHGE data through multiple sensors on a single portable device, obtain energy data from daily records. The managers can set up a continuous feedback loop with supervisors to change certain sub-processes such as fleet management, or use less equipment's but of larger size etc. and simultaneously visualize the effect of these actions reflected on dashboards.

The idea is to move India towards a smart mining concept where the mine processes are managed in a dynamic fashion. Overall energy efficiency leads to reduction in cost and reduced GHGE as well as lower emissions of PM2.5, TSP, and PM10 per ton of coal produced (^{1} + emission)/ m3 coal). Overall, this project makes mines climate friendly while simultaneously enhancing profitability and suggesting the right alternative form of energy in any mining process

Objectives of the research

This project aims at creating energy consumption (EC) and Greenhouse gas emissions (GHGE) data for the selected Indian surface coal mines in collaboration with the mining company. The research will concentrate on selected key unit operations. **These include hauling (fuel) and loading (electricity). If time and resources permit, communition and drilling & blasting operations may also be considered for investigation.** However, to identify the operation that stands as the highest consumer of energy, a detailed study of all inputs and outputs in the mining operations is required. The objectives of this project are:

i. Digitize mine operations for energy usage (fuel + electricity) and GHG emissions to provide data for control and management through state-of the-art technology in data collection, data transmission, data storage and data analytics.
ii. Define a methodology to compute, track and display in real-time, the energy consumption of coal produced. Also establish the percent increase in energy consumption per unit increase in coal production or percent increase in GHGE.
iii. Define a methodology to compute, track and display in real-time the (GHG +PM) emissions in m3/ metric ton of coal produced and emission intensity (CO_2 eq ton/ unit time) at different locations in the mine. This will help identify hotspots of high GHGE or PM concentrations.
iv. Machine learning algorithms will be used to forecast the consumption of energy and emission intensity of selected unit operations on short- and long-term basis.
v. Establish a relationship between energy consumption KJ/hr and productivity coal Mt/hr.

Research gaps

Previous studies have focused either partly on energy consumption or on GHG emission due to blasting, or mine-site ore hauling etc. Real time monitoring using sensors that can measure GHG's spatially and temporally is missing.

Currently Energy Benchmarking for various mine processes in Indian Coal Mines is not Digitized, thus dashboard based quick and accurate decision analytics proposed will be the first such attempt to form an early warning alarm systems as well week over week or month over month performance of the mine. Early warning systems for informing the managers about peak demands in energy or peak emissions from a particular area or process in the mine. There is currently no data to support (^{1} energy+ emission)/m3 coal).

METHODOLOGY

General methodology to achieve the specified goals mentioned in the objectives

- **Data gathering**
- **Digitize and integrate engineering data**
- There are in general 3 sources of big data for this project. Firstly, the data from fuel sensors, then electricity sensors, thirdly GHGE and AQP sensors. Finally, a fourth data source could be manual that will incorporate some historical or missing records. The first three sources are automatically digitized as they

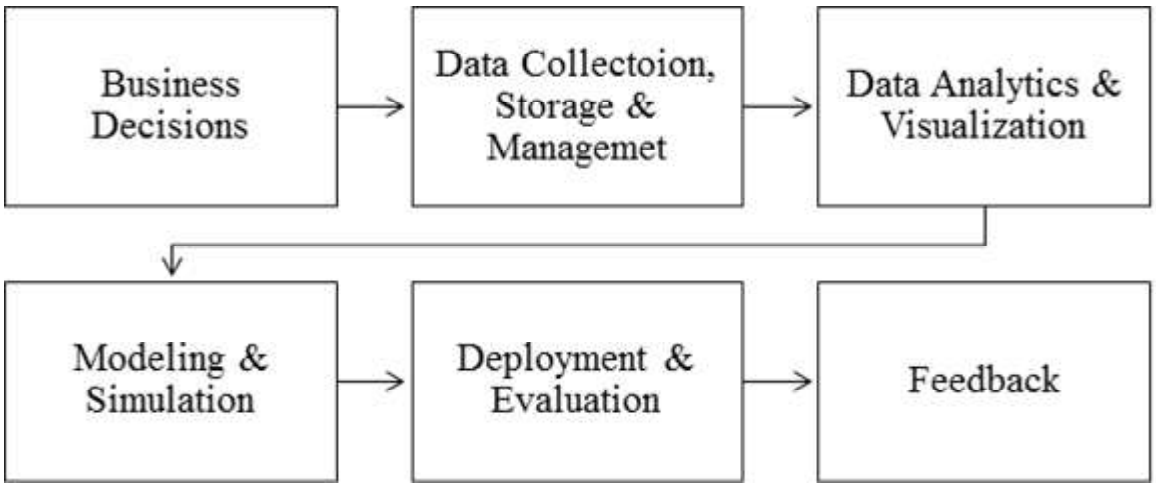


Figure: General methodology for the study

are stored in the cloud database. The manually entered information will be digitized through excel files or MSAccess Database.

- The integration lies in merging or joining these datasets for doing big data analytics. This will be done through Power BI (Microsoft based big data analytics and visualization tool). This tool has the capability to join different databases on the same platform.
- **Dash board configuration and information**
- There will be 3 dashboards used in total. One dashboard will be devoted to energy consumption, the second will be focused on GHG emissions and third dashboard will focus on the key indicators or KPI's defined above. These dashboards will also be visible via mobile apps designed.
- **Data synthesis, analysis and interpretation by use of AI/ML techniques**
- Data will be used for forecasting energy and emissions for various processes using AI/ML
- Also identify processes as well as any particular regions within the mine that cause high and low energy consumption or emissions

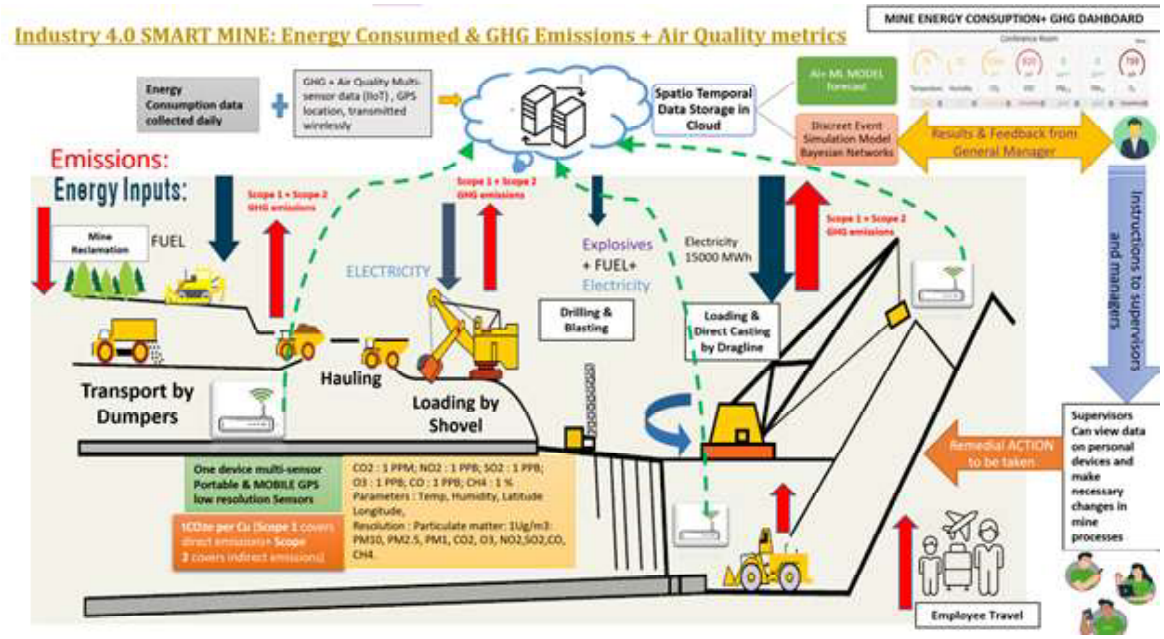


Figure: Overview of the research proposal methodology

Input – Output Process Model

Input-output (IO) analysis is an approach to trace the production process of products by economic sectors, and their use as intermediate demand by producing sectors (industries) and final demand including that by households and the public sector (Miller and Blair, 1985).

This type of analysis basically redistributes the emissions occurring in producing sectors to final consumption. It can be used to quantify GHG emissions. associated with import and export (Wyckoff and Roop, 1994), with national consumption (Hertwich and Peters, 2009), or the consumption by specific groups of society (Lenzen and Schaeffer, 2004), regions (Turner et al., 2007), or institutions (Larsen and Hertwich, 2009; Minx et al., 2009; Peters, 2010; Berners-Lee et al., 2011).

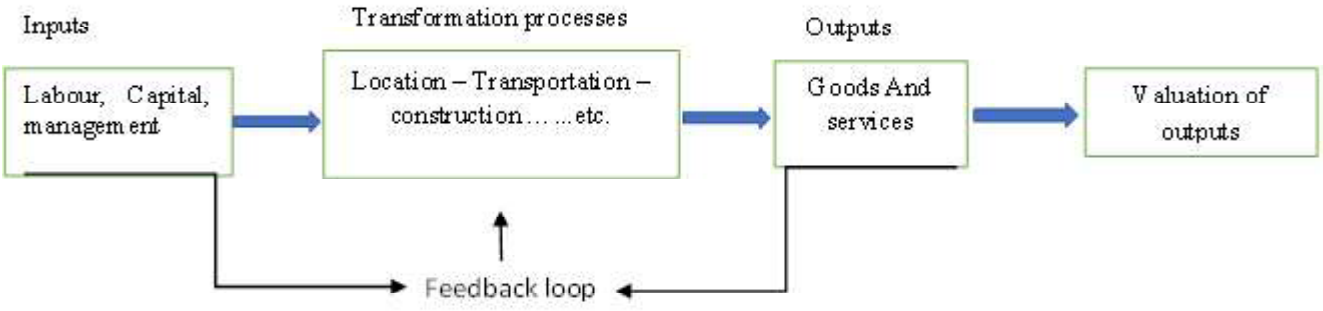


Figure: Structure of input – output process model

Inputs, processes, outputs, and valuation: concepts

- Every production system has ***inputs*** such as: Capital and infrastructure; Human resources; Raw materials; Energy; Natural resources (water, air, geology). These affect ***production cost.***
- All ***processes*** that "convert" inputs or output/s from a process to "value-added" and "negative-value" products. These ***are designed to*** result in sustainable positive "Revenue- Stream" for the system.
- ***Direct outputs of these processes*** are value-added product/s for the markets, and negative-value waste products.
- ***Indirect outputs*** include items such as socio-economic, property values, etc.
- The outputs can be translated into ***valuations (positive and negative) with*** the goal to achieve a sustainable production system with maximum profitability given the inputs, processes, and outputs.

Salient points of the digitalization structure

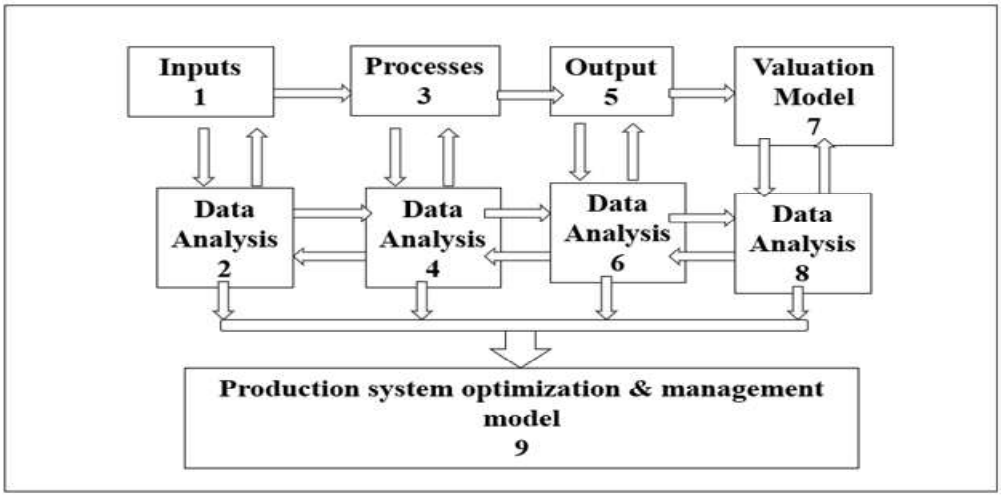


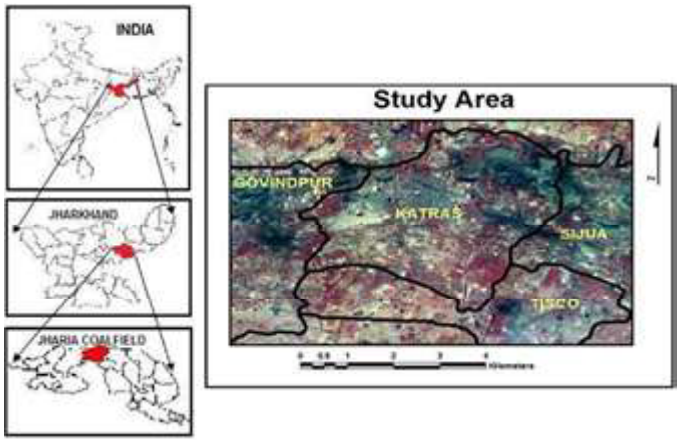
Figure: A conceptual digitalization model of a production system (chugh & agarwal, 2021)

- Inputs, processes, outputs, and valuations have ***well-defined dynamic characteristics***.
- The above ***data are collected in Blocks 1, 3, 5, and 7*** and fed into their respective ***analytics cells 2, 4, 6, and 8.***
- For ***continuous improvement***, these data must be collected at intervals and analyzed in their respective blocks.
- Each ***data analytics block provides feedback to their respective block*** as well as to all other blocks ***to account for interactions***.
- Thus, it has ***multiple closed feed-back loops***.
- Above data analyses may ***affect supply chains, nature of the production system inputs, processes, outputs and their values (positive or negative)- Blocks 3, 5, and 7.***
- The above data ***affect the overall profitability of the production system*** and requirements for its management.

CASE STUDY

Field work & other relevant information: Katras mines (AKWMC)

Katras Area consists of three mines-Amalgamated West Mudidih-Keshalpur Colliery (Mixed), Amalgated Gaslitand Katars Chaitudih colliery (OCP) & Salanpur colliery (UG).



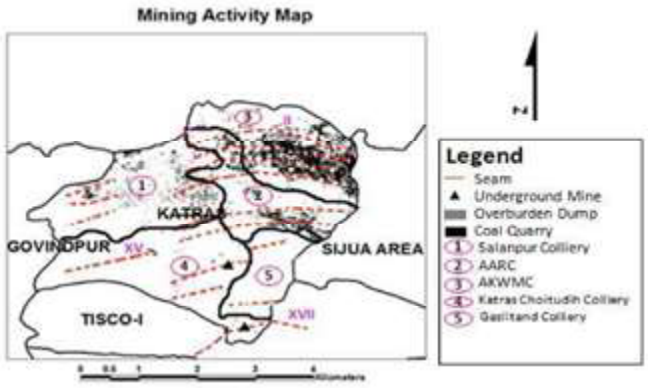
RESULTS AND DISCUSSIONS

The proposed model has a great potential to capture the complex relationship among factors and establish causal influence among predictors. To the best of our knowledge, this is the first study to use Bayesian networks to model causal influence among factors associated with enteric

Salanpur Colliery (UG) has ceased operation since September 2021 because of non-viability. The Area is known for its all-round performance in every dimension. In the field of production activities, the Area was able to register double digit growth since past 4 years (except for 2021-22 due to Covid-19). AKWMC (Mixed) mines is one of the largest producing mines of BCCL and has been listed in the Top 100 producing mines of the nation.

Amalgamated keshalpur and west mudidih colliery (AKWMC) Katras, also known as area-1v as shown in figure 1, is one of the major mining clusters among the twelve clusters of BCCL. It is located in the northern side of jharia coal field (JCF), with estimated reserve of 414.377 million tonnes (BCCL, katras area 2015.At present IV & above seams are being extracted by open cast method. However, on the up-throw side of 35 m fault running east-west direction, III seam is taken as base seam of OC.

The present opencast mine started in 1990 with IV seam as base by shovel dumper combination (departmental as well as outsourcing). The present depth of the mine is 100m. The OB is internally being dumped over IV seam floor in the de-coaled area. Winning of coal and overburden is by drilling and blasting with explosive. There are 5 coal benches and 7 OB benches running in the mine. Consumption of diesel and petrol/ month is about 9898 liters/day.



methane emission from milking cows. Saved energy is money earned and that could be used for other purposes. This would save 10 EJ of additional energy use compared to the NPS. Savings would mainly come from industry (45%) and buildings (30%), followed by the transport sector.

This is the first attempt to map end to end energy

Details of machinery Available

Table: The list of HEMM existing on roll of the AKWMC opencast

Si. No.	Particulars	On roll (No.)	Remarks
A	EXCAVATORS		
1	Elec. Rope shovel 5.0 m3	5	EKG
2	Hyd. Shovel 5.0 m3	3	BE 1000
3	Elec. Hyd. Shovel 1.2 m3	1	CK 220
4	Hyd. Shovel 3.8 m3	2	CK300
	Total	11	
B	DUMPERS		
1	Rear Dumper 60t	30	
2	Rear Dumper 35t	30	16 no. surveyed off.
	total	60	
C	DRILLS		
1	250 mm drill	1	
2	160mm drill	9	
3	100 mm drill	1	
	Total	11	
D	Dozers		
1	Dozer 320 HP	4	
2	Dozer 335 HP	11	
	Total	15	
E	WATER SPRINKLERS	4	
F	CRANES		
1	8T	2	
2	16T	1	
3	36T	2	
	Total	5	

consumption along with total Greenhouse Gas emissions (GHG) in the Indian open cast coal mining engineering industry with its diverse mining equipment, mining methods, and mine reclamation techniques. The aim is to collect data for fuel and electricity consumption for various mine processes and the amount of major GHG's along with volatile organic compounds, low explosive level gases, emitted by them spatially as well as temporally. Firstly, using the above data base, data analytics and data visualization techniques can be used to gather business intelligence that assists in decision making strategies. can be identified to optimize the energy usage thus reducing GHG emissions in near-term and longer-term for each of the mines.

CONCLUSION

This project has the potential to significantly improve the profitability and GHG emissions and environmental characteristics of mining operations in India. To the best of the authors knowledge such a systematic project has not been conducted in India. Similar studies ongoing in natural gas industry in the western countries to reduce carbon footprint and in some cases achieve net-zero emissions by 2035. The UK and US governments are

Templates for data collection

Table: Energy inputs and respective emissions for different unit operations

Source	**Process /Activities**	**Types of Equipment**	**Number**	**Consumption of fuel + electricity**	**GHG Emission**	**Emission factors**	**Total Equivalent CO_2**
Hauling	Move ore to crusher	Dump Truck	6	xx	NO_x+ CH_4+ SO_x		
Loading	Shovel-dumper	Hyd. Shovel	4	xxxx	CH_4 + CO_2		

Table: The list of HEMM working in AKWMC

S. No.	Type of M/C and Model	No. on Roll	No. in working order	Total working hours per month	Total maintenance hours per month	Net working hours per month
1	SHOVELS	8	8	1758.6	302.8	1455.8
2	DOZERS	10	10	1014.5	384.5	630
3	DRILLS	12	7	577.9	130.5	447.4
4	BEHL BH50M-1 (old) DUMPER	4	4	480.3	210.3	270
5	BEHL BH60M-1 (old) DUMPER	5	5	970.7	185.1	785.6
7	CAT DUMPER OLD	13	13	324.1	129.7	194.4
8	CAT DUMPER NEW	16	16	2945.6	386.9	2558.7
11	SCANIA TIPPER	8	8	206	175.7	30.3
12	W/TANKER	4	4			0

Table: The list of HEMM and their Power consumption

S. No.	Machinery	Age (years)	Model	Power Consumption	UOM
1	SHOVELS		EKG shovel 265	282-394	kW
2	DOZERS		D355 BS6D170-1	310	kW
3	DRILLS				
4	BEHL BH50M-1 (old) DUMPER		BSA6D170A-1	483	kW
5	BEHL BH60M-1 (old) DUMPER		BSA6D170A-1	485	kW
6	CAT DUMPER OLD		777E	708	kW
7	CAT DUMPER NEW		773E	501	kW
8	SCANIA TIPPER		P380	279	kW
9	W/TANKER				

supporting such studies. Since India will be using coal and other fossil fuels for a long time based on current projections, the impacts of this study will be far reaching to India.

This project will also identify opportunities for energy transformation to renewable energy. Both energy efficiency and energy transformation opportunities are well documented to produce high economic and employment benefits. The case study mines will be identified in collaboration with the stakeholders. They will have diverse mining process characteristics of production geological environments, reclamation planning, and markets transport systems. Once the desired database has been developed and demonstrated for all case study mines in this project, it will be made more inclusive in terms of production characteristics processing approaches and markets served.

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Digitisation & Innovation In Mining

Ishika Kaithwas*

ABSTRACT

The global mining industry is under pressure. Looking ahead, many existing mines are maturing, resulting in the extraction of lower ore grades and longer haul distances from the mine face; ore-body-replacement rates are in decline; and new-mine-development times are increasing. On top of this, worldwide mining operations are as much as 28% less productive today than a decade ago—and that's after adjusting for declining ore grades. The key environmental impacts of mining are on disruption of the ecology. Mining is one of the most hazardous industries amongst where the rate of casualty is still very high from work place accidents. A large number of mobile mining equipment such as haul trucks, dumpers, tractors, tankers are used for different operation and such operations contribute significantly in causation of fatal and serious accidents. Mining damages health in many ways: Dust, chemical spills, harmful fumes, heavy metals and radiation can poison workers and cause life-long health problems as well as allergic reactions and other immediate problems. Heavy lifting and working with the body in awkward positions can lead to injuries to the arms, legs, and back. Exposure to coal mine dust causes various pulmonary diseases, including coal workers' pneumoconiosis (CWP) and chronic obstructive pulmonary disease (COPD). Coal miners are also exposed to crystalline silica dust, which causes silicosis, COPD, and other diseases. Machine-related accidents accounted for 41% of all severe accidents in the mining industry. Machinery most often involved in these accidents included conveyors, rock bolting machines, milling machines and haulage equipment such as trucks and loaders. The most common activities associated with these accidents were operation of the machine and maintenance and repair. The current methods to safeguard workers near machinery include mechanical guarding around moving components, lockout/tag out of machine power during maintenance and backup alarms for mobile equipment. To decrease accidents further, researchers recommend additional efforts in the development of new control technologies, training materials and dissemination of information on best practices. Digitization in mining refers to the use of computerised or digital devices or systems and digitised data that are to reduce costs, improve business productivity, and transform mining practices. However, it remains increasingly difficult for mining companies to decide which digital technologies are most relevant to their needs and individual mines. Miners have been using digital technology in virtually all aspects of their operations for decades, but some of the uses to which it is now being put sound as if they belong in the realms of science fiction. For example, 'Digital Twinning' is now being configured and installed in many mines, by many companies. This concept is of a computer-generated virtual model that mimics a mine's physical operations, allowing operators to review the status of equipment, from the largest dump trucks down to the throughputs of the smallest valves. Innovation plays a critical role in the mining industry as a tool to improve the efficiency of its processes, to reduce costs, but also to meet the increasing social and environmental concerns among communities and authorities. In foreign all work is done by automation. Machines are operated by remote area. By this, Factor of safety is increased. And Because of innovation in HEMMs diesel operated are replaced by EV resulting less air and noise pollution. Less diesel consumption will help to conserve our natural resources. CCT technique is very beneficial for Environmental impact reduction. Coal gasification technique is also trending by which The work will go on in UG mine without disturbing single person and the material will come on the earth surface. In digitization we cover all digital improvement in machines, like EV and remote sensing, GPS tracker for reducing loading and unloading time.

KEYWORDS

- ***Innovation, HEMMs, EV, CCT technique. Coal gasification technique***
- ***Digitization, Remote sensing, GPS tracker.***

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INTRODUCTION

The producing industry has reallocated its focus to improving productivity by "sweating "accessible assets, but this strategy will go only so far. Regardless of industry's booms and busts, the nature of mining has stayed the same for decades. Achieving a breakthrough on productivity performance demands rethinking how mining works. This comes to the point of industry's reach through digital and technology innovations that could transform key aspects of mining.

In this article, illustrates a number of digital technologies that's long lasting and are available and affordable.

Digital technology in the mining sector, as well as improve conceptual digital transformation agenda that is envisioned to identifying the core managerial area on which attention should be focused in implementation of the digital transformation strategy.

Development of future focused innovation oriented activities that allow industry to adapt to the change and uncertainty. The digital transformation effectively centralise the development of mining sector along with other relevant trends that are likely to shape the future of the mining.
In this study, the process of adopting technologies, digital devices, method, system, digitalized data, and an advances analytics in an appropriate way is termed as digitisation in the mining industry.

In leads to achieve desired strategic organizational objectives and business outcomes, such as cost reduction, operational performance improvement, and a general transformation of mining practice toward making is secure and more efficient and sustainable.

This innovation focused on defining a theoretical basic in a deep to understand the current global trends with regard to digitalization that's likely to the shape the future of the mining.

It also involves a review of the significant drivers and barriers related to digital transformation in the context of the mining industry.

Aiming for the consolidation of latest digital technologies into the operating model to initiate successful digital transformation, managerial implications are at-hand which can be conceptualized at the secured level.

PRODUCTIVITY

Coal is an essential fossil fuel in India. The production of coal in India hit 730mt (Million Tonnes) in the financial year 2019-2022.

Even when COVID 19 hit the mining industry it reduced man power which indirectly affected the mine productivity. Operation of the mine which lead to low production. In India, about 55% of total fuel source for power by thermal power itself, and it consume a total of 80% of the coal produced.

Our research shows that some mining companies are already turning around productivity performance, indicating that improvement is possible, and that there is room for throughout the industry.

Increase the production volume became the industry's top priority.

The industry needs a methodology that help manger to understand whether or not they are boosting their performance at breaking and moving rock.

To that end, we have developed a measure the aspects of productivity that are within their control.

Rather than peril disruption in acceptable production, it could possible comprehensible for an industry that has expected to surpass the production record year after year in past decade to learn toward what has always worked for them profitably. Even after the super cycle period, industry rate of production, innovation and technology. Didn't brought any majorly economic and productivity impact.

ENVIRONMENTAL EFFECTS AND HEALTH ISSUES

Mining is one of the most hazardous occupational in the world.

It has adverse effect in life, due to long term impact such as cancers and respiratory conditions, including silicosis, asbestosis pneumoconiosis.

Air and drinking water and habits, permanently scar natural landscapes get polluted by mining. Modern mines as well

as reckless mines are responsible for significant environment damage.

The primary source of water pollution from mining is acid mine drainage.

Acid mine drainage can burn human skin and kill fish and aquatic organisms because acid mine drainage can be 20 to 300 times more acidic than acid rain.

Signification increasing the amount of dust and particulates in the air due to hundreds of tons of rock are unearthed, moved and crushed in mining operations. In addition, mine tailing which may contain even toxic waste which became airborne. Due to which these air pollution can directly affect human health.

Analytical studies indicates connection between mining pollution and human disease and mortality as mining can cause serious health problems.

ACCIDENTS

Mining accidents are accidents that occur during the extraction of minerals or metals. Thousands of miners die from mining accidents each year, especially from underground coal mining, although accidents also occur in hard rock mining.

Coal mining is considered to be much more dangerous than hard rock mining due to flat rock formations, generally poor quality rock, and the presence of methane and coal dust. Most deaths today occur in developing countries and rural areas of developed countries, where safety measures are not fully implemented. A mining disaster is an incident where five or more people die.

Sr. no.	Date of accident	Name of mine	Killed	injured	Brief cause
1	02.02.2022	Abandoned coal mine - Gopinathpur Open Cast Project (OCP) of Eastern Coalfield Limited (ECL), Nirsa, Jharkhand	05	00	The sealed coal mine caved in after a mining equipment fell from a height of 20 feet
2	02.01.2022	Bhiwani mining site, Dadam zone in Bhiwani district, Haryana	05	02	Over-exploitation of the mine beyond the permissible limit led to the landslide
3	10.11.2021	SRP-3 mine in Srirampur in Mancherial district, Singareni Collieries (SCCL)	04	00	Mining roof collapse
4	11.08.2021	Mining site for quartz stones, Lachhuda village, Bhilwara district of Rajasthan	07	00	Stone mine collapsed
5	07.04.2021	Kakatiya Khani (KTK) coalmine in Bhupalpally Mandal, Hyderabad	02	00	Due to roof collapse
6	24.02.2021	Moonidih Coal Project area of Bharat Coking Coal Ltd (BCCL), Putki, Jharkhand	02	00	Due to roof collapse
7	21.01.2021	Illegal coal mines near Rymbai village of Meghalaya's East Jaintia hills, district.	06	00	Fell into the mine while digging a tunnel in one of the illegal coal mines after the machine, which they were using to dig the channel, broke.

8	08.12.2020	Khudiya Kadan mine of Eastern Coalfields Limited in Mugma area	02	02	Flooding of underground mine.
9	23.06.2020	Kurasia Underground Mine, South Eastern Coalfields Limited.	01	00	Explosives
10	29.05.2020	Churcha Mine (R.O.), South Eastern Coalfields Limited	01	00	Transportation machinery (Conveyors)
11	01.11.2018	VK-7 Mine(Rudrampur Coal Handling Plant) of Singareni Collieries Company Ltd.	01	00	Due to breaking of the iron sheet of the roof of an abandoned switch room and felling down on ground from a height of 1.8m and got buried beneath the coal slush.
12	14.09.2018	Dhori Khas Colliery of CCL, Dist. Bokaro	01	00	Due to Electrocution while shifting of hydraulic bolter machine, belowground.

Source: Envis Centre, Ministry of Environment & Forest, Govt. of India

DIGITISATION

In recent times the digitisation field has grown significantly and it continuous to advance and aYpt to meet the demands of mining companies around the globe.
Due to external factors the Mining industry in general is highly fluctuating such as commodity prices declining over great quality rising labour cost pressure of New Market depleting results in some commodities (ex .Tier 1 Gold producing mine) (Exhibit 1) takes place in remote locations in extreme conditions. With so many factors to consider companies place a huge importance on streamlining operations in order to remain profitable throughout these cycles.

A step towards digitisation mining industry is enormous. It also looks at the emerging technology is used to help mining companies optimise their investment on equipment while safeguarding operators apart from it is used to optimise process and maximize the value of a company existing applications.

As a result, the majority of mine side workers are carrying day to day functions very differently to how they did even 10 years ago this is due to companies leveraging available improve process across the board. This in turn has seen companies remodelling the strategies and business models accordingly.

Therefore, it comes as no Surprise that the digitisation have accelerated Mining industry more than before. Digitisation introduce automation and information system which is biggest change of all that has come due to which miners being re located from the cab of machines to automations centres where they can control their machines with all the similar functions from an ergonomic chair safely located away from the mine face with comfort and safety.

Accidentally they are easy accessible current information available making it more influential for impactful changes digitisation has completely transformed the Mining industry all over and companies being able to achieve positive outcomes in areas includes: profitability, safety, productivity, efficiency , digitization bounce many things on many levels it is not about simply connecting network.

DECISION SUPPORT DATA ANALYSIS

To prevent concerns arising in the upcoming future due to fore sights, advance data and analytics with current inference support and upcoming projections for Mining industries are becoming essential because they supplement real value of mining executions.

The use of sensors amend this data which catches and collectively informing it allows companies to make quickly and more informed decisions to help streamline operations by removing in efficiencies.

The saying is “Information is power” it rings true when applied to the Mining industry. If management is delivered with correct actual-time information about their fleet, they

RCT

Shift Towards Automation

	PRE 1930s	1930-1980	1980-2005	2005-PRESENT
LABOUR	Intensive labour for mining.	Use of equipment – Mechanisation of mining processes. Human interaction with machine at large.	Automation of simple, minimalistic mining processes.	Automation takes bigger role, with more autonomy and power to connected mines.
CONNECTIVITY	Manual reporting with data collected through manual processes.	Data captured in semi electronic format; computers at later stage.	Introduction of 2G. Data captured and communications through the internet.	Rapid development with 3G and 4G; faster and high bandwidth data communication.
DATA CAPTURE		Mine data captured through legacy systems.		Mine data monitored continuously through machine learning, IoT. Big Data Analytics, Machine-to-Machine communication.

Fig.1

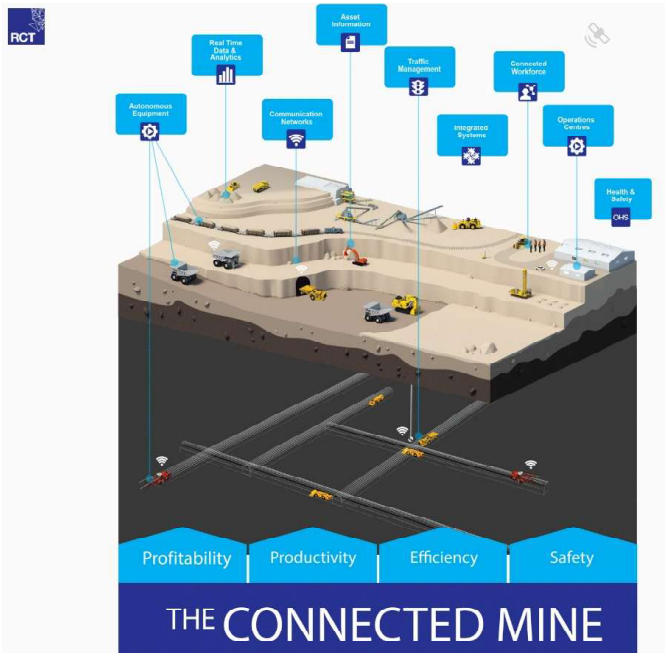

Fig.2

are capable to better supervise its performance. This is especially useful for detecting machine failure before it occurs in demand to recognise the root cause. By ignoring machines failure can prevent unpredicted down time and save money and time of company.

Additionally outcomes efficiencies when it comes to motor-activated machinery, data and analytics play and fundamental role in recognised geological characteristics during the exploration stages when it comes to setting up or value and the best exception method.

The benefits of setting up and efficient competency distribution of resources leads to increase in productivity with the help of data and analytics. It has detrimental effect that sees the mining environment the company is operating in also benefit with an overall reduction in land, water and energy.

In Today's world, information conveyed quickly and now it is applied to mining with operational intelligence been delivered immediately to smart devices by the way of tablets and smartphones.

We are fostering a digital culture on mine site. A sensor can traced from the mine side to the board room and itself strongly making a positive change that customers profit from the increase product quality that comes via more accurate production process.

Technology such as RCT' S Earth track play load management system. Transfer the payload data between the truck and loader; per meeting loader operator to see the truck's weight so they can fill the adequate load. Strut pressures from the truck send both 'weight' and 'weight distribution' to the loader-resulting in even and precise payload. By ascertaining opportune payload, the accentuate on trucks is decremented which maximises machine life and limits extemporaneous downtime.

Fig.3

ECOSYSTEMS COMMUNICATION NETWORKS

Gradually, organisations in a variety of industries are using Internet of Things (IOT) to operate more capably, better grasp process, enhance operations, improve decision-making and increase the value of the business.

IOT empower companies to automate processes and reduce labour costs. It also cuts down on waste and improves outcome, declining operational costs, as well as offering clarity into overall business activities.

The digitisation journey is wide and in order for all this information to be processed and delivered a digital communications network is required to permit the large volumes of information to be conveyed straight way.

This helps companies automate the mining process; provides them with applicable information in real-time, machine-to-machine communications and effective fleet management systems.

Digitising communications has make possible the seamless exchange of data between machines and users in both surface and underground mining.

The major impact of digitisation has had is in the underground mining space, where reliable communications systems have been an extremely difficult feat in the past for a number of reasons including the remoteness of most underground mines and the exposure to extreme conditions (the topography constantly changing).

The latest research conducted by Inmarsat, the world leader in global mobile satellite communications, has found that the global mining sector is experiencing an IOT revolution, and with respondents reported a significant increase in the adoption of connected technologies.

According to the research, most organizations have fully implemented at least one IOT project, while 33% are testing or have tested a project, only 2% of respondents have not started an IOT project yet.

These findings echo predictions reported in Inmarsat's 2018 mining study, where only 2% have fully deployed an IOT solution, 29% are testing one and 69% are planning to start. IOT projects within the next two years.

The ability to design communication solutions to overcome these challenges was paramount for the underground mining space to continue to develop in a safe and efficient manner.

There is no one-size-fits-all approach when it comes to digitizing communications in mining, as there are many factors to consider as each mine is at different stages, layouts and remoteness.

Technology example: RCT Connect RCT systems can be connected and operate on any network – Wi-Fi, LTE, hybrid or analogue – but can also provide their own full RCT Connect digital communication system.

Fig.4

INTEROPERABILITY INTEGRATED SYSTEMS

It's one thing to have all the latest technology in place, operating at a mine site, but the key to making those investments profitable is that they all work together; this is why interoperability is such an important factor. Interoperability is the ability of one system to work with or use parts of another system's equipment. This allows for the seamless capture, analysis and reporting of data from all systems operating at a mine site. This includes mobile equipment, beechnuts, people and the environment.

The fully integrated mining business enables companies to maximize value through effective planning and efficient operations

When companies choose to embrace digitization, they are able to balance resources efficiently, uniting a secure production file at all times, as dictated by business and technical reality.

It is necessary to have platforms capable of working with or using other system's equipment on a multi-brand digital operation, multi fleet open interprets.

Fig.5

HEALTH AND SAFETY

Digitization and the application of autonomous technology have a major impact on mine health and safety for better digital pathways.

The biggest factor is, of course, that the operator is removed from the machine cabin and can enjoy the safety and comfort of an ergonomically designed seat.

Automation technology also has the potential to transform the transitional form of FIFO by allowing machines to be controlled independently from a central location, away from the field, for some workers.

Fig.6

INNOVATIONS

Fundamentally changing means transforms how the mining sector operations are rapid advances in technology innovation, including automation, digitization and electrification.

Autonomous vehicles, remote operating centres, automated drilling and tunnel-boring systems, machine learning and more are the sectors which new technology is are reshaping.

In mining, green technology acts like pollution barrier. This technology reduces carbon emissions in operational and mitigate adverse environmental impacts. This technology includes the use of minerals and metals that support a transition to low carbon technologies such as solar panels or wind power.

Nowadays, technology has very wide impacts. For example it impacts on mining operations, including safety and productivity, environmental protection and opportunities for women.

Due to these technology working in mining sector becomes safer and safer working conditions through improved underground communication, automation, more sophisticated mineral and metal transportation, and emergency response measures are achieved by integrating technology into mining projects.

In mining technological advancements are making operations more productive.

Evidence of this statement are seen in the use of robotics operating 24 hours a day real time monitoring of minerals and metals through mines and processing plants and using simulation at the mind design stage to test different solutions before implementation.

The improved waste management effect and telling are being processed more efficiently by which mining sector will also play an important role in the circular economy through using renewable such as solar energy to power the verticals will also ensure more sustainable mining sector this is how innovation also support environmental conservation.

The technology in mining also help to eliminate the excuse of this sector being too dangerous for women it helps women to see employments and gender gaps reduce thanks to technology.

At the time of adopting innovative technology the mining sector should we careful and consider new trends in traceability and collaboration which helps for the betterment of mining future mining companies also need to focus on the social impacts of new technology's especially like auto-motors which replace low and medium skill workers.

Talking about outside of India, countries like Chile are using the cluster method of grouping multi-sectorial organizations together such a university, mining company and government department to achieve the benefits of technology. Inclusive work with different actors within those sectors is key to implementing technology in mining responsibly.

For large scale mining operations developing countries such in India often review foreign direct investment arrival of these foreign investment with more and new technology increases Productivity during the mining concession period.

Government need to be up to date with the latest innovations and the charges brought to their jurisdictions to ensure that the increased productivity comes with balanced economic and social benefits over the life of the mine.

Taking glace to brighter side, governments will be able to ensure high environmental standards within mining operations by encouraging certain technology. This can include giving aimed tax estimates to mining companies, making researches and education opportunities for their local workforce on the technology, and makes easy the achievement of local intellectual.

There are some innovations that today's mining company should strongly considered implementing. The good news is that these innovations lower caste and increase safety.

MINING SIMULATION

Simulators can be as simple as a software program to train workers on equipment operation. Mining simulators are on effective and save way to train employees on the use of various types of mining equipment. Like a flight simulators a mining simulation can create the experience of using, a large and complicated piece of equipment. Simulators allow workers to learn in a controlled environment. The simulation can be set up to mimic specific side. A mining simulator can also recreate a whole mining operation.

Former complex equipment a screen can be surrounded by wheels and levers. Some simulators are mounted on a track or wheels and include pneumatic operations to train workers in equipment such as cranes and drills.

Most importantly mining simulators protect people and equipment. Workers trained on simulators are more prepared to handle difficult situation that often arise on the job site. Workers competences reduce accidents. Proper uses of equipment protect a mining company's Major investment. Workers can refresh their skills using mining simulation. They can ramp up more quickly on a new project as well.

There are many benefits to mine simulation. Employees can experience different scenarios that will improve their performance on a real job site. Workers can also use simulators to determine the most efficient equipment placement. They can test different work plans to determine how best to handle operations such as drilling and its excavating.

UNDERGROUND EXCAVATORS

One of the most dangerous features of mining is drilling and blasting. The risk of death and injury is high, as the rock and field are pierced with explosives at night, as the rock is free from obstructed ground and toxic fumes.

Sovereign drill rigs and excavators keep women out of danger and standardize the blasting process. Electric cordless drills eliminate emissions.

Drilling rigs can be operated remotely. And the employee can continue the multiplication from one of the side control stations. Rex may be in similar pattern or in separate pits. End this autonomous recording and also perform non-free activities such as drumming, raging the cutting pile and plugging the hole, such as the field inspection driver.

An atlas copco pit viper drill rig was analysed/reviewed by an Australian mine 837 miles away.

Gold Company. expands its use of autonomous drilling the company retrofitted two Epiroc pit viper PV 351 rigs with autonomous capabilities at its penasquito gold mine in Mexico in 2018, other Reigns are expected to launch this year and in 2020 they will be kept in a control room that can control up to 12 drills. Automation-ready Pit Viper PV 271s protect Goldcorp workers from the dangers of surface drilling.

In addition to protecting women, autonomous drills can do a lot. Dehatu increases penetration rates, improves counters per operating hours and reduces operating costs. Goldcorp reports that execution hours per day for Dream increased by 25% and meters drilled per hour increased by 12%. The company has achieved productivity gains of 40% in meters per day.

QY Research reports that the global underground mining equipment market was $17.3 billion in 2018. They are approaching a compound annual growth rate of 6.8% between 2019 and 2025.

DRONES

Drones, or drone systems, are currently used by miners for maintenance, monitoring, mapping. Drones take advantage of a miner and secure record. The advancement of artificial intelligence in drone design is helping miners reach heights and depths once inaccessible - or just dangerous to workers.

A drone could be used to fly over and around a 310-foot, 722-foot monster and detect maintenance issues. It reduces operating costs compared to the «deal with it when it breaks» approach. Drones can also quickly deliver spare parts to the mining site, helping to get the mind back online faster.

In mining, drones have several applications like mine surveying, inventory management, stock estimation and hotspot detection, etc. Mine surveying can be done using drones to provide detailed information about locations before starting with mining projects and record their progress to visualize overtime site changes.

Drones can access highly toxic, hard-to-reach areas to provide better insights for mine planning. In coal mines, drones can be used to detect hotspots in coal stocks to assess potential areas of spontaneous combustion and enable personnel to take preventive measures. Drones could further assist watershed management, eruption planning, shipping route surface optimization and emergency response.

3D PRINTING AND MAPPING

Fortes cue Metals Group (FMG) is currently trying to manufacture parts on mine site using 3D printing technology. As of the mines are present of rough terrain and delivering heavy equipment parts there is a very difficult job to do, that's why this 3D printing technique will save a lot of money and time for the mine which can be utilised to increase the productivity and efficiency of the mine. An agreement was signed between FMG and Aurora Labs in the year 2018 to manufacture equipment parts using 3D printing technology.

3D PRINTING

The benefits/advantages of having a 3D printing facility in the mines are,

- The mine does not have to stop working for a long time if machine equipment breaks while operating. In some cases mine had to stop it's working from a few weeks to 18 months.
- It will eliminate onsite parts inventory as we can keep the spare parts in stock by printing them before hand and use them whenever needed.
- It will affect the cost on a large scale. CEO of Aurora Labs stated that the mine will be able to save around 90% which will indirectly improve the economy, higher production, and quality.

MAPPING

BHP is a producer of metallurgical coal, iron ore, and copper and it creates 3D maps of the sites using drones carrying military grade cameras. BHP testified their drone technology at their Queensland facilities of mining in the year 2015. Planes cost a lot more than drones for the 3D mapping of the site, so by using drones BHP saves 5 million dollars per annum in site-mapping. They have supercomputers developed specially to enhance the operating speed of the company site-mapping and decision making skills. BHP's drone help to clear the area before blasting, can tell whether there is traffic on the mine site or not, can analyse and update the information on stockpiles and compliance, which helps the company to improve safety and productivity.

UNDERGROUND TELECOMMUNICATIONS

As the communications system is a key part for underground mines, execution of TTE and TTA technology should be done beside the cable system as a backbone. Nowadays, TTA wireless system for underground mine is more popular as contrast to TTE communication system. The important is to develop new technologies as the depletion of radio waves causes the biggest problem for data transmission from surface to underground. Additionally research should be carried out on earth conductivity, radio antenna and the other factors affecting the data rate.

DIGITAL TWINNING

Digital Technology has become a key factor for all the virtual aspects according to the mining operations from the past few decades, but now Digital Technology is developed so much that it feels like it is too good to be true in reality.

"Digital Twinning" us a great example of future ready Digital Technology which is coming to reality and is already installed in a number of mines. Digital Twinning uses computer generated virtual model also known as "simulation " to analyse and record the operating status of an equipment, whether it is currently working in the mine or the mine operators are planning to install it in the future.

It can monitor, record, and present you the data from the smallest valves to the largest dump trucks using the sensors which are equipped in every part of mining equipment. This helps in adjusting the parameters in real time based on the "learned" parameters from the sensors.

After Digital Twinning system is installed in a mine, mine operators will have easy access to the data about all the improvements done to the overall performance of the mine, which is hard to analyse as every mining operations is unique in its own way.

CLEAN COAL TECHNOLOGY

The development of clean coal technology seeks to provide significant economic, environmental and health benefits. Economic benefits arise in many areas.

The CCT program has been influential in the commercialization of technologies such as AFBC and IGCC. The program has also shown many new ways to control emissions of sulphur oxides, nitrogen oxides, and particulate matter from coal-fired power plants.

CCT benefits the environment by reducing S02 emissions and NOx by reducing acid rain, which internally overcomes concerns about acidification, eutrophication of lakes, and damage to forest and other vegetation.

Another great benefit is in the area of human health. A decrease in smog precursors is very beneficial for human health, especially people with respiratory problems such as asthma. Reducing emissions of mercury and other toxic substances into the air is expected to lead to fewer cancers and other diseases. These benefits should reduce healthcare costs by tens, if not hundreds, of billions of dollars over the next few decades.

Additionally, market participants expect large-scale infrastructure development related to luxury automakers in their region. So the increasing complexity of on board electronics is fuelling the industry's global demand. Advances in clean coal technology are expected to result in lower emissions from coal-fired thermal plants.

Coal-fired power plants accounted for the majority share of worldwide electricity generation and are expected to drive market growth.

GPS TRACKER

GPS tracking provides complete solutions to reduce business risks. Make sure your driver is safe with the right

tax filing system, seat belt sensors and lanyards.

With GPS Tracking, you can track lone workers, fatigue, and warn drivers of outside dangers. Reduce the risk associated with speeding by enforcing on-site acceleration zones and being alerted to any acceleration events with location, duration, and high-speed details the point.

Speed is detected from the engine management system to ensure 100% accuracy. GPS tracking provides mine operations managers with control over all mining equipment. You can see where your vehicle is, on the map at any time, and see whose driving.

Regulators are also alerted when mining equipment enters the exclusion zone, giving you information to prevent any damage before it happens.

CONCLUSION

The journey of digitization has the power to change the way companies reshape their strategies and business models. Like most industries, the mining sector is constantly evolving, while in the last decade we have seen a significant increase in digitization and in particular real-time information devices and the use of autonomous machines, this is really only the beginning with even more technological advances. Come in the near future to benefit the mining industry.

RCT specialists can conduct mine audits to identify technology gaps, overlaps and new opportunities to improve operations using smart technology.

Although relevant, mining companies typically show low levels of R&D intensity, similar to mature industries and far from high-tech industries. The tendency towards vertical disintegration has led companies to focus on their core business and rely primarily on equipment manufacturers and suppliers to develop innovative solutions.

Cooperative alliances between mining companies, suppliers and research centres also play a significant role in the development of new technologies.

Automation, robotics, remotization of operations, internet of things, analytics, and digital twinning, among others, have the potential to enhance processes along the whole value chain of mining.

However, though DT is frequently mentioned as one of the main concerns among most large-scale mining companies, the level of digitization of the industry remains low, indicating that most of the potential of DT for the sector is still to be unlocked.

The main challenges that firms must face to achieve a successful digitization are the commitment and joint-task coordination between the different business units, implementing proper organizational structure changes, and promoting a new cultural mind set regarding cyber security strategies and their continuous improvement.

Other important trends are electro mobility, invisible zero-waste mining, and continuous mining. These concepts answer the necessity of building a more sustainable and efficient industry, reducing the environmental footprint, and enhancing safety of mining operations.

Finally, though the concept of continuous mining has been applied for many years in the coal mining industry, its application in other mineral sectors has the potential to increase productivity, reduce costs, and improve safety, along with technological tools brought by DT, such as automation, robotics, and remotization of operation.

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Underground Coal Gasification (UCG) Technology: A Sustainable Approach for Utilization of Indian Coal and Lignite Resources

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ABSTRACT

India aims to achieve 100 metric tons of coal gasification production by 2030, according to the policy document released by the Indian government. Underground coal gasification is a lucrative area to be explored under the aegis of the same project. Coal gasification involves the production of syngas from conventional fuels like coal and biomass under a partial combustion process in a gasifier. The underground coal gasification (UCG) process utilizes the existing know-how of the traditional gasifiers for the coal seam buried underground. Extracting the coal from the coal seams is a labor-intensive and hazardous process from an environmental point of view. Various carcinogenic particles are generated during coal mining, making the overall process environment unfriendly. UCG is advantageous since the whole process is buried under the earth (unmined coal), and there is no issue related to the ash disposal mechanism making it environment friendly. Therefore, in this article, we target to highlight the different aspects of UCG technology that have the potential to be commercialized in an environmentally sustainable way.

Keywords: Underground coal gasification (UCG), coal, lignite

BACKGROUND

India, one of the world's fastest-growing economies, needs vast energy resources to fulfill the needs of different sectors. Therefore, it is essential to note that this high electricity demand doesn't affect its social and environmental conditions and should proceed holistically. Coal is the country's most vital traditional fossil fuel, where almost all the coal power plants are based on sub-critical pulverized coal technology. But these conventional energy production techniques based on fossil fuels are leading to a rise in greenhouse gases which requires advancement in the available methods.

To resolve both the energy crisis and environmental pollution issue, thermal and catalytic conversion based on the gasification methodology of coal is becoming a matter of great interest. Recent technological advancements in coal gasification are vital in resolving the energy crisis issue. Technologies like Integrated Gasification Combined Cycle (IGCC) and Underground coal gasification (UCG), which are based on Carbon capture, utilization, and storage (CCUS), are quite important precursors for the growth of the country in a sustainable way.

UCG PROCESS AND DIFFERENT METHODS

In the UCG process, an underground extraction well is bored into the coal seam, generally located 300 m to 10 km underground and lined with steel lines and cement. Another injection well is bored at some distance away from the extraction well to produce a fluidic passage to the extraction well. Further, an igniter is inserted from the injector well to partially combust the coal seam (Ignition stage) for the duration of some hours in order to sustain combustion. Eventually, steam and oxygen (Oxygen and steam gasification stage) are injected from the injection well, which reacts with the carbon atoms present in the coal seam to produce well- known syngas. The syngas is extracted from the earlier bored steel-lined extraction well and sent further for purification and processing. UCG is advantageous since the whole process is buried under the earth (unmined coal), and there is no issue related to the ash disposal mechanism making it environment friendly. UCG is preferred for low-grade coals as their mining activity is expensive and causes pollution. A typical process flow diagram (PFD) of underground coal gasification (UCG) is shown in figure 1.

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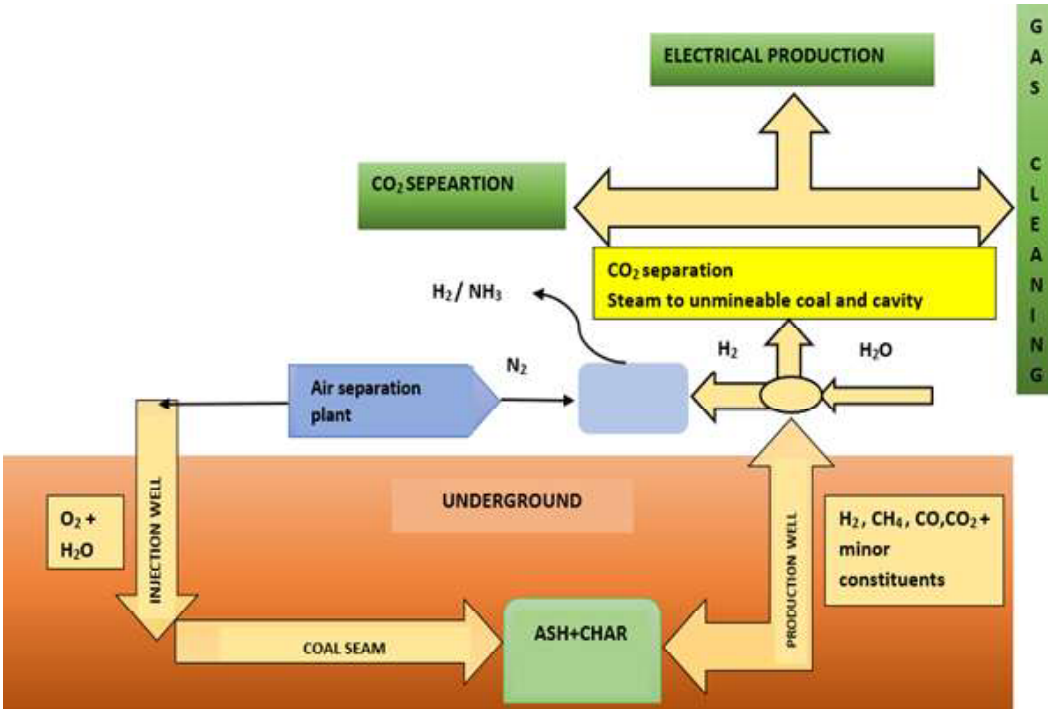

Figure 1. Process flow diagram of underground coal gasification (UCG)

Three major methods for UCG –

i. Soviet Union technology-based method where vertical wells coupled with the pressured air passage.
ii. Man-built galleries-based Chinese method where boreholes constructions are done to provide the gas passage.
iii. American and European methods which are inspired by oil and gas drilling technology. Here injection points for the gases are dynamic and dedicated boreholes are created.

UCG EFFORTS IN INDIA AND ABROAD

NITI Ayog is pushing the coal gasification technology development in India with a major push to adopt Methanol as a fuel blend/fuel. It has taken all the major steps, including fund allotment, blocking coal reserves for the purpose, setting up R&D committees, developing guidelines, etc. Considering the benefits of UCG, there has been significant theoretical and applied research work on it at various geographical locations. The following section highlights the development of underground coal gasification (UCG) technology in India –

i. National project on UCG studies with the support of Soviet experts – Mehsana in Gujarat, Merta road in Rajasthan and Jharkhand.
ii. ONGC study in Mehsana, Gujarat from 1984-86.
iii. Experimental and simulation studies at IIT Bombay, CSIR-CIMFR in partnership with NIET and IIT Kharagpur.
iv. UCG study by GAIL and CSIR-NCL at Barmer, Rajasthan, in collaboration with Ergo Exergy of Canada.

The following section highlights the UCG program at the international level –

i. Over 30 pilot trials were carried out in the USA between 1975 and 1996. The former Soviet Union also had over 50 years of hands-on experience operating UCG plants, including one of the most successful plants in Angern, Uzbekistan, which is still operational (47 years old). EKSOM set up another successful demonstration plant in Majuba power station, South Africa.
ii. China has completed at least 16 successful commercial UCG plants in the past two decades. One has been successfully demonstrated in the year 2015.
iii. Linc Energy, Australia, commissioned a UCG plant in Chinchilla, Queensland, in the year 1999, which produced syngas for three years. Furthermore, Carbon

energy limited, Australia, also demonstrated the usage of UCG syngas in the 1 MW power plant. These projects operated at shallow depths and had to face shutdowns due to environmental issues.

iv. In the European Union, the UCG plant has been successfully installed for the field trials in El Tremedal in Spain and two other locations under Polish Central Mining Institute.

v. In the UK, a step further has been taken to explore the possibility of the off- shore UCG resources.

In this article, we target to highlight the different aspects of the UCG technology and the work done by various groups on this technology that has the potential to be commercialized.

RESEARCH AND DEVELOPMENT WORK ON UCG

In the paper by Marian Wiatowski et al. [1], a set-up of a coal seam ranging in length 7.0m, with a cross-section of 1.0m x 1.0m, was arranged. At atmospheric pressure and temperature of 1600°C, the gasification process was carried out wherein the gas agent system, take-off, and cleaning-disposal of resulting process gas were done. For the test, hard coal-"Piast" was used along with wet sand for insulation and a layer of siderite as the mineral interlayer. Oxygen gas with 99.95% purity was utilized as the gasifying agent. Oxygen at a rate of 2 m^3/h was used as an ignition source. The charge also contained 800g granulates for the explosion. The process initiation was considered complete when the amount of oxygen was less than 1% for the following process. Gradually, the flow rate of oxygen was increased and later kept constant. To cool the gasified coal seam, N_2 was used. The supply of pump-feeding water prevented the clogging by gas pipes with liquified tar to the scrubber. After the test, the CO_2 was studied. However, it was found that the increased temperature of gasified coal produced a Bouduard reaction, which increased the concentration of carbon monoxide. The difference in CO_2 content in the siderite layer before and after the process proved that the flow of gasifying agent impacts the process. Moreover, the wet sand containing moisture produced water gas, improving gas concentration and balancing energy. Also, removing the process gas quickly led to the high efficiency of the gasification process.

In the paper authored by Anil Khadse et al. [2], the scope of UCG in India was studied in detail. India consists of coal which is suitable to harness for the UCG. The weak, non-coking bituminous sub-bituminous and lignite reserves are found in Gujarat, Rajasthan, Tamil Nadu, and West Bengal. According to the ultimate analysis report from seven power plants, the ash content of the Indian coal was 30%-40%. Coal mining poses many threats and difficulties, including transportation, non-uniform distribution, and storage. Thus, UCG is the economically optimal solution. In this process, two adjacent bores are drilled: injection borehole and production borehole. The produced gases are CO_2, CO, CH_4, H_2, and steam. In UCG, coal is converted to gaseous fuel, making it easy to handle and a clean form of energy. In the feasibility study which was conducted, it was shown that the coal found at a depth greater than 300m could be used economically. The lignite reserves in North Gujarat are 63 billion tonnes with a thickness of 5-50m, found at a depth of 700-1700m, making it highly favorable for UCG. On the economic front, too, UCG has the upper hand over the IGCC, making the capital cost of the former to be 210 crores lesser. The coal vision 2025 supports the development of UCG in India. Therefore, India needs to implement UCG because of the problems like high ash content, disposal of ash, transportation of ash, and surface gasification. Due to this, the consumption of coal is reduced. However, UCG can work with low-grade coal and produce gases effectively for power generation.

In the paper titled "Development of underground coal gasification in India," authored by Akshay Singan et al. [3], the key factors influencing the UCG and modeling of UCG for deployment were investigated. The parameters include coal thickness, depth of coal seam, dip, single parting thickness, fault displacement, coal rank and moisture, ash content, seam permeability, distance to the nearest overlying water-bearing unit, and coal aquifer characteristics. The desired values for the above are mentioned in the paper. In India, UCG research has already begun at CSIR-CIMFR in partnership with NIET and IIT-KGP. They worked on the feasibility analysis of coal and produced a database on the availability of coal in Northeast India. Another group in CSIR-NCL established a systematic study of a model for conversional strategies and created a detailed framework for opting a methodology to use the data. The IIT-B group carried out cavity formation and development operations in micro-UCG conditions. A report proved that the UCG saves 20-30% in capital expenses in a route of a 100mW power plant. Furthermore, it is essential to develop a characterization of coal heterogeneity and reactivity, better measurement techniques for monitoring, and improve the computational

models of UCG. The new policy framework for the development of UCG in coal and lignite reserves has been approved.

In the paper titled, monitoring and control in UCG, authored by Yuteng Xiao et al. [4] performed an investigation on the UCG monitoring system based on the Internet Of Things(IoT) and optimization using deep learning, the network model. A real-time water quality monitoring SCADA system was developed. It generates, collects, and produces instant reports displayed on the Web browser. It aims to reduce the workforce and costs, and improve water distribution and monitoring efficiency. The combustion state and the rate of heat released from the furnace were identified by the deep learning model-CNN (convolution neural network). The experiments showed that the recognition speed of each image was less than 1ms and the accuracy was 99.91%. Thus, it is a highly useful and proven tool for industrial applications.

Moreover, the design of moisture and thermal insulation was done by developing a theoretical model of radio wave propagation under high temperatures and designing a node antenna for solving the communication problems of the UCG. However, even the new technologies face issues like developing the package structure for moisture-proof and thermal insulation, strategy for management of energy optimization, and extraction design. So, these areas are yet to be explored.

In the paper by S. Bhaskaran et al. [5], a comparison between the two types of Indian coal for the feasibility of UCG with the help of lab-scale experiments was made, and the best suitable one was identified. Coal A belonged to the lignite type of soft Indian coal with volatile matter and high moisture content. Coal B was of hard Indian type of coal with relatively less volatile matter and moisture content. The coal blocks were cut into 350 x 220 x 130 mm for the experiment. Two bores were drilled for injection and production, connected through a horizontal channel at the base. The gas that comes out as products were studied with the gas chromatograph. The experiment started with the ignition, where the coal was ignited with a mixture of liquid petroleum gas and oxygen gas, which is combustible. The LPG was cut off upon ignition, and coal burning was continued with oxygen. This is the combustion phase. The steam is infused at the inlet stream to initiate the process of gasification. Later, the spalling behavior of coal was studied by heating the bottom of the coal block with the conditions being inert and atmospheric. It was observed that coal A possessed the maximum calorific value of product gas, 170kJ/mol, whereas coal B had only 69kJ/mol. The reasons for this are that coal A had the tendency to spall both in inert and atmospheric conditions, whereas B did not. Coal A also developed numerous cracks after pyrolysis; coal B had only a few cracks. The lignite type coal (A) contains high moisture and volatile matter, resulting in the structure being highly porous and the cracks development leading to spalling. Therefore, the experiments suggested that coal A (Lignite type) is much more feasible than coal B of hard type for UCG.

The Central Mining Research Institute (CMRI), Dhanbad, had extensively researched underground coal gasification [6]. As per their reports, the coal is focused in the direction of syngas production to facilitate the conversion of ammonia and Methanol. Factors like pressure, flow rate, the composition of input gas, and the catalyst affect the production and composition rate of the product gas. The properties of coal, geological conditions, and the conditions created locally during the linkage and gasification also influence.

In 1981, an agreement for the development of UCG between the government of India and the government of the then Soviet Union was signed. Recently, ONGC drilled two pilot wells near Mehsana city in North Gujarat. The results were that coal reserves of about 63 billion tonnes at depths ranging from 700-1700m were found. The carbon content is between 72-76%. The composition of methane was 1-6m^3/t. The hydrogen content was high compared to any other lignite deposits in India. The efforts taken by CMRI are the detailed evaluation of the coal samples from various coal seams for their in-situ gas content, reactivity, petrology, and different physio-mechanical properties. Water samples were also examined. It is also conducting laboratory studies with physical models. The findings were that the incorporation of steam into the well of injection decreases the temperature of the zones of reaction and improves the gasification efficiency.

Moreover, the large proportion of steam slows the gasification due to further lowering temperature in reaction zones. In CMRI, there is a facility for mathematical modeling of coal, reactions of ash and char, and heat transfer to study the cavity changes in volume, composition, and product gases. The depletion of groundwater and the contamination and the preparation of the environmental impact assessment is implemented for UCG projects. The

future scope and visions aim to compile the overall characteristics of the coal seams and identify suitable sites for UCG, evaluate technical and economic indices, and assess CO_2 capture and storage potential in cooling cavities.

According to the geological survey of India [7], the Gondwana coal is found in the eastern and central part of peninsular India of rank Bituminous to sub-bituminous, with moderate to high ash content. The tertiary coal is found in North-eastern India of meta and ortholingnitous rank. It is high in sulfur, and the lignite is located in the western and southern parts of India, which is of high moisture and volatile matter. 21% of the net in-situ proved resources are extractable within the present mining technology. The desirable coal characteristics are that it should have high reactivity, high moisture content, low rank, easily gasified, and less caking. The possible areas for deeper coal (greater than 300m) level coal reserves are the eastern part of Raniganj coalfield, the western part of the Talcher coalfield, the central part of the main basin, Singrauli coalfield, the eastern part of Pench-Kanhan coalfield, and last but not least, the central part of North Godavari Coalfield.

CONCLUSION

It is evident from the above brief analysis that there is an immediate need to create a national-level program to promote UCG with close collaboration between research, academia, and industry.

Detailed research on the Underground coal gasification process is being carried out in many places in India. The review of the above reports and journals strongly suggests that the process of UCG eliminates the need for mining, thereby protecting the earth cover and other environmental dangers. With the deployment of two borewells, namely, the injection well and production well, the coal seam can be converted to electricity. Moreover, despite India ranking fifth in the world's largest coal reserve [8], the country is facing an electricity shortage. This is understandable because of the rise in demand for alternate green energy resources. Compared to conventional coal-fired power plants, UCG has the upper hand regarding environmental safety. However, with stringent environmental rules in the country, the implementation of UCG will prove helpful in the long run because it not only is in-situ but also the burning of gasified coal produces tremendous energy, which upon harnessing it, can produce electricity.

With structured incorporation of environmental impact assessment and scientific and mathematical modeling, India can meet its energy demands by harnessing the Underground coal gasification process. Additionally, it will also assure long-term production.

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Integrated Monitoring System Design for Mine Safety Using Embedded System

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ABSTRACT

Miners' safety is a big concern today. Mining activities release harmful and toxic gases in turn exposing the associated workers into the danger of survival. This puts a lot of pressure on the mining industry. To increase the productivity and reduce the cost of mining along with consideration of the safety of workers, an innovative approach is required. Miner's health is in danger mainly because of the toxic gases which are very often released in underground mines. These gases cannot be detected easily by human senses. This paper investigates the presence of toxic gases in critical regions and their effects on miners. A real time monitoring system using wireless sensor network, which includes multiple sensors, is developed. This system monitors surrounding environmental parameters such as temperature, humidity and multiple toxic gases. This system also provides an early warning, which will be helpful to all miners present inside the mine to save their life before any casualty occurs. The system uses ESP32 WIFI module to establish wireless sensor network.

Keywords: ESP32 WIFI module, Sensors, wireless communication.

INTRODUCTION

An underground mining operation proves to be a risky venture as far as the safety and health of workers are concerned. These risks are due to different techniques used for extracting different minerals. The deeper the mine, the greater is the risk. These safety issues are of grave concern especially in case of coal industries. Thus, safety of workers should always be of major consideration in any form of mining, whether it is coal or any other minerals. Underground coal mining involves a higher risk than open pit mining due to the problems of ventilation and potential for collapse. However, the utilization of heavy machinery and the methods performed during excavations result into safety risks in all types of mining. Modern mines often implement several safety procedures, education and training for workers, health and safety standards, which lead to substantial changes and improvements and safety, level both in opencast and underground mining.

Coal has always been the primary resource of energy in India, which has significantly contributed to the rapid industrial development of the country. About 70% of the power generation is dependent on it thus; the importance of coal in energy sector is indispensable. But the production brings with it the other byproducts, which proves to be a potential threat to the environment and the people associated with it. In lieu of that the present work is a sincere attempt in analyzing the graveness and designing a real time monitoring system of detection by using the ESP32 WIFI module.

Wireless sensor networks (WSNs) have earned a significant worldwide attention in current scenario. A WSN is a special ad-hoc, multi-hop and self-organizing network that consists of a large number of nodes arranged in a wide area in order to monitor the phenomena of interest. It can be useful for medical, environmental, scientific and military applications. Wireless sensor networks mainly consist of sensor nodes or motes responsible for sensing a phenomenon and base nodes, which are responsible for managing the network and collecting data from remote nodes.The design of the sensor network is influenced by many factors, including scalability, operation system, fault tolerance, sensor network topology, hardware constraints, transmission media and power consumption. A real-time monitoring system may assist in monitoring and control over the mining environment. ESP32WIFI module offers its most of the advantages ideal for the real-time monitoring system. Thus, the primary objective of this project is decided to design an efficient real-time monitoring system so that various leaked mine gases could be identified at times and preventive measures could be devised accordingly. The research investigations to be carried out with the following objectives:

i. Detection of different toxic gases within mining

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environment
ii. Communication establishment between sensors and ESP32 module
iii. Establishment of Wireless Sensor Network
iv. Design of a real-time monitoring system

RELATED WORK

Isaac O. Osunmakinde (2012) studied the different types of toxic fumes in dangerous regions and their conditions and trends in the air for preventing miners from contracting diseases. They developed an autonomous remote monitoring system of WSNs which combines Ohm's law and mobile sensing coupled with ambient intelligence governing decision-making for mine workers. The system has been monitored the indoor scenarios which is successfully deployed in underground mines.

Mr. Kumarsagar *et al.* (2013) designed a wireless sensor network with the help of MSP430xx controller, which is monitor the smoke, gas, temperature and humidity in an underground mine. This system also controls the ventilation demand to miners depending using upon the monitoring data from the mine. This system utilizes a wireless Zigbee transceiver for remote logging of data at a central location to control the environmental state with the assistance of a motor and valve control circuitry.

Zhang Xiaodong *et al.* (2014) presented the problems and faultiness of current coal mine monitoring system. They examined the plan and implementation of a platform to remotely monitor and control coal mine production processes over Industrial Ethernet based on the embedded engineering. Integrated with each lower computer terminal are S3C2410 microprocessors that can be utilized for linking up to the monitoring network effectively.

SYSTEM MODEL

This monitoring system contains several components like ESP32-WROOM-32board, different sensors and other small electronic components. This chapter gives a detailed review of each of this part along with its working principle.

SYSTEM SPECIFICATION
ESP32-WROOM-32

ESP32-WROOM-32 is a powerful, generic Wi-Fi + Bluetooth + Bluetooth LE MCU module that targets a wide variety of applications, ranging from low-power sensor networks to the most demanding tasks, such as voice encoding, music streaming and MP3 decoding.

Fig.1. ESP32- WROOM-32

At the core of this module is the ESP32-D0WDQ6 chip*. The chip embedded is designed to be scalable and adaptive. There are two CPU cores that can be individually controlled, and the CPU clock frequency is adjustable from 80 MHz to 240 MHz. The chip also has a low-power coprocessor that can be used instead of the CPU to save power while performing tasks that do not require much computing power, such as monitoring of peripherals. ESP32 integrates a rich set of peripherals, ranging from capacitive touch sensors, Hall sensors, SD card interface, Ethernet, high-speed SPI, UART, I2S and I2C.The integration of Bluetooth®, Bluetooth LE and Wi-Fi ensures that a wide range of applications can be targeted, and that the module is all-around: using Wi-Fi allows a large physical range and direct connection to the Internet through a Wi-Fi router, while using Bluetooth allows the user to conveniently connect to the phone or broadcast low energy beacons for its detection. The sleep current of the ESP32 chip is less than 5 μA, making it suitable for Battery powered and wearable electronics applications. The module supports a data rate of up to 150 Mbps, and 20 dBm output power at the antenna to ensure the widest physical range. As such the module does offer industry-leading specifications and the best performance for electronic integration, range, power consumption, and connectivity. The operating system chosen for ESP32 is freeRTOS with LwIP; TLS 1.2 with hardware acceleration is built in as well. Secure (encrypted) over the air (OTA) upgrade is also supported, so that users can upgrade their products even after their release, at minimum cost and effort.

DHT22 Temperature Humidity Sensor

Small size & low consumption & long transmission distance (20m) enables DHT22 to be suited in all kinds of

harsh application occasions. Single-row packaged with four pins, making the connection very convenient.

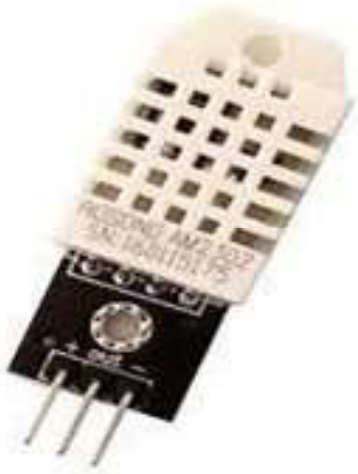


Fig. 3. DHT22 Temperature Humidity Sensor

MQ2- GAS SENSOR

The MQ2 gas sensor module is use full for gas leakage detection (home & Industry). It is suitable for detecting H2, LPG, CH4, CO, Alcohol, Smoke or Propane. Due to its high sensitivity and fast response time, measurement can be taken as soon as possible. The sensitivity of the sensor can be adjusted by potentiometer.

Fig.4. MQ-2 Gas Sensor

MQ7- GAS SENSOR

MQ7 sensor has an acute sensitivity to Carbon Monoxide and can detect the concentration of carbon monoxide in the surroundings. MQ7 sensor has a small heater inside with an electrochemical sensor to measure different kinds of gas combinations. Thus, it can be calibrated. We can use the gas sensor module at room temperature.

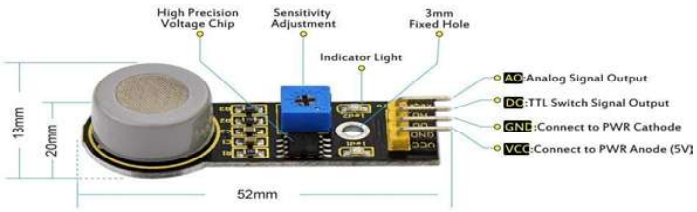


Fig.5. MQ7 Gas Sensor

MQ135 GAS SENSOR

The gas sensing material used in the MQ135 gas sensor is tin dioxide (SnO2), which has low conductivity in clean air. When there is polluted gas in the environment where the sensor is located, the conductivity of the sensor increases with the increase of the concentration of polluted gas in the air. The MQ135 gas sensor has a high sensitivity to ammonia, sulfide, and benzene-based vapors, and is ideal for monitoring smoke and other harmful gases. This sensor can detect a variety of harmful gases and is a low-cost sensor suitable for a variety of applications.

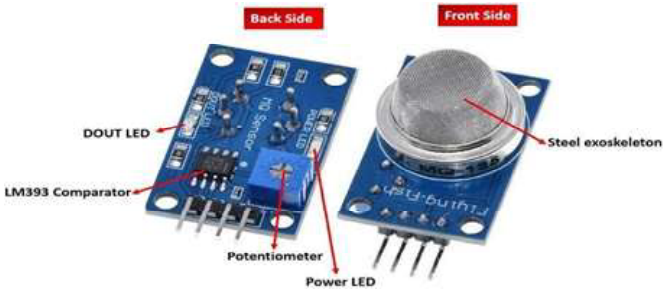


Fig.6. MQ135 Gas Sensor

ULTRASONIC SENSOR

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. High-frequency sound waves reflect from boundaries to produce distinct echo patterns. Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules include ultrasonic transmitters, receiver and control circuit.

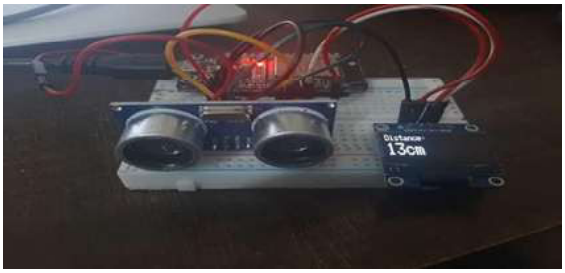


Fig.7. Ultrasonic Sensor with Esp32

WORKING MODEL

Real time monitoring system is designed to be used in the regions like mining, where it is dangerous for a human being to go without any prior knowledge about the true surroundings. This robot is deployed by MQ-2,Ultrasonic,DHT-22 sensors, which collects the information about the gases that are present in its environment and also, it is equipped with ESP32 module to transfer the information that is collected by the sensors from surroundings to the base station, at the base station we can monitor the changes that occur in the surroundings at frequent intervals, this gives us a detailed information about the environment depending on which we can take preventive measures for the mining employees to be safe. This is an autonomous robot which can go through the mining areas by avoiding the obstacles around it using the ultrasonic sensor.

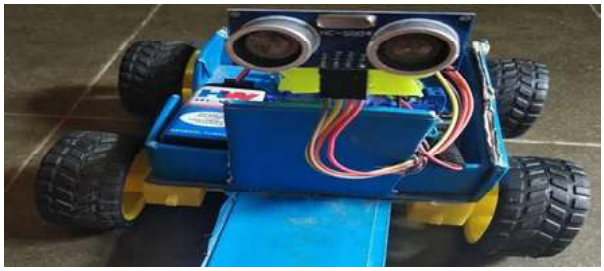


Fig.8. Autonomous robot using ultrasonic sensor

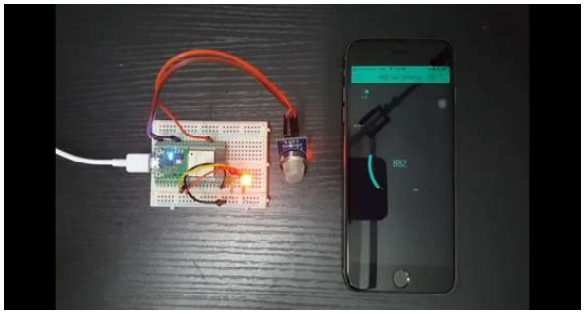
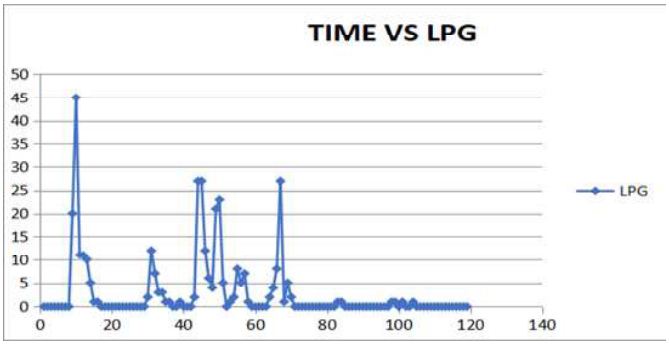
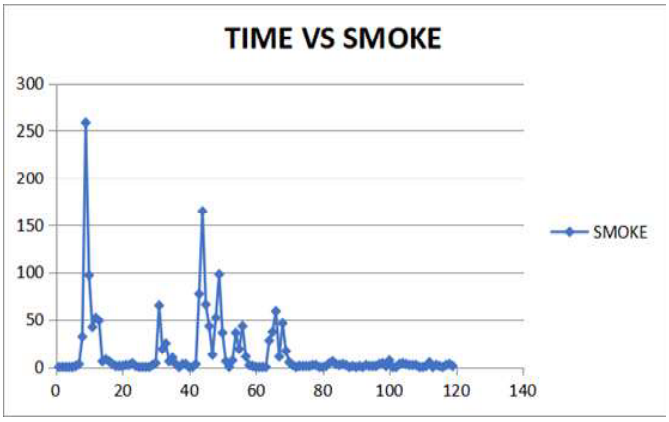


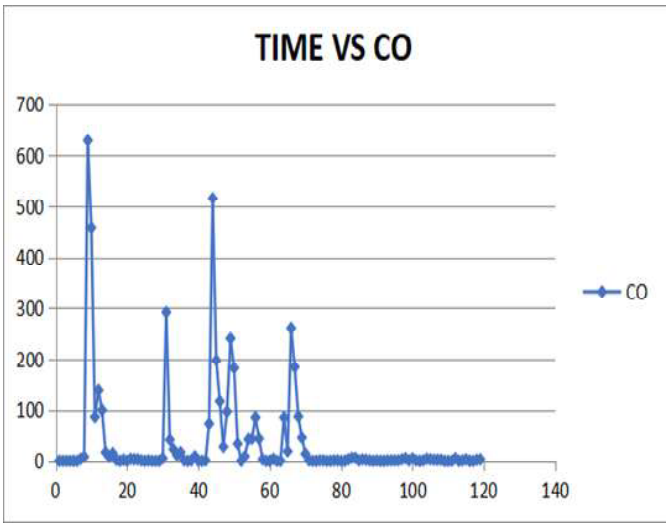
Fig. 5. Sensor Unit of Monitoring System

RESULT

The hardware and software for the real time monitoring system of mine gases has been implemented in an artificially created mine environment. The different mine gases were observed through this system and the detection were plotted in the graph as well as the data were stored in PC.







CONCLUSION

The study on real time monitoring of toxic gases and other parameters present in underground mine has analyzed using wireless sensor network. A real time monitoring system is developed to provide clearer and more point-to-point perspective of the underground mine. This system is displaying the parameters on the OLED at the underground section where sensor unit is installed as well as on the monitoring unit; it will be helpful to all miners present inside the mine to save their life before any casualty occurs. Alarm triggers when sensor values cross the threshold level. This system also stores all the data in the computer for future inspection.

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Design of Safe Blasting Parameters in Opencast Coal and Metal Mines to Pretect Structures

Jaganbandhu Naik* Chinmay* S. Pritiranjan** Singam Jayanthu***

ABSTRACT

Blasting near sensitive areas has always been a cause of concern and utmost care has to be taken to keep the charge per delay below the stipulated level. Part of the scientific studies conducted on ground vibrations induced by blasting, and to estimate safe maximum charge per delay to protect the nearby structures are presented. This paper also presents instrumentation with accelerometers, and scientific studies conducted on ground vibrations due to blasting with various types of explosive and accessories (Cartridge, Site Mixed Emulsions, electronic detonators etc) at Dunguri limestone mine, Jindal Power Opencast Coal Mine- Tamnar, and Baphlimali Bauxite Mines under M/S Utkal Alumina International Limited, Jayanthipuram Limestone Mine, The Ramco cements Ltd, Manuguru OCP etc to design safe blasting practices to contain the ground vibration levels below the damage criteria to protect the structures surrounding the blasting site. A number of field visits were made to collect the geotechnical data, and monitoring ground vibrations induced by blasting for above excavations. A number of blasts were monitored to study various blast parameters related to blasting Overburden and pit benches and to understand the effect of blast on the surrounding structures, and rock mass conditions at the above four excavations. Further studies with application of trans-disciplinary research including Wireless Sensor Network (WSN) and Internet of Things (IoT) is also recommended for collection of more relevant data, analysis and communication of data for better implementation of the results at mine sites.

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Mining Industry CO_2 Emission & Reduction

Prof. Rajesh Sulkhe* Ashish Churhe**

ABSTRACT

Climate change has grown to be a major issue for humanity in this anthropocentric era. According to scientists, the amount of greenhouse gases—particularly carbon dioxide—varies directly with the rate of global warming and climate change. Carbon Capture and Storage (Sequestration) (CCS) has been suggested as a possible strategy in recent years to continue using fossil fuel-powered power plants and other industrial processes, including the mining industry, while keeping CO2 emissions from entering the environment. We will be talking about CO2 transport and storage. The significance of optimising the CCS system as a whole is addressed. Other topics briefly discussed include the viability of both the capture of CO2 from the air and CO2 reutilisation as climate change mitigation strategies.

INTRODUCTION

The increasing average atmospheric temperature has led to global warming, which drives a set of changes to the Earth's climate and weather systems. These rapid alterations are taking place as long as humans continue to release heat-trapping greenhouse gases (GHG) into the atmosphere. Among these emissions, carbon dioxide (CO2) is the major anthropogenic greenhouse gas because of its abundance and tendency to dwell in the atmosphere for a long period of time. Companies engaged in mining and mineral processing are considering ways to utilise less energy in order to cut costs and emissions, particularly in light of any potential carbon emissions plan. Companies need to have a comprehensive awareness of their present energy usage in order to accomplish this, thus they need tools that will enable people to make decisions. Energy is needed by the mining sector to transport and process ore, as well as for employees, supplies, and equipment to be deployed in far- off locations. All of these processes direct or indirect emit CO2 to varying degrees during these activities.

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The Carbon Disclosure Project reported that in 2015, 20 mining corporations and 50 other heavy fossil fuel industry companies produced half of all industrial greenhouse gas emissions globally. Between 4% and 7% of the world's greenhouse gas emissions currently come from mining.

THE PARIS AGREEMENT

The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP21 in Paris, on 12 December 2015 and entered into force on 4 November 2016. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century.

The entire value chain must significantly contribute to any endeavour that has any chance of being successful in achieving the objectives of the Paris Agreement. All sectors would need to reduce CO2 emissions by at least 50% by 2050 relative to 2010 levels to stay on track for a global 2°C scenario. It would take a reduction of at least 85% to keep global warming below 1.5°C.

CARBON CAPTURE AND STORAGE (CCS)

There are many methods we can implement to reduce carbon emission but the most promising way is Carbon Capture and Storage, or CCS. Reducing carbon emissions using CCS could be crucial in the fight against global warming. It's a process, involving: capturing the carbon dioxide produced by industrial activity, such as mineral

processing; transporting it; and then storing it deep underground.

The mining industry must take swift action to implement carbon capture and storage (CCS). All new plants should be constructed to be carbon capture-ready in advance of expected domestic or international legislation to restrict industrial carbon emissions. Existing cement, iron/steel, and minerals processing plants with a long operational life must assess their CCS potential. Such a law will be part of global efforts to keep temperature increases below 2 degrees Celsius, above which the effects of climate change will be unpredictable, harmful, and difficult to control. By 2050, it is expected that global temperatures will have risen 6 degrees as a result of unchecked carbon emissions.

The International Energy Association (IEA) estimates that CCS technology will be responsible for up to 14% of CO2 reductions by 2050, which would be a substantial contribution to decreasing emissions. Energy efficiency has the potential to reduce carbon emissions more than other techniques, but because this depends on demand-side management, which is more difficult to implement, other carbon reduction measures, like CCS, must do more.

CCS is currently the only technology that can assist in lowering emissions from significant industrial facilities. It might be a crucial piece of technology in the fight against climate change. CCS has the ability to produce "negative emissions," eliminating CO_2 from the environment, when combined with bioenergy technology for power generation (so-called BECCS - bioenergy with carbon capture and storage). In order to achieve the Paris Agreement's aim of keeping global temperature rise to under 2°C, many scientists and policymakers argue that this is essential.

Carbon capture and utilization (CCU) and CCS are sometimes discussed collectively as carbon capture, utilization, and sequestration (CCUS) This is due to the fact that CCS is an expensive procedure that results in a product with a low intrinsic value (i.e. CO_2). Since the low cost of CO_2 may be utilised to manufacture high- value compounds, carbon capture makes greater economic sense when it is combined with a utilisation process. This helps to offset the high costs of capture operations.

There were 51 large-scale CCS facilities globally as of that time, according to the Global CCS Institute's 2019 report. 19 of them were already in use, 4 were being built, and the rest were in various phases of development. Two were in the Middle East, 24 were in the Americas, 12 were in Europe, 12 were in Asia-Pacific.

The Intergovernmental Panel on Climate Change (IPCC) emphasised that, in addition to stepping up efforts to cut emissions, we also need to use technology to remove carbon from the atmosphere if we hope to meet the Paris Agreement's goals of limiting future temperature increases to 1.5°C (2.7°F). Since CCS is one of these technologies, it can be crucial in the fight against global warming.

HOW DOES CCS WORK ?

There are three steps to the CCS process:

- *The CO_2 is separated from other gases produced in industrial operations, such as those at steel or cement factories, or coal- and gas-fired power plants.*
- *After compression, the CO_2 is sent to a location for storage using pipelines, ships, or land vehicles.*
- *Finally, the CO_2 is pumped into subterranean rock formations for long-term storage.*

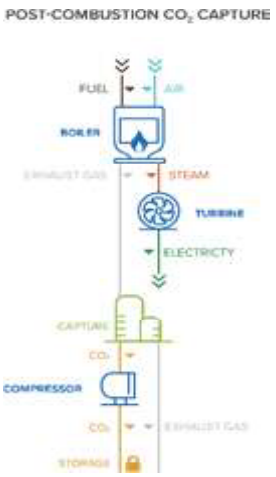
CAPTURE

The most economical places to capture carbon dioxide are at point sources, such as big carbon-based energy facilities, industries that produce a lot of carbon dioxide (like steelmaking and cement production), plants that process natural gas, and facilities that make synthetic fuels and hydrogen from fossil fuels. Although it is technically possible to extract carbon dioxide from air, the lower carbon dioxide concentration in air compared to combustion sources complicates the engineering and raises the cost of the procedure. Sulphur and water impurities in carbon dioxide streams can significantly alter their phase behaviour and raise the risk of corrosion in pipelines and wells. When CO_2 contaminants are present,

especially with air capture, the flue gas must first be cleaned using a scrubbing separation process. It is feasible to sequester approximately 65% of CO2 that is embedded in it in solid form. All new mine plants, including mineral processing units, should be constructed to be carbon capture-ready in advance of expected domestic or international legislation to restrict industrial carbon emissions. Existing cement, iron/steel, and minerals processing plants with a long operational life must assess their CCS potential.

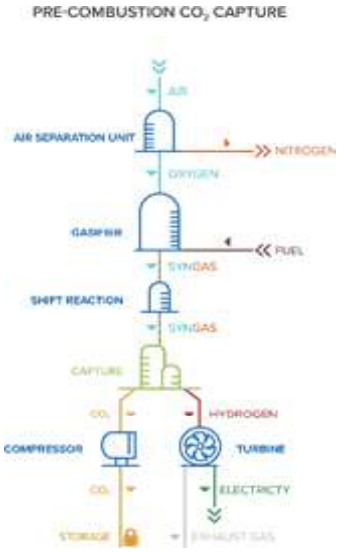
Broadly, three different technologies exist: post-combustion, pre-combustion, and oxyfuel combustion:

Post combustion capture method—



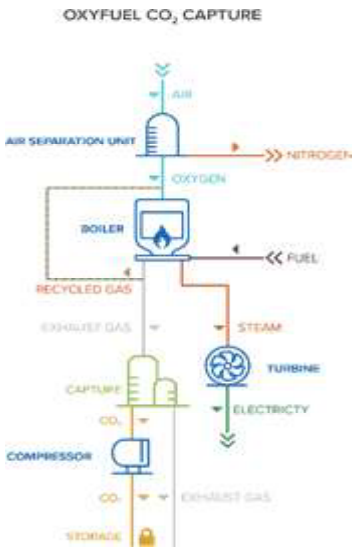
Involves the removal of CO2 after the combustion of the fossil fuel. Flue gases at power plants or other point sources are used to extract CO2. Although at a lesser size than necessary for a commercial scale station, the technology is well known and is being used in various industrial applications. Because fossil fuel power stations may be upgraded to integrate CCS technology in this arrangement, post combustion capture is the most often studied technique.

- *Pre-combustion capture method—*
  Pre-combustion technology is used widely in the production of fertiliser, chemicals, gaseous fuel (H2, CH4), and electricity. In these situations, the fossil fuel undergoes partial oxidation, perhaps in a gasifier. When additional steam (H2O) is injected, the CO from the resultant syngas (CO and H2) reacts and shifts into CO2 and H2. An exhaust stream that is comparatively pure can be used to capture the generated CO2. The CO2 is eliminated prior to burning, and the H2 can be used as fuel. Various benefits and drawbacks are applicable when compared to post combustion capture. After burning but before the flue gas expands to atmospheric pressure, the CO2 is extracted. The CO2 is removed after combustion, but before the flue gas expands to atmospheric pressure.



The capture before expansion, from pressurized gas, is standard in almost all industrial CO2 capture processes, at the same scale as required for power plants.

- *Oxy-fuel combustion capture method—*



Instead of burning in air, oxy-fuel combustion burns fuel in pure oxygen. Cooled flue gas is pumped back into the combustion chamber, limiting the resulting flame temperatures to those common of conventional combustion. Mostly CO_2 and water vapour, which is condensed through cooling, make up the flue gas. The end result is a stream of CO_2 that is almost entirely clean. Because the CO_2 stored is not a fraction taken out of the flue gas stream (as in the situations of pre- and post-combustion capture), but the flue gas stream itself, power plant processes based on oxyfuel combustion are frequently referred to as "zero emission" cycles. Unavoidably, some CO_2 will end up in the condensed water.

SEPARATION

The following are the main technologies for carbon capture:

- *Cryogenic*
- *Membrane*
- *Oxyfuel combustion*
- *Adsorption*
- *Chemical looping combustion*
- *Calcium looping*
- *Absorption*
- *Multiphase absorption*

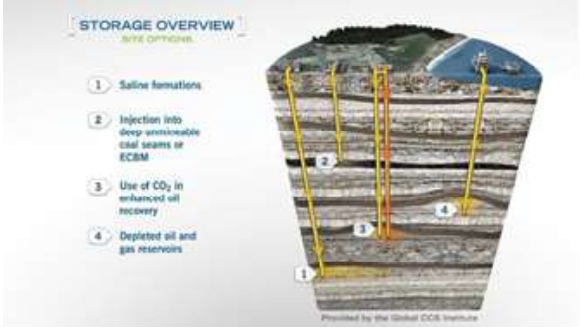
The most popular capture method is absorption, or carbon scrubbing using amines. The only carbon capture technology that has so far been applied industrially is this one.

Depending on the porosity and selectivity of the MOF, CO2 adsorbs to a MOF (Metal-organic framework) through physisorption or chemisorption, leaving a CO2 poor gas stream behind. In order to reuse the MOF, the CO2 is subsequently removed from it using temperature swing adsorption (TSA) or pressure swing adsorption (PSA). Adsorbents and absorbents need regeneration processes that remove the CO2 from the sorbent or solution that took it from the flue gas in order to reuse the sorbent or solution. The most effective amine for trapping CO2 is Monoethanolamide (MEA), which has a heat capacity of 3–4 J/g K because of its high-water content. In the solvent regeneration process, higher heat capacities increase the energy cost. Low heat capacities and temperatures of adsorption are therefore desired for a MOF to be optimised for carbon capture. To capture as much CO2 as feasible, excellent selectivity and working capacity are also preferred. Selectivity and energy use are complicated by an energy trade-off. The energy and, hence, the cost needed to renew grow as the amount of CO2 captured increases. The restriction imposed by their chemical and thermal stability is a disadvantage of MOF/CCS. The characteristics of MOF are being optimised for CCS in research. Metal reservoirs are still additional restriction.

TRANSPORTATION

The CO2 must be transferred to appropriate storage locations after being captured. The least expensive mode of transportation is by pipeline. Ships can be used in places where pipelines are impractical or over relatively long distances. They may be less expensive than pipelines. These methods are used to transfer CO2 for a variety of purposes. Pipelines and ships cost about half as much as rail and tanker trucks. In Norway, a 160- kilometer pipeline was used to transport CO2 to oil production locations where it is injected into older fields to produce oil, while in the United States, approximately 5,800 kilometres of CO2 pipelines were operational in 2008. Enhancing oil recovery is the term for this injection. Pilot initiatives to investigate long-term storage in geologic formations that don't produce oil are now being developed.

SEQUESTRATION (STORAGE)



Different strategies have been developed for long-term storage. These include the storage of gas in subterranean geological formations (such as salt domes and depleted gas fields) and the storage of solids through the reaction of carbon dioxide with metal oxides to generate stable carbonates. CO2 storage in the oceans was once proposed, but the London and OSPAR conventions forbade this since it would worsen ocean acidification.

- ***Geological storage***
  Injecting CO2—typically in supercritical form— into subterranean geological formations is known as geo-sequestration. Alternatives have included oil deposits; gas fields; saline formations; unmineable coal seams; and saline-filled basalt formations. The CO2 can't reach the surface because of physical (such as highly impermeable caprock) and geochemical trapping mechanisms. Because CO2 molecules cling to the coal surface, unmineable coal seams can be utilised. The permeability of the coal bed determines technical viability. Methane that has already been absorbed by the coal is released during the absorption process, and this methane can be recovered (enhanced coal bed methane recovery). Methane income can help cover some of the costs, but burning the resulting methane creates another stream of CO2 that needs to be absorbed.

  Mineralized brines are found in saline formations, but they haven't yet been of any use to people. On a few occasions, saline aquifers have been used to store chemical waste. Saline aquifers have a lot of potential storage space and are widespread, which is their principal advantage. The fact that saline aquifers are mostly unknown is one of their biggest drawbacks. Geophysical exploration may be restricted to make storage costs manageable, which would increase ambiguity over the aquifer structure. No side product can make up for the expense of storage, unlike storage in coal beds or oil fields. The CO2 underneath may be immobilised and the risk of leaks reduced via trapping processes like structural trapping, residual trapping, solubility trapping, and mineral trapping.

- ***Mineral storage***
  Metal oxides and CO2 can exothermally react, resulting in stable carbonates (e.g. calcite, magnesite). Much of the surface limestone is produced by this process (CO2-to-stone), which happens naturally over several years. One such MOX is olivine. A catalyst, higher temperatures, pressures, mineral pre-treatment, or any combination of these can speed up the reaction rate, albeit these techniques may demand more energy. According to the IPCC, a power plant using mineral storage and equipped with CCS would require 60–180% more energy than one without. According to theory, carbonates can develop from up to 22% of the mineral content in the crust.

ADVANTAGES OF CCS

According to the Grantham Institute at the London School of Economics, CCS has a number of advantages over other kinds of carbon removal technology and is currently the only carbon capture technology that can cut emissions from industrial plants.

- CO2 can be removed more easily at point sources
  The fact that there is not much CO2 in the atmosphere is one of the main drawbacks of extracting it from the air using methods like direct air capture. Pre-combustion is a type of CCS where fuel is processed to create a combination of hydrogen and carbon monoxide. The mixture, often referred to as syngas, interacts with water to create hydrogen and extremely concentrated CO2.
- *CCS can reduce emissions at the source* Nearly 50% of the country's greenhouse gas emissions are caused directly by industry or energy production. The capacity of CCS to absorb CO2 from these point sources and then permanently store it in geological formations is perhaps its greatest benefit. According to the International Energy Agency, CCS has the potential to eliminate up to 20% of all CO2 emissions from industrial and energy generating plants.
- Multiple pollutants can be eliminated simultaneously. Oxyfuel combustion results in a large reduction in nitrogen oxide (NOx) and sulphur dioxide emissions due to the high oxygen concentrations employed during the combustion process. According to a study done for the Argonne National Laboratory, burning of oxyfuels results in a 50% reduction in NOx emissions when compared to combustion of ordinary air. An electrostatic precipitator can be used to remove the particles produced by oxyfuel combustion CCS.

DISADVANTAGES OF CCS

Despite the benefits of employing CCS to lessen the quantity of CO2 released into the environment, there are still a number of implementation-related problems that need to be resolved.

- *Using CCS for Oil Recovery Could Defeat Its Purpose*
  Enhanced oil recovery is one current application for the CO2 captured during the CCS process. Oil firms buy the CO2 that has been caught in this procedure and inject it into exhausted oil wells to release trapped oil that would otherwise be inaccessible. Eventually, when that oil is burned, additional CO2 will be released into the environment. Without taking into consideration the CO2 emitted by the oil that was made available, the quantity of CO2 gathered during CCS will only be increasing the amount of greenhouse gas in the atmosphere.

- *Costs for CCS Are High*
  If no subsidies are provided, the cost of the product being produced must rise in order to equip current industrial and electric generation facilities with CCS technology. According to one study by University of Utah scientists, the cost of power is expected to rise by 50% to 80% in order to pay for the adoption of CCS technology. The expense of building infrastructure to transport it, store it, and separate CO2 may be prohibitively expensive because there are currently few legislative mechanisms in place to encourage or mandate the adoption of CCS.

- *CO2 Transport and Storage Sites Could Be Dangerous*
  Although there aren't many accidents when moving CO2, there is still a chance for a serious leak. The Intergovernmental Panel on Climate Change claims that if a pipeline were to leak CO2, a level of 7% to 10% in the surrounding air might immediately endanger human life. Another issue is leakage at the location of subsurface storage. The health of nearby people and animals could be at danger if there were a sudden CO2 leak at an injection site.

RESULT

The International Energy Association (IEA) estimates that CCS technology will be responsible for up to 14% of CO2 reductions by 2050, which would be a substantial contribution to decreasing emissions. Energy efficiency has the potential to reduce carbon emissions more than other techniques, but because this depends on demand-side management, which is more difficult to implement, other carbon reduction measures, like CCS, must do more.

If CCS is implemented across the industry, there will surely be disruption and added costs for businesses if legislation makes it essential. There are actually a lot of similarities to flue gas desulfurization, which was made necessary in the 1990s. Sulphur dioxide was never considered in our calculations until new laws were passed in response to acid rain, at which point it became a necessary component of industry and electricity production. CCS will experience the same thing. The industry will need to adjust, and governments will impose it. However, the companies that are already preparing for CCS will be the ones least impacted by new laws.

Such a law will be part of global efforts to keep temperature increases below 2 degrees Celsius, above which the effects of climate change will be unpredictable, harmful, and difficult to control. By 2050, it is expected that global temperatures will have risen by 6 °C as a result of unchecked carbon emissions. Governments will gather in Paris for the COP21 climate negotiations at the end of the year in the hopes of reaching an agreement on a legally-binding policy to combat climate change. Multinational action to reduce emissions is essential.

The cost of CCS will also decrease as technology advances, and there has been significant advancement recently. The British government is funding CCS projects at Drax, North Yorkshire's Peterhead gas-fired power station and the White Rose coal-fired power station. Nine power plants in India have been assessed for CCS "future proofing," and the first CCS iron and steel plant in the UAE will be finished in 2016. 32% of CCS is anticipated to be industrial by 2050, primarily in the mining industry.

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Slopes Stability

Yash Tiwari*

ABSTRACT

In Opencast Mines, Slope failure has caused heavy losses of production, life and property, and production delay over the past few years. To prevent losses, slope stability is a crucial consideration. Slope stability refers to the condition of inclined soil or rock slopes to withstand. About 18% of accidents in India occur in opencast mines due to slope failure. When the stability conditions are not met, the soil or the rock mass of the slope may experience downward movement, which could be either slow or devastatingly rapid. This phenomenon is known as slope failure or landslide.

The causes of slope failure include the opening of joints with a subsequent reduction in the cohesive and friction forces, the presence of groundwater and its flow through the distressed zone reducing the effective normal force on potential plane failure, presence of geological disturbances such as fold, fault, dykes, etc.

Factors that can trigger slope failure include hydrologic events such as intense or prolonged rainfall, progressive soil saturation, increased water pressure within the slope, earthquakes, internal erosion, artificial slope loading, slope cutting, or slope flooding. Plane failure, wedge failure, Circular failure, and Toppling failure are different types of slope failure.

Factors affecting the slope stability are the Height of the slope, Slope angle, Angle of repose, Geological structure, Lithology, Groundwater, Mining method and equipment, Dynamic forces, Cohesion, Angle of internal friction, Temperature, and Vegetation.

Specific ways to improve the slope stability in surface mining are - Reduction in bench height, Reduction of slope face inclination, Drainage of slope (surface drains, Horizontal drains, Collector drains), Reinforcement of slopes with bolts and cables (Rock bolting, Rock anchoring, anchoring with retaining wall), Controlled blasting technique (Buffer blasting, Pre-splitting, Smooth wall blasting).

Slope stability analysis assesses the safe design of human-made or natural slopes and the equilibrium conditions. Various methods are available for slope stability analysis - 1: limit equilibrium, 2. Finite element method, 3. Numerical method of modeling. The finite element method is commonly used as the development has made in the performance of computer applications in finite element method. In this, the critical surface is automatically found by Software. The finite element method has the advantage of model slopes with a degree of very high realism (complex geometry, sequence of loading, presence of material for Reinforcement, action of water, and laws of complex soil behavior). It also better visualizes the deformation of soil in place. The finite element method can model progressive failure.

The stability of a slope is essentially controlled by the ratio between the available shear strength and the acting shear stress, which can be expressed as a safety factor. A slope can be globally stable if the safety factor is always larger than 1 (1 and 1.5). Vegetation should be done on a dump to control the landslides or slope failure, proper monitoring should be done, and special arrangements should be made for the rainy season and provide enough illumination.

Keywords – Slope stability, Opencast mines, Slope failure, Causes, Factors aûecting, Methods, Factor of Safety.

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INTRODUCTION

Slope stability is an inclined surface of soil or rock capable of suffering failure or undergoing any moment. Slopes are generally classified into two groups which are artificial slopes and natural slopes. The artificial slope includes the earth dams, embankments, and road cuttings that are established for the projects. Natural slopes include plate tectonics and weathering/erosion.

Slope stability uses principles of, geotechnical engineering, soil or rock mechanics and engineering geology. The stability of a slope is of empathetic importance in Geotechnical Engineering applications. Whenever the slope stability is not in balance the rock/soil experience the downward moment and this downward moment is referred to as the landslide. It may be a very rapid or slow moment. Landslides occur due to earthquakes, heavy rainfall that causes water pressure on the rock/soil, or the degradation of the mechanical property of a ground. Slope failure causes huge losses to human life and infrastructure.

For mining and civil engineering projects, slope stability plays a very important role. For example, in landfills, embankments, surface mining, underground mines, tailings dams, and as well as large excavation. Slope design is also an important consideration in slope stability. Slope design requires information regarding the site's geology and its characteristics. For example, the properties and status of rock mass, soil, and groundwater in and around the excavation. These are the information required for a successful slope design. It requires great skills and expertise for designing and monitoring slope stability.

To evaluate the stability of slopes in rock and soil, slope stability analysis is the empirical method for determining slope stability. The analysis is generally aimed at understanding the causes of an occurred slope failure, or the factors that can potentially trigger a slope movement. There are three methods available for slope stability analysis are - limit equilibrium, Finite element method, and Numerical method of modeling.

SLOPE FAILURE

Slope failure means a gradual or rapid movement of rock or soil caused by gravitational stress acting on the unstable slope. Slope failures are generally triggered by the intense rainfall and weathering effect on the soil or rock or movement of Heavy Earth Moving Machinery.

The angle of the sloping bench should be either equal to the angle of repose or less than the angle of repose of the bench rock. For loose and friable rock, the angle of slope is necessarily up to the angle of repose of rock to prevent the subsequent falling of rock. For competent rock, the angle of slope of the bench varies from 70 to 85 degrees. The angle of slope depends upon the plane of weakness, the orientation of bleeding planes, etc.

Types of Slope Failure

The various types of slope failure are:

1. Planar failure
2. Circular failure
3. Wedge failure
4. Toppling failure

PLANE FAILURE

Block sliding along a single-week plane. Plane failure occurs when geological discontinuity such as a bedding plane strikes parallel to a slow face and dips into the excavation at an angle greater than the angle of internal friction of the joint surface.

General condition

The following geometrical condition must be satisfied for a plane failure to take place.

- The failure plane must strike parallel to the slope face.
- The dip of the failure plane must be smaller than that of the slope of the face.
- The deep of the failure plane must be greater than the angle of friction of this plane

CIRCULAR FAILURE

When the material is very weak, as in the overburdened soil, or when rock mass is heavily jointed or broken as in Christ waste the failure may be defined by a single discount annuity surface but will tend to follow a circular path.

Circular failure of three types

1. Toe failure
2. Slope failure
3. Base failure

Toe failure
Here failure occurs with the surface that passes through the toe. It is the most common failure.

Slope failure
In which the failure occurs along the surface that intercepts the slope above the toe.

Base failure
Here failure occurs with the surface in which the failure surface passes below the toe.

Condition
a. When the individual particles in a soil or rock mass are very small as compared with the size of the slope.
b. When the particle is not interlocked.

Wedge Failure

It occurs in rock masses with two or more sets of discontinuities whose lines of intersection are approximately perpendicular to the strike of the slope and dip towards the plane of a slope.

The wedge in rock resting on these discontinuities will slide down the line of an intersection when the inclination of the line is greater than the angle of friction.

Condition
- Out of two planes, one plane may be flat and another may be steep. Plane 'a' is cheaper than plane 'b'.
- The dip angle of at least one joint intersection is greater than the friction angle of the joint surfaces
- The line of joint intersection intersects the plane of the slope.

TOPPLING FAILURE

Toppling failure occurs when columns of the rock are formed by steeply dipping discontinuities in the rock structure and it involves overturning or rotation of rock layers about some fixed base.

Types of toppling failure

a. Flexural toppling
b. Block toppling
c. Block flexural toppling

a. Flexural toppling
In this type of failure, the continuous columns of rock which are separated by well-developed steeply discontinuities break into flexures as they bend forward.

b. Block toppling
Block toppling occurs when an individual column of hard rock is divided by widely spaced orthogonal joints.

c. Block flexural toppling
This type of toppling failure is characterized by the pseudo-continuous flexure along columns that are divided by numerical cross joints.

FACTOR OF SAFETY

The factor of safety is the ratio of the maximum load or stress that a soil can sustain to the actual load or stress that is applied. For highway embankment side slopes the minimum factor of safety should be as low as 1.25. The factor of safety should be in the range of 1.30 to 1.50

To design safety factors for a particular project depends on

- The stability analysis method is used.
- To determine the shear strength.
- The degree of confidence in the data.
- The chances of failure.
- How critical the application of failure is.

STABILIZATION STRATEGIES TO REDUCE SLOPE FAILURE

The main objective of slope stabilization is to prevent slope failure and to increase the safety of the public. Some techniques used for slope stabilization are given below:

1. To make the nearby locations safe for public usage provide rock fences or walls along the slope side.
2. To strengthen the jointed rock mass use the rock bolts.
3. In rockfall, locations alerts signal should be provided.
4. Use of dowel bars.
5. Constructing rock trap ditches at the toe of the slopes.
6. For rock fall collection bench or berms should be constructed.
7. Tunnels and rock sheds should be constructed.
8. Constructing concrete with weep holes.
9. Providing mesh secured by bolts and grunted to protect

the friable formation
10. Provides drain pipes and holes.
11. Adopt a rock anchor to prevent movement along discontinuity joints.
12. Constructing rock fall barriers at the toe of slopes.
13. To slow down the toppling of blocks provide hanging chains.
14. Dressing of unstable rocks.
15. Providing free-hanging mesh.
16. The overburden slope must be flattened.
17. Scaling of loose materials or blocks should be done.

SLOPE ANALYSIS METHOD

1. Limit Equilibrium Method
2. Finite Element Method
3. Numerical method of modeling

Limit Equilibrium Method

Slope Stability Analysis by the Limit Equilibrium Method: For the safe design of slopes some fundamentals and Methods are presented. For two and three dimension limit equilibrium method is the most common approach for slope stability. This method drives the factor of safety for the particular geotechnical situation and identifies the failure mechanism of the slope. It is an ideal choice for assessing the shallow and deep foundations, stability of retaining walls earth and rock dams, potential landslides, and surface mining sites.

The fundamentals of slope stability describe slope movements and the appropriate methods for stability analysis, factors of safety and mechanics of slope failure, laboratory and field methods to estimate the phreatic surfaces, estimation of shear strength of soils, and remedial measures for correcting slides. Stability analysis Methods provide simple formulas for estimating the factor of safety for plane failures, methods of slices for two and three-dimensional analysis, stability charts, and reliability of slope design.

A preview of a companion product provides, LEAME Software and User's Manual: For analyzing Slope Stability by the Limit Equilibrium Method, for performing the slope stability analysis by a computer program presented in this work.

Finite Element Method

Structural engineers in recent years have developed the technique of analysis in which a continuum structure can visualize as an assemblage of finite elements. The deformation of each element is related to nodal displacement which is related to nodal forces.
The summation of nodal for displacement relationship overall elements of the structure results in a set of simultaneous equations of the form
{A}={S} {U} ——————1

In which {A} and {U} are common vectors representing nodal forces and displacement respectively. {S} is a square and symmetric matrix called the stiffness matrix of the structure. To affect a solution to a problem by the finite element technique equation 1 is solved for {U}.

The stresses and displacement fields in the structure are compacted from the displacement the step-by-step procedure in analyzing a problem using the finite element analysis is described by 'zienkiewiez'.

The formation of finite elements permits different physical behavior to be easily introduced in the analysis thus it has been possible to investigate stress around mine openings located in a non-homogeneous continuum such as coal seam overlying or underlying by hard, sandstone, or shale. The behavior of jointed rock mass under load may be analyzed through detailed knowledge of the independent behavior of rock blocks and joints. The finite element technique has been developed to permit the treatment of rock blocks as elements of a continuum and joint characterized by line elements.

The stiffness of all line elements then are added to stiffness{S} of the continuum and analysis is completed in a usual manner. Thus it has been possible to study the influence of the presence of joints on stress distribution displacement and failure pattern of u/g opening of joint rocks.

Numerical Method of Modelling

Conventional types of analysis are restricted to simplistic problems in their scope of application, basic loading conditions, and ambient simple slope geometries, and as such provide little idea into slope failure mechanisms. Many rock slope stability problems involve complexities relating

to geometry, non-linear behavior, material anisotropy, in situ stresses, and the presence of several coupled processes.

To lecture these limitations, numerical modeling techniques have been used to provide an approximate solution to the problem, which cannot be solved using a conventional method.
For analysis of rock slope stability, numerical methods are divided into three ways:

- continuum modeling;
- pig modeling
- hybrid modeling

For large, intact rocks, weak rocks, and soil-like or heavily jointed rock masses continuum modeling is the best suited for slope analysis. Discontinuum modeling is best suited for slopes controlled by discontinuity behavior. For coupling, these two techniques (i.e., continuum and discontinuum) hybrid codes involve maximizing their key advantages.

FACTORS AFFECTING SLOPE STABILITY

Slope geometry
The most important parameter that affects the slope stability is

- Height of slope
- Slope angle
- Angle of repose

Slope stability generally decreases with the increase in height of the slope, as the slope height increases, the shear stress within the toe of the slope increases due to added weight of the slope.

Generally, an oral slope angle of 45 degrees is considered to be safe by DGMS. The steeper and higher the height of the slope less is the stability.

Geological structure
The main geological structure which affects the stability of slopes in the open pit mines are:

- Amount and direction of dip
- Intra formation shear zone
- Joints and discontinuities
- Faults

Many slopes are stable at steep angles and heights of several hundreds of meters. This difference is because the stability of the rock's slopes varies with an inclination of discontinuity surfaces such as bedding planes, fractures, faults, folds, and cavities. When these discontinuities are horizontal or vertical, and where simple sliding cannot take place.

Lithology
The rock materials forming a pit slope determine the rock mass strength modified by discontinuities, faulting, folding, old working, and weathering.

Shear strength depends upon many factors such as the type of material, rate of loading, degree of compaction, and moisture content.

The shear strength is the most important engineering property of the soil and rock spoils it represents the ability of a material to withstand shear stresses.

Groundwater
It alters the collision and frictional parameters and reduces the normal effective stress. The physical and chemical effect of pure water pressure in joint filling material can thus alter the slope stability to a great extent.
Physically and chemical effect as the water pressure in the pores of the rock causes a decrease in the compressive strength, particularly where confining stress has been reduced.

Mining method & equipment
Usually, there are four methods of advance in opencast mines.

- Strike cut – advancing down the dip
- Strike cut – advancing up the dip
- Dip cut- along the strike
- Open pit working.

Dip cut offers the most stable method of working but suffers from restricted production potential.

Mining equipment that piles on the benches of the open pit mines gives rise to the increase in surcharge which in turn increases the force which tends to pull the slopes face downwards and thus causes instability.

Dynamic forces
Vibration, blasting, and shear stress effects are increased momentarily as a result of a dynamic acceleration of material and thus increase the stability problem in the slope face.

Cohesion
It is the characteristics property of a rock or soil that measures how well it resists being deformed or broken by forces such as gravity.

Slopes having rocks/soils with less cohesion tends to be less stable.

Angle of internal friction
It is an angle (è) measured between the normal force (N) and resultant force (R) that is attained when failure just occurs in the response to the shearing stress (S).
Where tangent (S/N) is the coefficient of sliding friction. It is a measure of the ability of a unit of rock or soil to withstand shear stress. This is affected by particle roundness and size as well as quartz content. Lower roundness or larger medium particle size results in larger friction.

Temperature
Occasionally, the effects of temperature influence the performance of rocks and slopes full stop large temperature changes can cause rock due to the company contraction and expansion. Water freezing in discontinuity causes more significant damage by losing the rock masses. Repeating freezing then cycles the main result in gradual loss of strength.

Vegetation
Plant roots can provide a strong interlocking network to hold consolidation materials together and prevent floor. Furthermore, plants are very effective and removing water from the soil, thus increasing shear strength. The extra weight of plants may cause a slight destabilizing effect if the roots network is of a limited extent, but overall vegetation increase slope stability.

WAYS TO IMPROVE SLOPE STABILITY

Reduction of bench height
- As we go on increasing the height of the bench, the stability of the bench goes on decreasing.
- There exists a critical height at which the bench is just stable theoretically.
- However, it should be remembered that reducing the slope height also affects the increase in several working benches resulting in an increased number of machinery and supervision.

Reduction of slope face inclination
As the face inclination is reduced its stability increases, so during designing by decreasing the face inclination we may improve its stability.

Drainage of slope
The influence of water pressure on slope stability is well known since the presence of water decreases the stability of a slope.

The water pressure decreases the stability of the slope so by reducing this water pressure the stability can be enhanced this is called de-pressurization.
The most common drainage and depressurization method are
- Surface drains
- Horizontal drains
- Collector drains

REINFORCEMENT OF SLOPES WITH BOLTS AND CABLES

A. Rock bolting
- Rock bolting can be used on the natural or artificial slope to prevent the failure of a block from the main mass due to the plane of fracture.
- The purpose of rock bolts is to transmit the stabilizing force into the rocky slopes and comprehend the rock joints.
- Using installed rock bolts, the joints are more closely spaced.
- Thus the friction between the surfaces of separation in the bolted zone is increased.
- The rock bolting necessary converts it into solely one block.

B. Rock anchoring
- This method is generally used for the protection of steeply inclined slopes.
- The presence of rock anchoring is similar to that of rock bolting only the difference is that longer holes than in rock bolting.
- These holes are filled with quick setting cement and then wire rope is inserted into it and tightened with a bearing plate from outside.

C. Anchoring with retaining wall
Unstable rock slopes may be kept stable using retaining walls and several rock anchors.

Controlled blasting techniques

There are some special blasting techniques for improving slope stability such as

- Buffer blasting
- Pre-splitting
- Smooth-wall-blasting.

INFLUENCE OF PIT SLOPE ON MINE ECONOMICS

- The geometry, mineralogy, and depth of an ore body are forced by nature but for any given set of geo-mining conditions and techno-economic environment, the planning engineer must determine the slope angles precisely to establish the geometric limits of the pit and profitability of the mine.
- The selection of slope angle is a critical decision affecting accumulating cash and the overall economics of the mining project.
- Stable slopes are essential for uninterrupted ore production while steep slopes are desirable to reduce stripping ratio and extend the life and improve the economics of open pit operation. Therefore a compromise must be achieved in light of these two conflicting requirements.
- The effect of slope angle on the economics of open pit operation becomes more pronounced with an increase in depth of mine working.
- It is the only final pit slope that should be designed as steep as possible but is also equally important to make the steepest possible operating slope so long as they remain stable and adequate working space can be maintained.
- Another important aspect of a steep slope is the effect on the cost of the management of an environment to get the same amount of ore from a deposit. The maintenance of the steepest slope will result in the excavation of less quantity of waste volume causing less land area to be affected, both by direct excavation and area required for the formation of the outside dump.
- This will reduce the cost of abatement measures to be taken against environment degradation during the phases of development and active mine as well as post-mining phase this furthermore availability of land for mining and waste disposal is becoming more and more restricted.
- Normally the interim or working, the slope will be much flatter than the ultimate pit slope increasing the angle of the working slope can be advantageous from an economic standpoint since this will increase early revenue i.e. Delay mining of waste rock.
- In many cases, it may worthwhile to conduct an optimization study also of the interim slopes, but establishing the mining sequence in an open pit is in itself a formidable task.

CONCLUSION

For new or existing slopes or excavations, the problem of slope stability is always there. The problem of slope stability is particularly important in the construction of buildings, such as embankments, road cuts, and excavations. Since roads are the most important structures and therefore for their safe and economical design a slope stability assessment is performed. During excavation work of natural slopes, the slope face can deform and it may lead to land sliding. Landslide is caused by a combination of geomorphological, geological, and climatic factors in response to triggering the movement.

As landslides directly affect the construction, which requires best practices for ensuring slope stability. The slope stability was determined by the factor of safety, to determine how close the slope is to a soil failure (landslide). The factor of safety was calculated according to generated critical sliding surfaces using various methods (Peter-son, Bishop, Sarma, and Spencer).

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A Project Report on Extraction of Underground Developed Pillars by Opencast Mine

P.Rajkumar* B.Suresh*

ABSTRACT

Dependency of our energy requirement on coal in future will still continue till the technology advancement in the field of renewable energy. Presently 60% of the total energy demand is fulfilled by coal. The coal production of country in the financial year 2021-22 is around 731 Mt. The share of opencast mines is more than 70%. Opencast mines are shrinking day by day due to exhaustion of virgin coal. Extraction of coal by Underground mining is very uneconomical. In future there will not be any virgin coal seam for opencast mining and only alternative for coal production will be by open casting of developed pillars of underground mines. There are nearly 3 to 3.5 BT of coal reserves in standing pillars in the country. Upcoming opencast projects are being planned on old underground mines. And future of mining engineers will be very- very challenging.

INTRODUCTION

Whenever coal pillars are left in the Underground working and be extracted by the opencast method necessary survey shall be carried out by bore holes to find out the location of any void place underneath. Dip side of the underground mines are separated from rise side workings by constructing dams and underground mines are running still on dip side of the property by making alternative approaches. Standing pillars & goaved out areas in Rise side of the old underground mines are being worked by opencast method. Working in this mine is challengeable as far as ground control & fire are concerned.

METHODOLOGY

In manual opencast all the developed gallaries shall be supported properly with wooden cogs and all the gallaries and junction shall be clearly demarcated and shown on the plan of open cast workings, the minimum thickness of the parting in between the Underground and opencast workings shall not be less than 3m where as in case of mechanzed opencast workings,it shall not be less than 5m to prevent accidental bogging down of any heavy earth moving machinery.

If the Underground working is accessible,it should be nicely surveyed all coal dust shall be cleared off and thickly stone dusted before starting extraction of any pillar . If not accessible holes should be drilled a head of the bottom bench 18m apart in the grid pattern from top of the overburden bench or surface to the Underground galleries.

Processes before starting extraction of developed pillars by Opencast methods are as follows:

The U/G workings to be quarried shall be isolated by explosion proof stoppings or by any other approved manner from any active working area either in the same seam or different seam or section as the case may be, so as to prevent transference of danger to the said workings area.

Before intended to close the U/G mine for conversion to O/C, a detailed off set survey has to be conducted by using latest survey equipments like Total Station etc. and the position of workings including the disturbances and falls should be clearly demarcated on the plan.

The U/G mine Manager should see that the plan prepared for handing over to Opencast mine manager is flawless, because once the U/G mine is abandoned, the O/C operation becomes blind folded and only guidelines remains with the O/C management is U/G plan submitted by the surveyor of U/G Mine.

It should clearly picturise the each and every detail of U/G workings. Cleaning of all coal dust and thick stone dusting before commencement of extraction of pillars.

Retaining of key personnel of U/G mine, like Surveyor, Overmen and Officers for safe and effective operation of O/C mine. After completion of all legal and statutory formalities, the mine is developed as per the permission conditions of DGMS.

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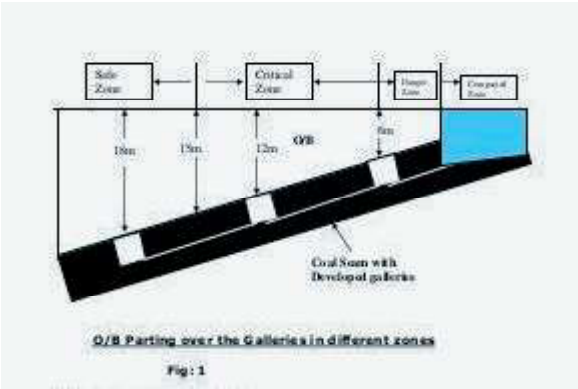


O/B Parting over the Galleries in different zones

Fig: 1

For safe and systematic excavation, the mine is divided into four zones viz.

A. SAFE ZONE.
B. CRITICAL ZONE
C. DANGER ZONE AND;
D. COMPACTED ZONE

(A) SAFE ZONE: It is the zone of safety, where the parting is over U/G galleries is more than 15m. In this zone all activities can be carried out and the zone is to be demarcated with `White` flags

(B) CRITICAL ZONE: It is the zone, where proper precautions are required for excavation. In this zone, the parting of working O/B benches over U/G galleries is more than 4m and less than 15m. Whenever, the plan parting reaches

15m to u/g galleries, further reduction shall not be done unless it is proved physically. After proving the physical parting, further parting is reduced to 4m hard O/B. In this zone the excavation is done by Back hoe shovel in level loading. This zone is demarcated with `Yellow` flags.

(C) DANGER ZONE: Danger zone means, the area where the parting over U/G galleries is 4m hard O/B or less. No work shall be done in this zone except dozing and drilling for compaction. The dozing and drilling shall be done under proper supervision. Danger zone is to be demarcated with `Red` flags.

(D) COMPACTED ZONE: When danger zone is converted to safe zone by Compacting the U/G galleries by drilling and blasting (4m O/B and coal seam combindely), it is termed as `Compacted` zone. This zone is permitted for normal extraction of coal/OB, as it is safe. It is demarcated with White flags.

Note: As per DGMS guideline, the extraction of O/B in Critical zone should be done upto 4m parting over galleries, but 4m hard O/B parting is not safe for running HEMM and formation of pot- hole can't be avoided.

Hence for extra precaution, Critical zone is assumed between 6-15m. When the working in critical zone reaches to 6m, it is treated as danger zone.

O/B Parting over the Galleries in different zones Fig: 1 Working in different zones:

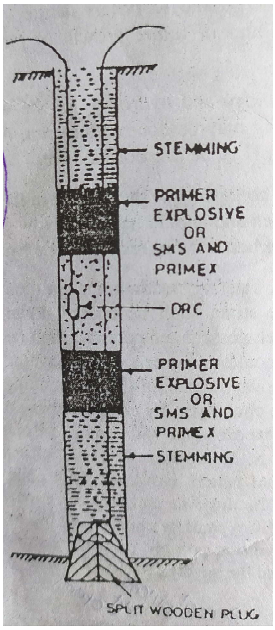
I. Whenever the area reaches to critical zone as per plan parting observed by the Surveyor, test holes shall be drilled at demarcated places to prove the physical parting. The critical area is demarcated with `Yellow` flags
II. Based on the proved parting, O/B benches shall be lowered upto danger zone.
III. Whenever the area reaches to danger zone, the area will be leveled for drilling under proper supervision. Then the surveyor will mark the position of U/G galleries and drill hole pattern on the benches with stone dust as per the approved plan. The surveyor will display the play cards at the junctions mentioning the place and plan parting on it.
IV. The Surveyor will hand over the notice of the galleries and parting with sketch to the Overman, Under Manager, Blasting In-charge, General shift In-charge and to the Manager of the mine, before operating in Critical and danger zone.
V. General shift In-charge will give the necessary instruction in writing to the concerned Shift persons regarding drilling and extraction in critical and danger zone.
VI. Test holes shall be drilled to ascertain the parting before commencement of actual drilling operation. 6m 15m 12m Danger Zone Critical Zone Safe Zone 18m O/B Coal Seam with Developed galleries Compacted Zone.
VII. Based on the above test hole report, the termination of holes over the galleries will be ascertained. In O/B, the holes above the galleries shall be terminated 1.5-2m before touching the galleries and in coal 2-3m for providing proper confinement of explosives column around the holes and to avoid blown through shots in the galleries.

VIII. The drilling on pillars and galleries shall be done as per the pattern shown in the sketch provided by the Surveyor and under the supervision of an Overman.

IX. The Overman and Under Manager In-charge will record the proved partings and pattern of drilling with depths and will be kept for the purpose.

THE PROBLEMS WHICH ARE ASSOCIATED WITH THE EXTRACTION OF DEVELOPED COAL PILLARS BY THE OPENCAST METHODS

1. Possibilities of coal dust and fire damp explosion.
2. Possibilities of dealing and extraction of burning or heated coal.
3. Problems of fire in exposed coal in opencast mines.
4. The fire in the seam may cause problems of air circulation within the ire areas.
5. Foaming agents for steady cooling and combating fire in the area if it erupts out in the coal seam, or in the explosive.
6. Blasting efficiency fall down.
7. Reclamation of the mined out area is very important.
8. Problems of changing of hydrogeology and hydrology in the working area.
9. There will be problems of drilling , blasting, loading, etc. in the coal seams associated with fire.
10. There is always presence of risk of collapsing of the parting in the junction gallery by the HEMM.



Charging of punctured hole with multi deck in holel method.

CONCLUSION

To avoid collapsing of under ground galleries and bogging down of men and machinery, effective compaction of galleries will be done to extract coal from standing pillars by opencast method. Surveying is very- very important in U/G turned O/C mine. The plan submitted by the U/G mine manager should be very handy and informatic. Surveying should be conducted with latest instrument like, Total Station etc. A dynamic leader and enthusiastic team work is required to take all these challenges smartly.

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Security Challenges and Best Practices for Internet of Things (IoT)

Veeranki sharan* Mudavath Mallesh* Khaja mohinuddin*

INTRODUCTION

Computer gadgets that are integrated into common objects and are connected via the internet to exchange data. One of the current technology innovations with the quickest rate of development is the Internet of Things (IoT). IoT Analytics predicts that by 2025, there will probably be more than 27 billion linked devices worldwide. However, growing security worries about things like software flaws and hackers may discourage many users from utilising IoT devices. These IoT security issues are particularly important for businesses operating in the healthcare, finance, manufacturing, logistics, retail, and other sectors that have already begin implementing IoT devices. In this chapter, we discuss the definition of IoT security, its importance, and the main threats it is vulnerable to. We also go over how to secure networks, devices, and data in IoT environments.

WHAT IS IOT AND IOT SECURITY?

A network of intelligent gadgets known as the "Internet of Things" connects to one another and uses the internet to exchange data without the need for human involvement. Wireless networks, cloud databases for communication, sensors, data processing software, and interconnected smart devices make up the architecture of IoT systems in most cases. The following elements are used by IoT systems to exchange and process data.

Smart devices: Smart gadgets that gather information about the environment and other objects and components, store it, and then share it.

Embedded systems: Smart devices use embedded systems, which can be made up of a range of processors, sensors, and communication equipment, and whose purpose is to gather, send, and act on environmental data.

IoT gateways: Devices that transit data between IoT devices and the cloud, such as IoT gateways, hubs, or other edge devices

Cloud or on-premises data centres: Data communication between remote servers and on-site or cloud data centres via wireless connectivity.Industries like manufacturing, transportation, healthcare, logistics, energy, agriculture, and more use IoT technologies. Depending on the objectives of a particular IoT system, smart devices might range from straightforward sensors to DNA analysis technology.

THE MOST POPULAR IOT USE CASES AND DEVICES ARE

Fig:Common Use Cases

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Home Automation Systems: Automation systems for homes keep an eye on and regulate features including lighting, temperature, entertainment, appliances, and alarm systems. Thermostats, refrigerators, plugs, and lightbulbs are examples of common smart home appliances.

Healthcare Medical IoT (MIoT): Healthcare. Medical IoT (MIoT) offers numerous chances for patients to self-monitor as well as for healthcare professionals to monitor patients. Glucometers, blood pressure and heart rate monitor cuffs, and wirelessly connected fitness bands are examples of smart devices for the Internet of Things (IoT).

Smart Cities: To improve infrastructure, public utilities, and services, smart cities leverage data collected by smart devices. These gadgets can be connected to air quality monitoring equipment, waste bins, metres, lighting, and sensors.

Wearable's: Sports and healthcare are the two main uses of wearables. These gadgets include smart watches, ECG monitors, blood pressure monitors, and fitness trackers.

Connected Cars: Vehicles with internet access and the ability to share their data with devices inside and outside the car are referred to as connected automobiles. With the help of this technology, users can enhance security, remotely access car functioning via a mobile app, and automatically pay tolls.

Smart Warehouses: To help organisations enhance productivity and efficiency, smart warehouses use automated and linked technologies.

WHY DOES IoT SECURITY MATTER?

Organizations must pay close attention to system security because IoT systems are used so widely. A system failure or hacking assault could result from any vulnerability, which could then have an impact on hundreds or thousands of individuals. For example, a home security system could be turned off by criminals, or traffic signals could cease operating, resulting in auto accidents. Because some IoT devices are utilised for human protection or healthcare, their security might be extremely important for people's lives.

In order to protect their data, IoT systems must place a high priority on security. Numerous cyber security laws, standards, and regulations must be followed in order to protect the massive amounts of sensitive data that smart devices collect, including personally identifiable information. A breach of such information may lead to legal action and penalties. Additionally, it can result in a loss of client trust and reputational harm. Internet of Things security is a collection of methods and procedures for defending against a variety of IoT security intrusions on the physical objects, networks, operations, and technology that make up an IoT ecosystem.

The two key goals of IoT security are to

i. Make sure all data is collected, stored, processed, and transferred securely
ii. Detect and eliminate vulnerabilities in IoT components

Most common Internet of Things security challenges

a. Software and firmware vulnerabilities
b. Insecure communications
c. Data leaks from IoT systems
d. Malware risks
e. Cyber attacks

SOFTWARE AND FIRMWARE VULNERABILITIES

IoT security is challenging to maintain, mainly due to the resource limitations and low processing power of many smart devices. As a result, they are less able to conduct robust, resource-intensive security operations and are more vulnerable than non-IoT devices.

There are security flaws in a lot of IoT systems for the following reasons:

- Lack of computational capacity for efficient built-in security
- Poor access control in IoT systems
- Limited budget for properly testing and improving firmware security
- Lack of regular patches and updates due to limited budgets and technical limitations of IoT devices
- Users may not update their devices, thus restricting vulnerability patching
- With time, software updates might be unavailable for older devices
- Poor protection from physical attacks ;an attacker can get close enough to add their chip or hack the device using radio waves

An IoT system is a target for malicious actors who want to infiltrate its communications, introduce malware, and steal

sensitive data. Hackers were able to access Ring smart cameras, for instance, by using weak, recycled, and default credentials. Even remotely speaking to victims over the camera's microphone and speakers was possible.

INSECURE COMMUNICATIONS

Since IoT devices have limited resources, it is challenging to deploy the majority of existing security techniques. Traditional security methods are therefore less effective at safeguarding the communication of IoT devices. The potential for a man-in-the-middle (MitM) assault is one of the most harmful dangers brought on by insecure communications. If your device doesn't use secure encryption and authentication protocols, hackers can easily carry out MitM attacks to compromise an update process and take control of your device. Even malware installation and functional changes are possible by attackers. Even if your device is not the target of a MitM attack, cybercriminals may still be able to intercept the data it transfers via clear text messages with other devices and systems.

Devices that are connected are vulnerable to assaults from other devices. Consider how quickly all other unisolated devices in a home network can be compromised if an attacker gains access to just one of them.

DATA LEAKS FROM IoT SYSTEMS

We've already demonstrated that hackers can access the data that your IoT system processes by intercepting unencrypted messages. This may even contain private information like your location, financial information, and medical history. Attackers can also obtain useful information by leveraging inadequately protected communications, albeit this is not the sole method. All data is transported through and kept in the cloud, and services hosted in the cloud are likewise susceptible to outside threats. As a result, both the devices themselves and the cloud environments to which they are attached could leak data.

Another potential cause of a data leak in your IoT systems are third-party services. For instance, it was discovered that Ring smart doorbells were improperly transferring user data to Facebook and Google. Due to third-party tracking services being enabled in the Ring mobile app, this event occurred.

MALWARE RISKS

Set-top boxes, smart TVs, and smart watches were determined to be the gadgets most susceptible to malware attacks, according to a recent study by Zscaler.An IoT system's functionality could be altered, personal information could be collected, and other attacks could be launched if attackers manage to introduce malware into the system. In addition, some gadgets may come pre-infected with viruses if their producers don't take proper software security precautions.

The most well-known IoT-targeted malware has already been dealt with by several firms in creative ways. A Microsoft tutorial on how to proactively defend your systems against the Mozi IoT botnet is available, and an FBI agent recently discussed how the agency stopped the Mirai botnet attacks. However, hackers continue to develop new exploits for IoT networks and devices. BotenaGo, malware created in Golang in 2021, can take advantage of more than 30 different vulnerabilities in smart devices, according to researchers.

CYBER ATTACKS

In addition to the malware and MITM attacks mentioned above, IoT systems can be vulnerable to a number of other intrusions. The following is a list of the most typical IoT device attack.

Denial-of-service (DoS) attacks: IoT devices are extremely susceptible to denial-of-service attacks because of their low computing capability. A DoS attack compromises a device's capacity to react to real requests by flooding it with phoney traffic.

Denial-of-sleep (DoSL) attacks: In order to continuously monitor their surroundings, sensors connected to wireless networks are frequently powered by batteries that don't need to be charged frequently. By leaving the Smartphone mostly in sleep mode, battery life is prolonged. The control of sleep and wakefulness depends on the communication requirements of various protocols, such as medium access control (MAC). Attackers may use MAC protocol flaws as opportunities to launch a DoSL attack. This kind of assault depletes the battery, rendering the sensor inoperable.

Device Spoofing: A device that has wrongly integrated digital signatures and encryption is vulnerable to this attack. For instance, hackers may use a weak public key

infrastructure (PKI) to "spoof" a network device and interfere with IoT deployments.

Physical Intrusion: Even though most attacks are carried out remotely, if a device is taken, it may still be physically accessed. Device parts can be tampered with by attackers to cause them to function improperly.

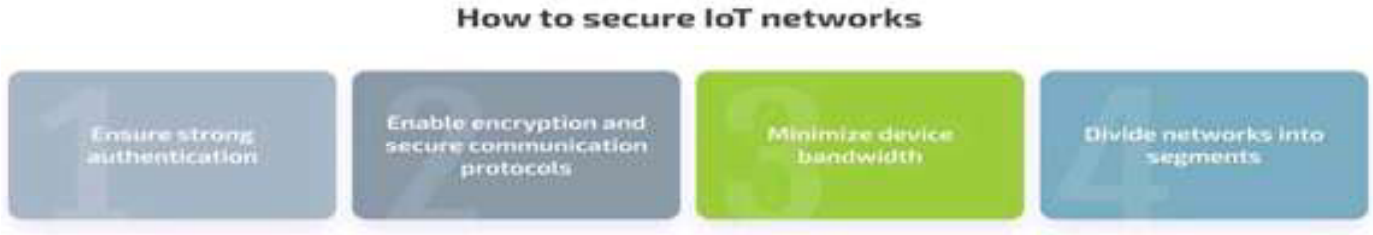
Application-Based Attacks: These kinds of attacks are conceivable when embedded system software or device firmware contain security flaws, or when cloud servers or backend apps have holes. Let's move on to the Internet of Things security best practises that can assist you in safeguarding your IoT system while keeping these difficulties in mind.

The best ways to guarantee the security of IoT systems: IoT security best practices can help you increase the protection of three main components of IoT systems: devices, networks, and data. Let's start by discussing ways to secure smart devices.
Secure Smart Devices:

Fig:Secure smart devices

- Make sure the hardware is tamper-proof. Attackers may steal IoT devices to tamper with them or access private data. Make sure your product is tamper-proof to protect device data. By implementing port locks, camera covers, strong boot-level passwords, and other measures that will render the device inoperable in the event of tampering, you may assure physical security.
- Updates and patches are needed. Continuous device upkeep requires additional expenses. However, regular updates and patches are the only way to guarantee effective product security. It is best to implement automatic and required security updates that don't need end users to take any activity. Customers should be made aware of the length of the product's support period as well as what to do after it expires. Once your system is available, be sure to monitor future vulnerabilities and create updates as necessary.
- Conduct extensive testing. Your primary tool for identifying flaws in IoT firmware and software and minimising the attack surface to the greatest extent is penetration testing. The most blatant problems can be located using static code analysis, and concealed vulnerabilities can be discovered via dynamic testing.
- Implement data protections for devices. IoT devices should guarantee data security before, during, and after use. Ensure that non-volatile device memory is used to store cryptographic keys. You can also provide a mechanism for people to get rid of used items without disclosing private information.
- Meet the performance requirements for the component. Hardware for IoT devices must adhere to a set of performance standards to guarantee optimal functionality. IoT devices, for instance, should have high computing capability while using less power. Devices must also guarantee reliable wireless connections, data encryption, and permission. Additionally, it's better for your Internet of Things solution to function even if its internet connection is just fleeting.

Secure Networks



- Enable reliable authentication. By using distinctive default credentials, this is possible. Use the most recent protocols when identifying or addressing your products to ensure their continued usability. Give your product multi-factor authentication if at all possible.
- Enable safe communication methods and encryption. Security protection is also necessary for device communication. However, given the IoT devices' constrained capabilities, cryptographic algorithms should be modified. You can use Lightweight Cryptography or Transport Layer Security for these applications. You can employ wireless or wired technologies including RFID, Bluetooth, Cellular, ZigBee, Z-Wave, Thread, and Ethernet with an IoT architecture. Additionally, using optimised protocols like IPsec and Secure Sockets Layer, you can guarantee network security.
- Reduce the device's bandwidth. Only allow the amount of network traffic required for the IoT device to function. Programming the device to restrict hardware and kernel-level bandwidth and flag suspicious activity is recommended. This will defend your product against potential DoS assaults. As malware can be used to take control of the device and use it as part of a botnet to launch distributed denial-of-service attacks, the product should also be built to reboot and clean code if malware is found.
- Networks should be segmented. By dividing large networks into numerous smaller ones, you can implement next-generation firewall protection. Use IP address ranges or VLANs for this purpose. You should integrate a VPN into your IoT system for safe internet access.

SECURE DATA

- Safeguard critical data. Install different default passwords for every product, or demand quick password updates upon device start-up. Make use of strong authentication to guarantee that only legitimate users have access to the data. If the user chooses to return or resell the device, you can also provide a reset function to enable the deletion of private data and wiping of configuration settings. This will go an extra mile to improve privacy protection.

- Only gather the information that is required. Make sure that your IoT gadget only gathers the information required for it to function. This will lessen the chance of data leakage, safeguard the privacy of consumers, and take care of any potential issues with non-compliance with various data protection standards, laws, and regulations.

- Communications across a secure network. Limit unnecessary communication between your product and the IoT network for increased security. Don't rely just on the network firewall, and make your product invisible via incoming connections by default to maintain secure communication. Use encryption algorithms such as the Advanced Encryption Standard, Triple DES, RSA, and Digital Signature Algorithm that are tailored to the requirements of IoT devices.

- Along with the above-mentioned procedures, be careful to abide by advice from documents like the NIST guide on IoT device cyber security, which was published in response to issues identified by the IoT Cyber security Improvement Act of 2020.

CONCLUSION

It's crucial to start considering security at the research and development phases of IoT projects. However, due of the frequency of intrusions and the difficulty of looking for potential system vulnerabilities, guaranteeing effective cyber security of devices, networks, and data in IoT contexts is difficult. It can be challenging to implement strong security measures in IoT applications. In addition to clashing with hardware constraints, adding security measures could raise a solution's price and length of development, which is undoubtedly undesirable for enterprises.

It takes skilled IoT software engineers and quality assurance professionals with penetration testing experience to create secure IoT devices. At Apriorit, we've put together teams of experts in security testing, embedded and IoT solutions development, and engineering for cyber security projects.

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Investigation into Influence of Selected Safety Management System Parameters on Mine Safety

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ABSTRACT

Mines safety has been one of the most complicated and concerned topic till date. To improve safety in mines, the application of risk management is current requirement in the industry. The effectiveness of mining risk management essentially depends upon the level of implementation of safety management system (SMS) in a mine, as the output of SMS help the mine to decide the control measures to be adopted to mitigate risk identified in mining. It is understood from the outcome of 11th safety conference held by DGMS that most of the mines in India are following and addressing SMS only on papers but are not practicing or completely implementing in the field. In this paper an attempt has been made to understand the SMS in detail through a parametric study before realizing the hardships in implementation of it.

Keywords: Safety, leadership and accountability, emergency management, behavioural safety and awareness

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A Case Study on Open Cast Mine Metal Mesaganahalli Granite Mine, Karnataka

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ABSTRACT

This paper attempts to study efficiency demand for metal rising frequently which is to be matched by increase in bench height, this granite mine has more bench height. It should be extracted by wire sawing and the non-parametric approach of data. A diamond wire cutting machine uses an abrasive diamond wire, wound around a drum on the machine to cut the rock, the machine can perform vertical and horizontal cutting processes (ozkental 2015). The main advantages of the wire sawing process are lower kept and water surface damage as water size increases and pollution may increases and production may increase by using and it will cut more than 450mm silicon water(and by using diamond wire sawing high efficiency and less waste (sugawarva et al,2001; Tso and yan 2005) and it can be useful to all marble, granite and store with impressive performance and durability of diamond wire and of maximum cutting speed.

In diamond wire cutting method bore holes are first drilled to start or extract block production process (sariisik and sarisik 2010, 2013 ozkam eta 2015). Vertical holes are drilled then two horizontal holes (vertical to each other) are drilled and these three holes are drilled to cut the diamond wire cutting machine and vertical cutting in same way then the granite block is separated from the main rock.

INTRODUCTION

- Mine is located near mayasandra village.
- This situated in devanahalli district at about 35km from banagalore district.
- The mine was opened in the year by 2020 by opencast.
- The depth of the deposit is 80mtrs and out crop height is 20mtrs.
- The exploration started in the year 2020.
- Total lease area for exploration is 8acres.
- Mining in the opencast is done by wire saw cutting and for transportation HEMM is used.

GEOLOGY OF THE MINE

- The grey granite strike length od ore body is 1.2km.
- At Anjaneya granite mine the granite ore is associated with grey granite.
- The total reserve of the mine is 947950 cu.m. as on march 2020.
- Proved reserves 60% recovery is 446250 and 40% waste is 297500 cu.m.
- Probable reserves 60% recovery is 122520 and 40% waste is 81680 cu.m

Category Wise Reserves Calculation of Grey Granite Quarry 8-04 Acres of M/s Sri Anjaneyaswamy Enterprises					
Section	Sectional area	Sectional Influence	Volume	60% Recovery	40% Waste
	sq.m.	m.	cu.m	cu.m.	cu.m.
Proved reserves					
1-1'	1421	250	355250	213150	142100
2-2'	2590	150	388500	233100	155400
				446250	297500
Probable reserves					
1-1'	392	250	98000	58800	39200
2-2'	708	150	106200	63720	42480
				122520	81680
TOTAL			947950	568770	379180

The details geological resources are given below

Mineable Reserves Calculation of Grey Granite Quarry 8-04 Acres of M/s Sri Anjaneyaswamy Enterprises					
Section	Sectional area	Sectional Influence	Volume	60% Recovery	40% Waste
	sq.m.	m.	cu.m	cu.m.	cu.m.
Proved reserves					
1-1'	1100	242.5	266750	160050	106700
2-2'	2288	142.5	326040	195624	130416
				355674	237116
Probable reserves					
1-1'	317	242.5	76873	46124	30749
2-2'	632	142.5	90060	54036	36024
				100160	66773
TOTAL			759723	455834	303889

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METHOD OF QUARRYING

- The proposed method of quarrying will be "opencast" method by semi mechanized quarrying method. The quarry operation is of semi mechanized open cast way by deploying machineries like excavation, tippers, cranes, line drilling equipment, wire-saw cutting machine, compressors etc. the technique like wire saw cutting and line drilling . the usage of latest technique of wire saw cutting both in horizontal and vertical way is best suitable for sheet rock quarrying of grey granite which reduce the generation of waste and increases the recovery. It will also avoid blasting now the deposit is fully exposed in the existing working pits.
- By considering the physical properties of the bed rock cutting and extraction operations is done by diamond of wire saw cutting ,high speed hard steel wire is using for cut the granite bed rock.
- Initially small diameter vertical bore hole are drilled to reach and accesss required thickness of the granite in to which these wires are passed to perform the horizontal cutting in the next stage.
- The sides are charged with mixed explosives to cleave and clear the slabs of desired width.
- Finally the blocks are extracted employing cranes and loaded into trucks. **Subdivision of large primary blocks into secondary blocks**
- The primary blocks may not be inashapeand size. So to bring into irregular scope or to a dimensional blocks will be cut into secondary blocks. The primary block sizes are around 9mtrs*6mtrs*3mtrs to 7mtrs*3mts*2mtrs. The removed primary blocks will be observed carefully by pouring water on all six faces to identify the defects. The inspected primary blocks will be cut into secondary blocks by using jack hammer.
- Drilling and wedges cutting to required sizes of 3.5 mtrs*2.2mtrs*2mtrs to 1.8mtrs to 1.5mtrs.

Production of commercial blocks and transportation

The blocks will be shifted to stock yard in the notified area or competent authority marked area, located at pit head by dumpers and the the blocks will be dressed to perfect shape and size with the help of jack hammers,drilling and wedge cutting before transportation. The dressed blocks will be loaded into hired trucks of capacity with the help of crane and then blocks will be transported.

MARKET REVIEW

Due to the changing trends in the construction industry, increased affordability of common middle class population and increased demand for the residential and commercial tenements across the country, utilization of Granite has picked-up a great pace since the last decade. Also, the very quality of its polishing ability, appearance, strength etc. have made granite as an obvious choice in the construction of residential houses/ apartments, religious centers (temple, church etc.), commercial complexes, hotels and business centers etc. The granite used for decorative purposes is a costly material in comparison with other materials. Hence its utilization and trade within the country has been at a low profile when compared with the exports. As explained above, with the emergence of rich middle class and spurt in the construction activity, the internal trade is on the rise.

PRIME VARIETIES OF INDIAN GRANITE

In the world market, there are nearly 300 varieties of granite. India supplies about 200 varieties. Out of these, prime varieties represent a wide spectrum of colour, texture and structure. These prime varieties have substantial resource base. Commercial names of granite are derived from area of origin, colour, pattern etc. Karnataka state specializes in the production of ruby red, chilly red, cera grey, Kanakapura Multi-colour, Himalayan Blue and Sira Grey varieties of granite. Andhra Pradesh is famous for Grey galaxy, Srikakulam Blue and Grey varieties of granite while Tamil Nadu is abundant in Jet-Grey and Tippu-White, Kashmir-White and Paradiso Sea green varieties of granite. Odisha specializes in Green colour, silver grey, sea weed green, chilka blueand grey wave varieties of granite.

PRODUCTION

Granite is declared as a Minor Mineral under MMDR Act 1957 and falls under the purview of the State Governments. Therefore, precise data on production of granite are not available. Also, the details regarding production of processed granite are not available. However, it is presumed that the processed material exported can be taken as production level in the country with addition of 5 to 15% for internal use. It is worthwhile to mention that India is in a position to produce the required quantity of granite to meet the domestic as well as export markets.

FUTURE LOOK

The granite resources in the country are very large, which can last for hundreds of years to meet demand – domestic and export. The Indian granite can match the best granites produced in the world, in terms of quality. The Indian granite is well established in the world market and it brings considerable amount of foreign exchange to the country.

PROPOSED INFRASTRUCTURE:-
GENERAL

To carry-out quarrying of Grey Granite Quarry, various infrastructural facilities are required for the main activity as well as for environmental protection & pollution prevention. The basic infrastructural facilities that are required for the proposed quantity of quarrying are described below.

SITE SERVICES

Statutory buildings like office building, rest shelters, first aid room, etc. shall be constructed in a semi-permanent construction using brick walls and tin sheet roofing. Drinking water is being provided in well-maintained tank near to the rest shelter. In addition, there will be proper sanitation facilities, including a septic tank with soak pit, for the discharge of the sewage from the toilets.

Facilities for Environmental Management

Generally building stone quarrying is expected to cause air pollution leading to breathing problems. Activities like drilling, blasting, excavation and movement of heavy vehicles generate dust and aggravate air pollution in addition to noise pollution. For mitigating the adverse impacts of the above, suitable control measures are planned, which are more detailed in the enclosed Environmental Management Plan.

For activities like drilling, dust suppression etc. water will be required. Also, for meeting the drinking and sanitary needs of the employees/ workers, water will be required. For the disposal of the sanitary wastewater (sewage), septic tank with soak pit is constructed at a suitable place, within close vicinity of the proposed area.

To take care of the occupational health and safety of workers at site, engaged at strategic locations/dust generation points like loading and unloading points, dust masks would be provided. Dust masks would preventinhalation of Respirable Particulate Matter (RPM) thereby reducing the risk of lung diseases and other respiratory disorders. Regular health monitoring of workers will be carried out.

The solid waste that is likely to be generated from the proposed activity will be mainly from the excavation process. This will be in the form of flakes, of irregular shape. This will be collected and broken into pieces and can be sold as aggregates for civil works, because of its hard nature.

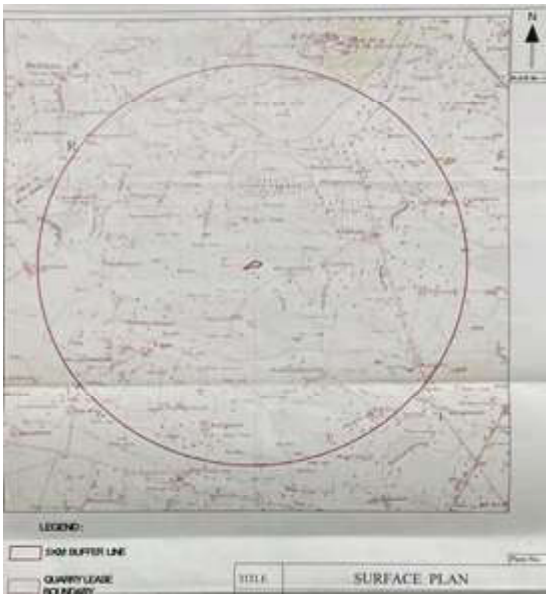
Most of the area is of sheet rock and the present proposed working is confined to sheet rocks. Less than 80% of materials are being treated as waste in this area. The rejected waste material is stacked in the Waste Dump as shown in the Mining Plan. A JCB will used to remove the over burden from the surface. When the dump reaches optimum height, suitable greenery will be grown on this dump to stabilize them.

In addition, as a proactive measure, the following activities will be initiated:

- The rainwater accumulating in the work area will be collected and will be drained-out to the downstream properly with guide drains, so that it can be used by the downstream fields for their agriculture and allied purposes.
- To avoid soil erosion, rain water entering into the mine pit, carryover of the material with rain water, suitable garland drains will be provided all along the active mine area.

VIEW OF MESAGANAHALLI GRANITE QUARRY

LOCATION OF QUARRY



CONCLUSION

The method of working building stone in the quarry lease area for the proposed plan period is by mechanized method of opencast quarry consider the technical parameter like surface topography, quality variation geotechnical aspects, required rate of production slope running towards wester to eastern side and contour level increasing towards eastern side slope running towards is above 964 meter above mrl in western side.

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Sustainable Mining

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ABSTRACT

In many parts of the world, the mining industry is seen as having a significant impact on environmental deterioration. It is frequently labelled as a "polluting industry" with a substantial environmental impact. Ecological deterioration is also being exacerbated by unlawful mining activity. Despite the fact that minerals are essential components for many manufacturing and economic sectors, extraction and processing have significant detrimental consequences on the environment and society.

Mining causes biodiversity loss, flora and wildlife extinction, extensive land clearing, air, water, and soil pollution, and it can even disturb the ecological equilibrium of a local area. Both the environment and humans are adversely affected by this. Relocating tribe members or communities living in mineral-rich locations has significant social consequences, including social resistance and debates over matters like resettlement, compensation, and indigenous people's land rights.

As a result, the World Conservation Strategy for Living Resource Conservation for Sustainable Development was created by the United Nations Conference on the Human Environment (UNCHE), which established the United Nations Environment Program (UNEP) in 1980. The goal of "The World Protection Strategy" was to encourage a more comprehensive approach to the conservation of living resources and to offer policy direction on how to achieve that goal.

As part of the Global Mining Initiative (GMI), which was supported by nine of the largest mining companies in the world, the International Institute for Environment and Development (IIED) conducted research, analysis, and consultation on the project Mining, Minerals and Sustainable Development (MMSD) in 2002. These companies were under intense pressure to enhance their social, developmental, and environmental performance.

The mineral professional community, made up of engineers, scientists, technical professionals, and teachers, held an international conference on sustainable development indicators in the mining industries in May 2003 on the Greek island of Milos. The Milos statement contains a summary of the conference's conclusions. The academic community, technological specialists, and business executives appreciated the statement. The Milos Agreement on Sustainable Development placed a strong emphasis on global conversation and communication with decision-makers at the national and international levels, allowing for the spread of best mining practices from one region to another. Sustainable mining has the potential to significantly improve global economic, social, and environmental circumstances once these are formalized and accepted as industry standards.

This paper summarizes and organizes various steps taken for the sustainable development which will help to understand that responsible Mining must be the message for now and especially in the future for everyone working in the mining industry. Daily practice is required. Exceptions need to be immediately fixed. We must prove that we are capable of mining minerals responsibly if we are to maintain the privilege of generating the minerals that the world's population needs.

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