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Prof.(Dr.) S. Jayanthu

Persons in the News

Shri Debasis Acharya presently Chief Manager, Eastern Coalfields Limited, has been selected to the post of Director (Personnel) at South Eastern Coalfields Limited (SECL). Shri Acharya started his career from Haripur Mines under Kenda Area of Eastern Coalfield. He has vast experience of Personnel Department in various projects of ECL and is considered to be well versed in Industrial Relations. He earned his B.Sc degree in the year 1986 and also holds the educational qualification of CAW, DSW (IRPM), MA (Environment). He has a special role in the operation of the vision portal related to the provisions and facilities of NCWA in ECL.

Md. Anzar Alam is set to be the next Director (Finance) of Eastern Coalfields Limited (ECL). He is currently serving as General Manager in Rashtriya Ispat Nigam Limited (RINL). Md Alam is a Science Graduate (B Sc) from BIT Sindri, Ranchi University. He has also completed a Post Graduate Diploma (MBA in Finance and Operations) from the Indian Institute of Management (IIM), Calcutta. He has been serving in RINL-VSP since December 1991. As Director (Finance) of ECL, Alam will be a member of the Board of Directors and will report to the Chairman and Managing Director (CMD). He will be overall in charge of finance and accounts of the organisation and will be responsible for evolving and formulating relating to finance and accounts as well as implementation.

Shri Prasanna Kumar Motupalli selected as CMD of NLC India Limited. Currently, He is serving as Executive Director in NTPC Limited. He is a gold medalist in Mechanical Engineering and Master of Business Management in Operations Management, HR Management, Mktg. Management, and Financial Management. He is having an illustrious career and vast experience spanning over three decades in multiple disciplines of the power sector and was Executive Director in NTPC before joining Managing Director of GSECL.

Natural Language Processing Based Method for Analysis of DGMS Accidents and Fatalities Reports of Indian Coal and Non coal Mines

Aman Agnihotri* Shivansh Gupta** Himanshu Shekhar*** Siddhartha Agarwal*

ABSTRACT

Due to the inherent danger involved in the profession, mining activities represent a serious threat to the safety of mine workers. Analysis of site mine safety data is essential for mine management to achieve the goal of preventing fatal and non-fatal accidents. The automated analysis of Directorate General Mines Safety (DGMS) death reports on Indian coal and non coal mines is being attempted for the first time in this research. Text mining and natural language processing (NLP) methods are used to carry it out. The suggested approach avoids the extensive review of each report and the technical competence needed to analyze mining incidents. The authors used data from the DGMS reports for both coal and non coal mines that covered six years, from 2010 to 2015.The attempt revealed valuable insights into the causes of injuries such as for Indian coal mines accidents occurring is highest in states of Jharkhand followed by Chhattisgarh. The leading indicators of fatality included dumpers, age above 50 years, worker class of 'Roof Bolter', and shift 2. For Indian non coal mines Rajasthan was the state where highest accidents occurred. It was evident that mazdoors' and 'workers' combined are most responsible for fatalities, followed by 'drivers' and 'operators. Furthermore, for Indian coal mines results show accidents happened mostly in southeastern coalfields Ltd. This will be a step forward for the Indian mining industry to extract meaningful results from more such text data quickly and accurately to make better decisions. The work done in paper can be extended to apply artificial intelligence techniques to identify types of accident based on probable risk of accident in Indian mines.

Keywords—Keywords— Natural Language Processing, Text Mining, Mines Safety, Fatality, Mining Industry

INTRODUCTION

In Industry 4.0 physical systems and cyber platforms are being integrated and transition from manual to the machine for performing tasks is happening. In the year 2020, the mining and quarrying industry share 2.5% of GDP in India. A push for a $5 trillion economy by 2025 has seen a rapid increase in the output of coal, metallic and non-metallic minerals by technological intervention. Artificial intelligence (AI) and data visualization are key drivers for achieving the objective.

DGMS under the Ministry of Labour and Employment is responsible for ensuring safety in mines and avoiding accidents by implementing rules and regulations. It's also responsible for the investigation of accidents and fatalities happening in Indian mines. The work done in this paper investigates various parameters such as age, shift timings, work experience, and occupation of the worker in fatal accidents. Text Mining (TM) and Natural Language Processing (NLP) techniques were used to process the DGMS reports. NLP is a subfield of AI whose main goal is to read, understand, and comprehend human language.

The present condition of Indian mines is still very conventional; it continues to be more manpower intensive thus human resources are exposed to greater levels of risk facing large numbers of fatal and non-fatal injuries. The mining industry is trying to keep pace with making the giant economical shift wherein India desperately needs to make technological interventions in mining operations. The work in this paper is an attempt to use modern AI and data visualization techniques on fatalities reports of Indian coal mines available online on the DGMS website.

The results from this exercise will be used to optimize the workers performance and to require effective steps to mitigate any fatal or non-fatal injuries, several dimensions must be looked upon. The concept is to acknowledge any

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trend or similarities supported for which necessary actions or warnings can be designed to forestall the fatalities. This research aims to Promote Safety 4.0, including better safety standards, thus boosting productivity. Further section II talks about previous work in the area of safety analysis using AI/ML. Section III shows the detailed methodology of the process, the results and analysis are presented in section IV and finally, the conclusions derived from this study are stated in section V.

BACKGROUND AND OBJECTIVE

Previously, Zhao, Zhigang, et al [1] implemented the TM (Text Mining) analysis of mine accident reports with the assistance of currently efficient Natural Language processing (NLP) technologies, to obtain the text summary of mine accident reports. After analyzing the general text framework of the mine accident report, supported it, combined with the TextRank method and Word2vec technique in NLP, the report text structure is optimized, and therefore the report summary library is additionally obtained autonomously, which helps the staff cope with accident reports intelligently.

The work of Mandal, A., and D. Sengupta [2] describes the analysis of fatal incidents in Indian coal mines from April 1989 to March 1998 and found that shift I followed by shift 3 was most accident-prone. The Indian open-cast mines are shown to be a minimum of hazardous to the workers because of the Indian underground mines. Few regression models have also been built for accident rate analysis. The break-up of the accidents by cause is additionally studied.

Within the work of Ganguli et al. [3], nine random forests (RF) models were developed to classify narratives from the Mine Safety and Health Administration (MSHA) database into nine accident types. a number of the accident types covered were overexertion in lifting objects, over-exertion in pulling or pushing objects and falling on a working surface.

The work of Mitchell, Olivia S. [4] investigated the association between employment risk and characteristics like age groups, industry groups, occupational groups, and states using multivariate multivariate analysis. . Analysis revealed that workers under the age of 25 were more likely to experience temporary injuries and Older age groups were particularly vulnerable to fatalities or lasting disabilities. within the work of Raj, V. K., and E. K. Tarshizi [5], sophisticated text mining methods and NLP were applied to the U.S. Mine Safety and Health Administration (MSHA) final fatality reports in metal and nonmetal operations (surface and underground) to spot insightful word relation patterns within the reports. The ultimate fatality reports from 2010 to 2017 were gathered and cleansed for this purpose. Topic modeling was also accustomed to organize the reports into categories with related overarching themes or topics.

Within the reports of the incidents that occurred in manganese mines, Verma and Chaudhari [6] 2017 employed a modified human correlational analysis and organization (HFACS) and an accident predictive fuzzy reasoning approach (FRA) based system. They found that both fatal and non-fatal events are significantly influenced by the worker's age, shift, and knowledge. They found that the Shift I work hours of 6 a.m. to 2 p.m., workers who are between the ages of 33 and 47, and employees with between 6 and 10 years of experience are the foremost crucial criteria for the creation of intervention strategies.
A few scholars have employed TM and NLP for accident report analysis within the past, in another nations. However, given the mining circumstances in India, There hasn't been any effort made particularly to investigate mortality reports. With some exceptions, this area has mainly remained unexplored. Some academics are examining the impact of varied worker-specific factors referring to fatalities in various Indian coal mines. Hence This study represents the primary try to use AI methods on reports of mining fatalities in Indian non-coal mines, additionally on research the age, shift, experience, and occupation effects.

METHODOLOGY

It is a very troublesome and painstakingly long task for human resources to read and analyze the fatality reports. Important information can be skipped by human carelessness while analyzing the report. That is why NLP and TM were used by the researchers for reading, extracting information, and analyzing from DGMS reports. By using modern techniques, we can very quickly and errorlessly analyze pages of reports within seconds and get the most efficient results. We can use NLP and TM in analyzing the fatality reports of coal and non-coal Indian mines. We will analyze fatality reports from coal and non-coal Indian mines

from 2010 to 2015 and collect useful results, which we can use to optimize worker performance and take effective action to reduce any fatal or non-fatal injuries. The goal is to spot any patterns or resemblances so that any necessary precautions or warnings can be developed to stop the fatalities.

The overview of applying NLP and TM to the DGMS report of Indian coal and non coal mines is illustrated in Figure 1.

A. DATA ACQUISITION

The accidents and fatality reports released by DGMS annually are available online in the form of pdf. The reports have information like cause of death, date, time, mine name, mine owner, district, state, profession of the deceased, age, description of the accident, and how it might have been prevented. Data collection, or getting data from the DGMS website, is the first stage in using NLP. On the DGMS website, it's presented as a pdf file, which was converted into a text file.

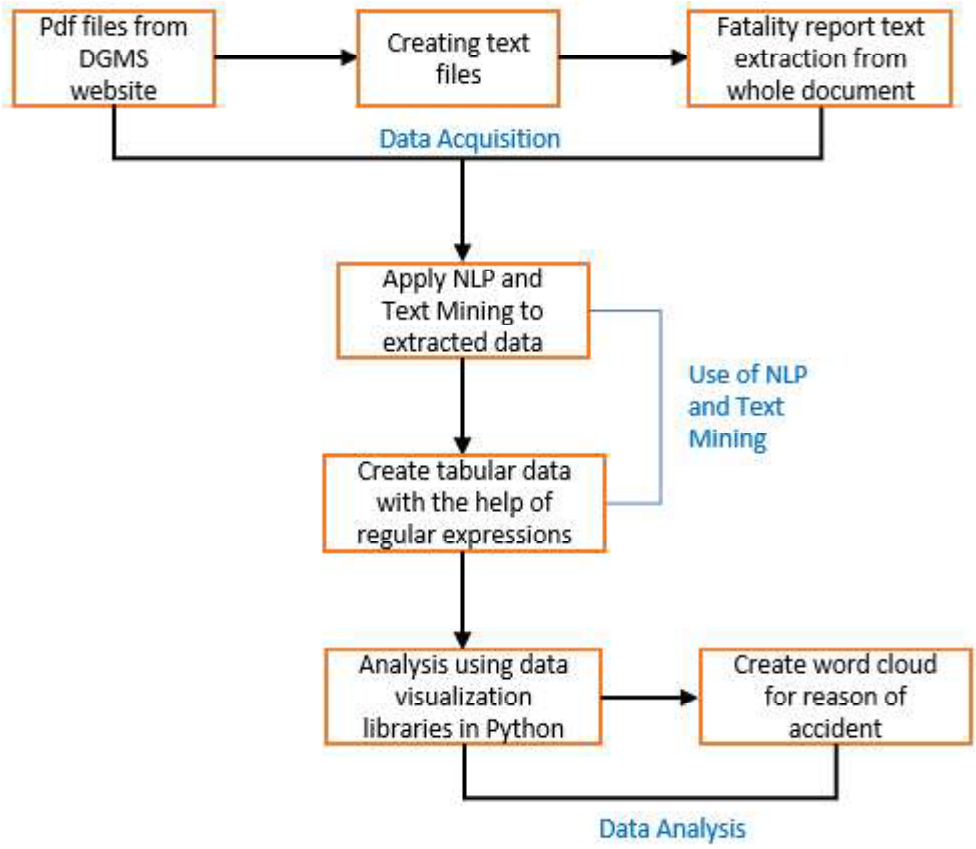

Fig. 1. Overall process of applying TM and NLP on DGMS fatality reports

B. APPLICATION OF TEXT MINING AND NLP

The data is then organized in a tabular format for ease of analysis after the pdf files are converted to text files.The authors have used Python libraries such as "Pandas", "Numpy", and "SciKitLearn" to do so. Then the regular expression language(RegEx) was used for ease of formatting the data. RegEx was applied using Python's built-in re library to identify the patterns and then reformat them based on the usage for analysis.

Figure 2 shows a sample of the final tabular data created. The data fields includes code for cause of accident, cause description, remedy, date, timing of accident, state in which the mine is situated, occupation, age, and shift of the mine operation.

Accident Code	Accident Reason	Date	Time	State	Mine	District	Owner Company	No. of persons died along	Name of person	Occupation of the person	Gender of the person	Age of the person	Reason	Remedy	Shift	SubShifts
111	Fall of Roof	1/2/2010	12:00:00	West Bengal	SHANKARPUR	Burdwan	Eastern Coalfields Ltd.	0	Ismail Mia	Dresser	Male	40	While a dresser was engaged for dressing coal ...	Had the roof of the gallery been made and kept...	2	1C
111	Fall of Roof	2/24/2010	13:30:00	Madhya Pradesh	BARTARAI	Anuppur	South Eastern Coalfields Ltd.	0	Poshan Das	Support Mistry	Male	44	While a driller was pulling a drilling cable a...	Had the roof of the working place been made an...	2	1D
111	Fall of Roof	3/20/2010	9:45:00	Chhattisgarh	BALGI PROJECT	Korba	South Eastern Coalfields Ltd.	0	Dhani Ram	Explosive Carrier	Male	47	While an explosive carrier in stooping positio...	Had I) the person carefully examined his workl...	2	1B
111	Fall of Roof	4/3/2010	14:40:00	Madhya Pradesh	BIRSINGHPUR	Umaria	South Eastern Coalfields	0	Daya Ram	Roof Stitcher	Male	56	While a roof stitcher was	Had the roof of the gallery been	2	2A

Fig. 2. Tabular data created from Fatality reports of Coal Mines of India

Then, after converting the data into the desired format, the first step that needed to be done was tokenization. Tokenization is the dividing of text into small pieces known as “toks.” A Python-based spacy package was used to do this task. Then (POS) part-of-speech tagging is done on each token. This creates grammatical relationships and dependencies amongst tokens This was done using the pos_tag method in the Python NLTK package.Then POS tagging and named entity recognition (NER) are done to recognize entities like names, places, date/time, etc.

Fig. 3. Process sequence for application of NLP

C. DATA ANALYSIS

Python data visualization packages like ‘Matplotlib’ and ‘seaborn’ and the public version of ‘Tableau’ were mostly used to carry out visualization.Word cloud was also built which highlights the major causes and remedies.

RESULTS

Many plots were created to see if there is any specific pattern in occurence of accidents.

A bar plot was created to see the relationship between number of accidents and the state in which it occurred for Indian coal mines:

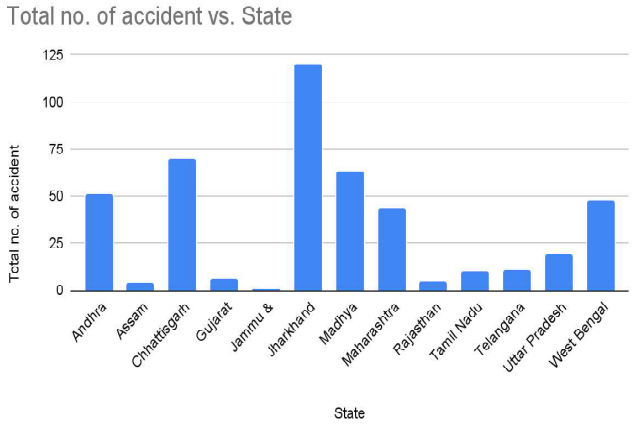

Fig.4. Number of Accidents Statewise for Indian Coal Mines

For Indian coal mines Jharkhand state has encountered the maximum number of accidents which is 120 while Jammu & Kashmir has the minimum number of accidents as 1.

A bar plot was created to see the relationship between number of accidents and the state in which it occurred for Indian non coal mines:

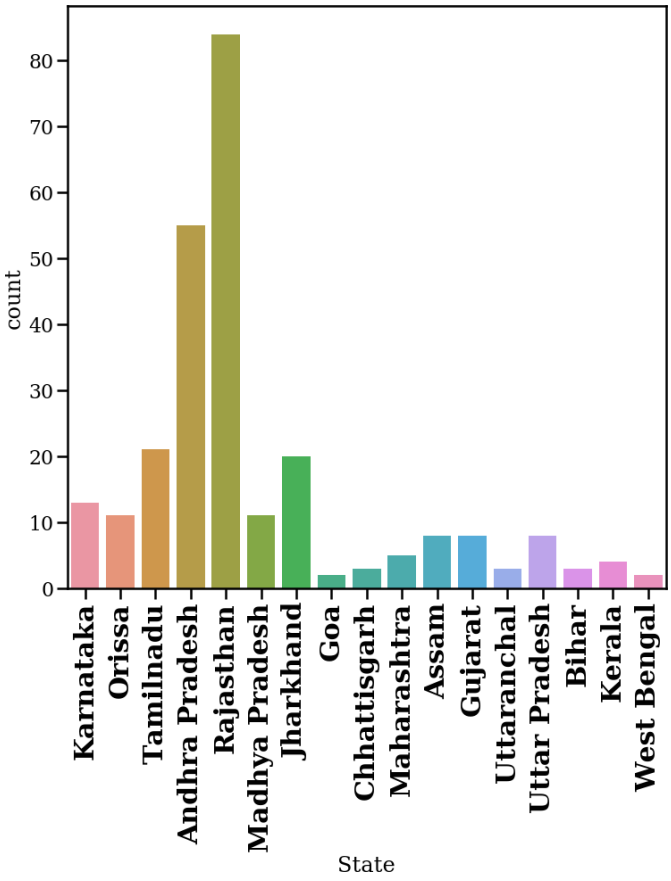

Fig.5. Number of accidents statewise for Indian non coal mines

For Indian non coal mines Rajasthan and Andhra Pradesh are responsible for 84 and 55 fatal accidents respectively. Goa and West Bengal have the least with 2 fatalities each. Rajasthan has a large number of stone mines of Granite, Marbles, Slate and Phyllite, Limestone, etc. Stone mines have a huge contribution to fatal accidents.

A bar plot was created to see the relationship between the number of accidents and number of people died occupation wise for Indian coal mines:

For Indian coal mines It is evident that maximum accidents have been encountered by dumper operators followed by general mazdoor and contractor workers. These classes of workers are exposed to higher risk for facing accidents so they must be given proper guidelines for execution of tasks, whereas least accidents have been encountered by pump operators.

For Indian coal mines the maximum number of person died along was from roof bolter worker class but number of accident happened from roof bolter worker class was only five which means roof bolters accidents are majorly fatal accidents.

A bar plot was created to see the relationship between the number of accident and occupation of Indian non coal mines:

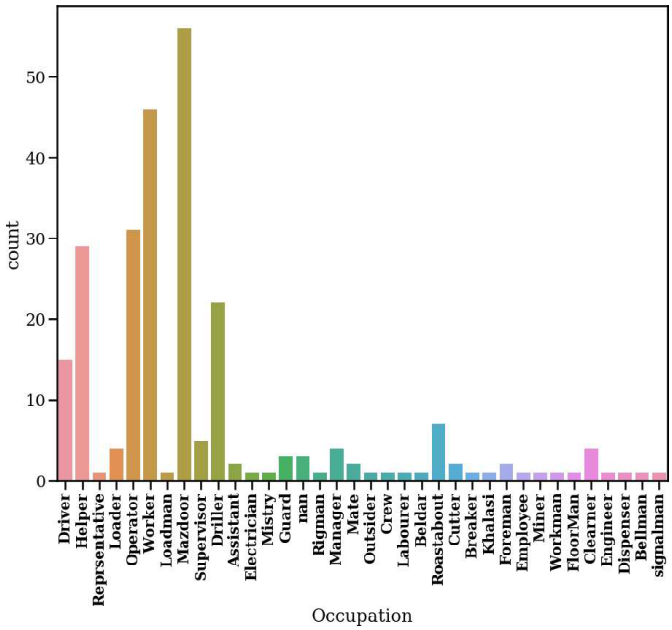

Fig.7. Number of accident occupation wise for Indian non coal mines.

For Indian non coal mines it is very obvious that mazdoors' and 'workers' combined are most responsible for fatalities, followed by 'operators' and 'helpers'. They are exposed to a higher level of risk and they require high situational awareness and training. Lack of which may increase the chances of accident occurrence.

A bar plot was created which shows top 10 company which have encountered maximum number of accident and people died along:

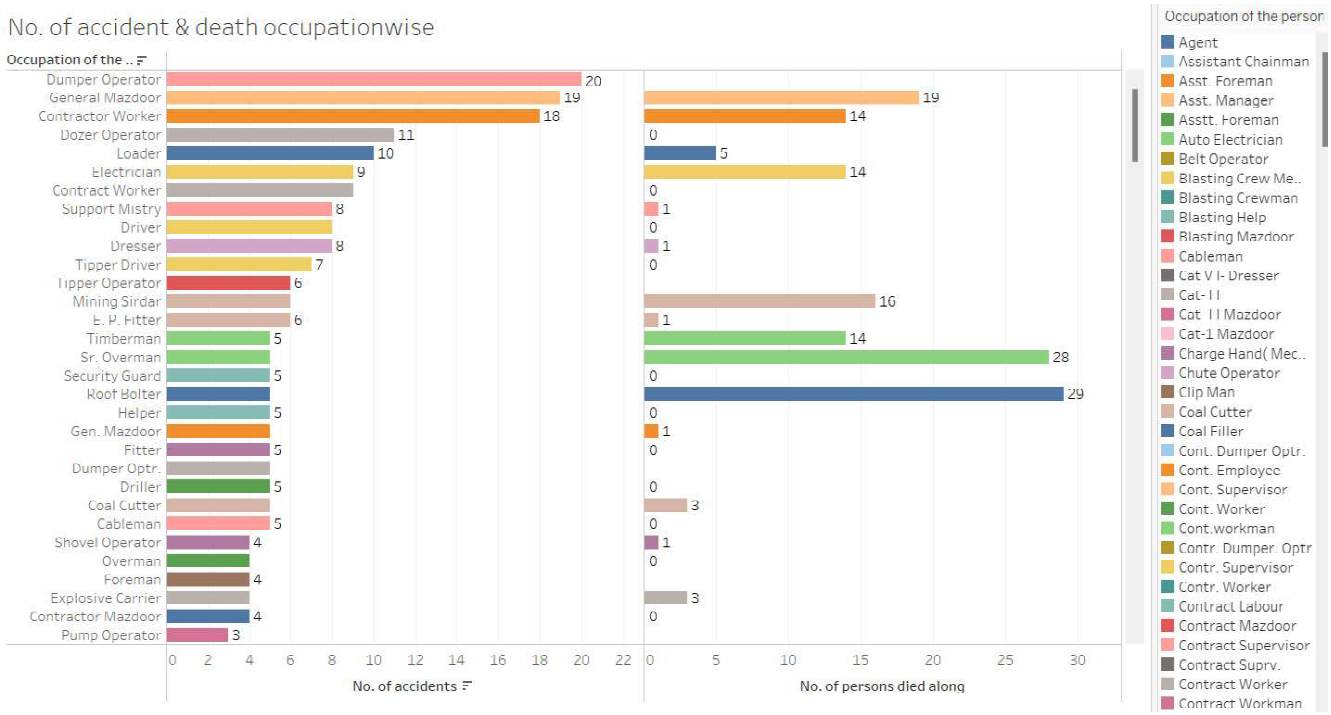

Fig.6. Number of accidents and number of people died occupation wise for Indian coal mines

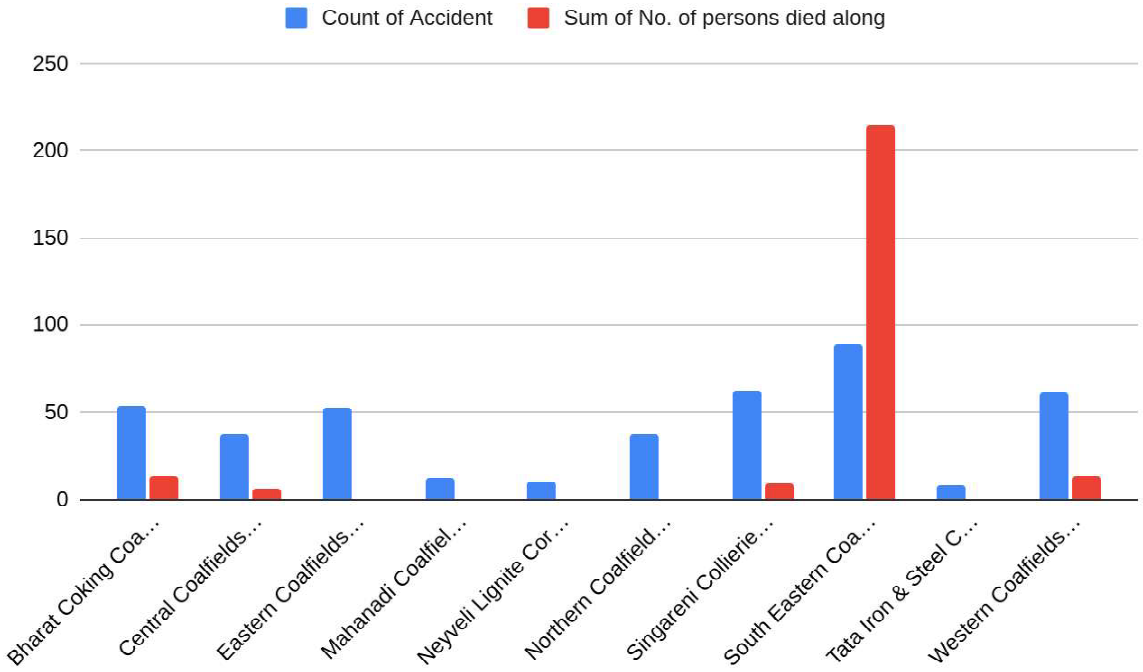

Fig.8. Top 10 companies which have encountered the maximum number of accidents and people died along for Indian coal mines.

For Indian coal mines it is clearly evident that Southeastern coal mines Ltd. has encountered a maximum number of accidents and people died along followed by Bharat coking coal mines Ltd.

A bar plots has been created for analyzing Number of accident happened at a particular day for Indian coal mines:

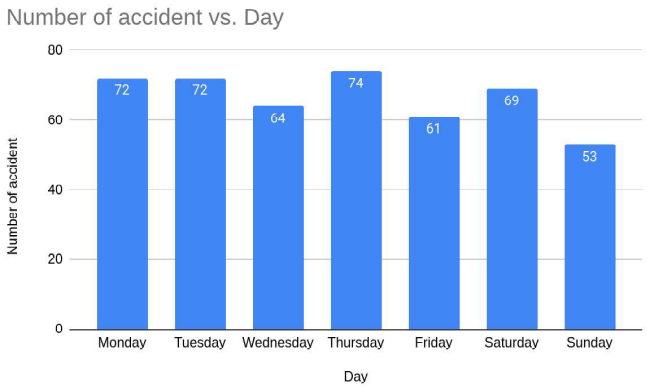

Fig.9. Number of accidents encountered on a particular day for Indian coal mines.

Maximum accidents have happened on Thursday followed by Monday and Tuesday.

A bar plots has been created for analyzing Number of accident happened at a particular day for Indian coal mines:

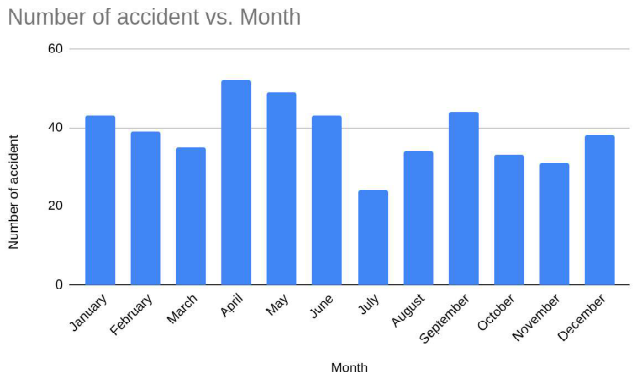

Fig.10. Number of accidents encountered in a particular month for Indian coal mines.

Maximum accidents have occurred in April and least accidents have occurred in July.

A bar plot has been created for seeing number of deaths happen per shift age group wise:

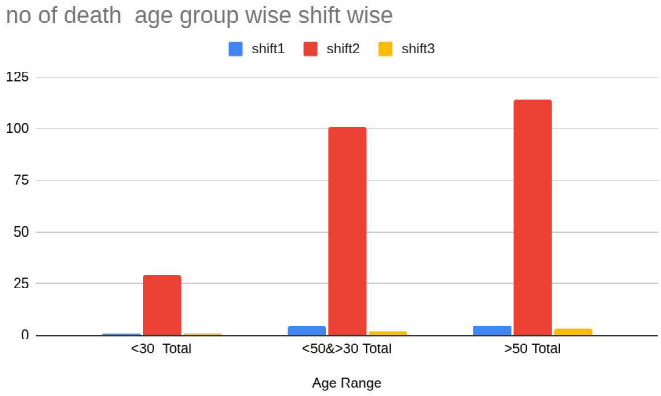

Fig.11. Number of deaths occured per shift age group wise for Indian coal mines.

Age is divided into groups like less than 30, greater than 30 less than 50, greater than 50. Number of accidents and the number of deaths have been plotted using age groups. Maximum number of deaths have occurred in the range greater than 50 age group and in the second shift.

A word cloud was created as shown in figure 12.

Nlp packages have been used to count the words and then word cloud is used using Tableau. It is quite clear that Dumper Operators faced most of the fatalities. It seems that a significant number of fatalities has been caused due to bench failure in opencast mines and in depillaring panels in Underground coal mine.

CONCLUSIONS

In the work, NLP and TM have been used for reading and extracting and analyzing information from reports of DGMS, which otherwise would have been a painstakingly long and arduous process requiring many technical experts and a more error-prone process. Based on the above work, the results and analysis authors have certain findings about accidents in Indian coal and non coal mines for the years 2010-2015, such as:

- For coal mines Southeastern Coalfields Ltd. has experienced the maximum number of accidents and deaths.
- For coal mines The age group of mine employees suffering a maximum death range greater than 50 years The authors advocate more stringent monitoring of employees' physical fitness after a certain age.
- For coal mines dumpers were the reason for the

Fig. 12. Word cloud of accident description

maximum accidents, followed by the fall of the roof, whereas the collapse of the shaft was the reason for the minimum accidents. Roof bolters' worker class faced maximum fatal injuries. Dumper operators and roof bolters should be given extra training as they lead to the most accidents and deaths.

- For Indian non coal mines it is very obvious that mazdoors' and 'workers' combined are most responsible for fatalities, followed by 'operators' and 'helpers'.
- In coal mines Special attention is needed between shift 2 working hours.
- For coal mines Jharkhand state has encountered the maximum number of accidents which is 120 out of 465 total accidents while Jammu & Kashmir has the minimum number of accidents as 1, whereas Chhattisgarh state has encountered maximum deaths which is 212 out of total 260 deaths.
- For non coal mines Rajasthan and Andhra Pradesh are responsible for 84 and 55 fatal accidents respectively. Goa and West Bengal have the least with 2 fatalities each.

To ensure Safety 4.0 in this period, the mining industry should begin using Industry 4.0 standards. Improvement of industrial safety through the use of the Industrial Internet of Things (IIoT) and technologies like AI, ML, and visual data analysis. Industries can use this accident report analysis process as well. Now, the authors would like to expand this research to include both surface- and underground coal mining. It is possible to further standardize the developed data. The appropriate normative denominator can be "Number of Man-Hours Worked" if the data are gathered or already available. If information regarding each age group's level of experience with the specified work is gathered, it will be possible to further clarify the analysis of age groups.

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Hazard Analysis of Rockfalls from High Wall Slopes in Opencast Mines - A Case Study of Dadam Quartzite Mine, Haryana, India

Rahul Verma* Harsh Kumar Verma* Ashok Kumar Singh**

ABSTRACT

The depth of open cast mines is continuously increasing to meet the production as per the high industrial demand. As a result, slope failure problems in open cast mining are gradually becoming severe. Rockfall is among the most common failure associated with such high and steep slopes posing huge risks to minors and machinery. In the present study, the rockfall problem in the final high walls of a stone quarry is taken up to understand the rockfall mechanism associated with high walls in opencast mining. Field-based rock mass and block characteristics have been done along with kinematic analysis to identify the rock type failures and their stability condition through Slope Mass Rating. Initially, the rock fall parameters were back-calculated and validated through trajectory simulation of past rockfall events. Then the potential rock falls from the high walls have been simulated to assess the associated hazard through rock fall parameters such as block trajectories, total kinetic energies, and maximum run out distance of fallen blocks. An optimized slope geometry of the final high walls of the mine has also been proposed to minimize the rock fall risk in future mining operations.

Keywords: Rockfall, Opencast mining, Rock failure, Trajectory simulation.

INTRODUCTION

Rockfall is a rapid mass movement of rock blocks detached from the slope surface and downward movement by rolling, sliding, or freefalling under the influence of gravity. It occurs frequently in open-cast mining environments and mountainous regions having jointed steep slopes with high kinetic velocities and unpredicted trajectories[1]. The rapid and unpredicted nature of block movements can be very hazardous and cause accidents and fatalities, especially in working mining scenarios. Stone quarries such as Dadam Stone Mines (Fig. 1) generally have jointed steep slopes on which rock falls are inevitable. The objective of this study is to analyze the hazard posed by rockfall on the eastern high wall of Pit 4 of the Dadam Quartzite Mine, Haryana, India. The approach for the study was to gather geological and geotechnical data through field investigation and to understand the rock fall mechanism through 2D rockfall trajectory simulation. In view of the rockfall controlling parameters, present study provides the rock fall characteristics in highly jointed steep high walls of open cast mines by simulating the run out distance and associated kinetic energies with varying block sizes and bounce heights.

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GEOLOGY OF THE AREA

Dadam Stone Mine is located near Dadam village in District Bhiwani, Haryana. The area is covered by Aeolian sand and is marked by Aravalli hill exposures. Dadam hill is one of the isolated inselbergs and is a part of Tosham Ring Complex (TRC) which is the remnant of the outer ring of a fallen chamber of an extinct volcano dated around 732 million years ago equivalent to the lower Vindhyan Group[2]. All other exposures of the TRC are intrusive rocks including Dadam hills which is a part of Malani igneous suit, the largest felsic igneous province situated in the NW part of India. Dadam hill consists of alkali feldspar granite and it is hard, homogeneous, and non-foliated. It is characterised by pink to grey coloured medium-grained rocks consisting quartz, feldspar and biotite as major minerals with porphyry texture. These granites are the host of minor minerals and for the production of road metal andmasonry stone[3].

MATERIAL AND METHODS

Geological and geotechnical investigation

The field investigations involve collection of geological and geotechnical data related to rock and joints (Fig. 1) to

characterize the rock mass through Rock Mass Rating (RMR).Slope Mass Rating (SMR) is also determined to quantify the stability condition along the eastern high walls in Pit 4 of Dadam Stone Mine.

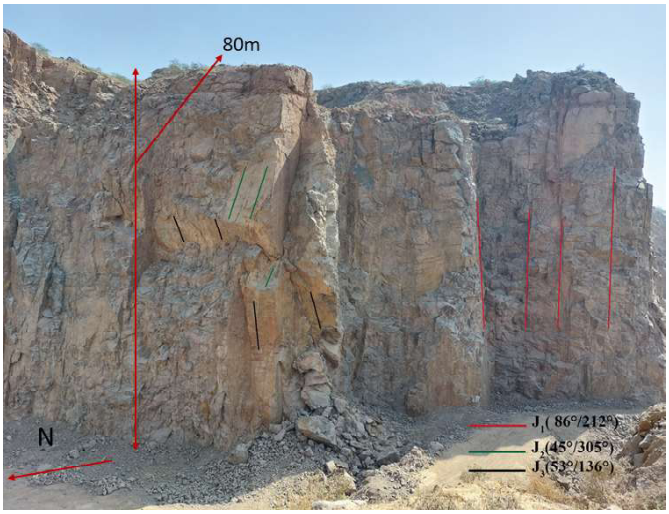

Figure 1: Eastern high wall of Pit 4 of Dadam Stone Mine with major joint sets

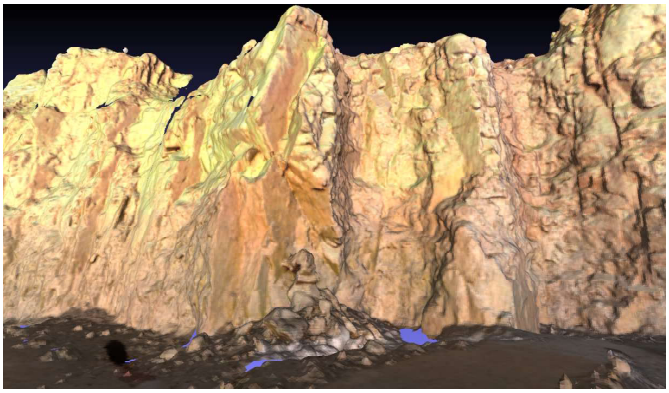

Figure 2.LiDAR image of the eastern high wall (mine lease boundary) of Pit no. 4

Apart from inherent joint sets, the rock is competent. However, an increase in the fracture densitydue to blastinghas been observed owing to the formation of several unstable blocks along the high wall slope. These over-hanged blocks can cause a major risk from rockfallat various locations. The size and shape of the rock blocks that define the block characteristics depend upon the pre-existing joint sets, their intensity, spacing, and persistence[4]as well as the newly formed fractures due to blasting. Block size and associated cumulative volume are the controlling factors of hazards posed by a rockfall event and also affect the associated protection methods. The height of the high wall slope at the mine lease boundary varies from 70m to 80mwithaslope angle of greater than 85° to negative at some places (Figure 2).

Rockfall Trajectory Modelling

Accurate prediction of rock falls is practically impossible due to complex block-slope interaction during block movement after detachment. However, various computer codes are available and being used in mining projects worldwide. These codes prove to be very handy to predict rock fall characteristics reliably with the probabilistic simulation of rock falls. They also assist in designing suitable remedial measures considering kinetic energy, velocity, bounce height, and end point locations of the falling blocks. Information about the kinetic energy and location of rock block impact along the slope profile helps to determine the rockfallbarrier capacity, size, and probable installation locations. In the present study, rock fall simulation has been done through Rocfall 2D v8.0 of Rocsciences.

RESULTS AND DISCUSSION

Rock Mass Characterization and Kinematic Analysis

The mean orientation of major joints J1, J2, and J3 are 86°/212°, 43°/305°, and 53°/136° respectively. Random joints and blast-induced fractures were also measured which are included in the kinematic analysis. All the major joint sets are highly persistent with greater than 20m extent. Spacing between the joints varied from maximum of 120cm to a minimum of 20cm. The joints also have varying aperture length. Joints with aperture size of about 17mm have clay coating while closed joints with 2mm aperture are observed free from any infilling material between the joint surfaces.The Volumetric Joint Count (J_v) was used to measure the Rock Quality Designation (RQD) using the relation, 115-3.3J_v, suggested by Palmstram (1982)[5].The calculated J_v varied from 10-12 for rock mass having little to non-disturbed by blasting. Whereas J_v varied from 16 to 20 at some locations where high rock mass damage due to blasting is observed. Therefore, RQD also varied considerably along the pit length ranges from 56 to 75. The moderate weathering condition led to the formation of clay coating at some of the open joints otherwise closed, rough, and undulated joint condition is observed. Kinematic analysis of the eastern high wall allows identifying the type of failure as well as the critical zones along which the

failure can occur. The slope in consideration is susceptible to planar sliding (Fig. 3a) along joint J_2, wedge sliding (Fig. 3b) along the intersection of J_1 and J_2, as well as direct toppling as shown in Fig.3c.

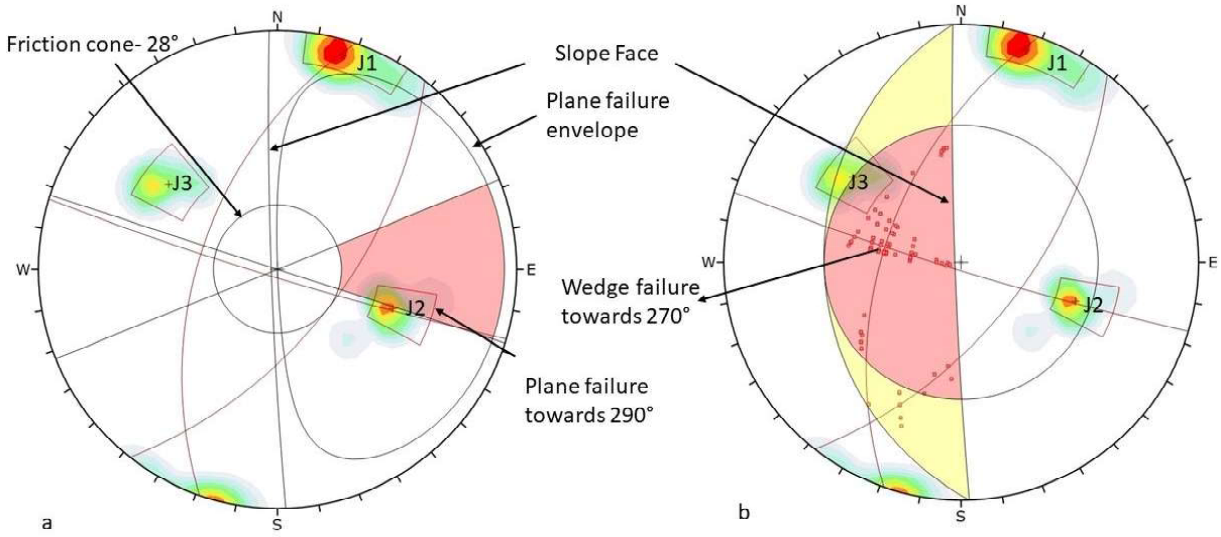

Figure 3. Kinematic analysis showing (a) Planar and (b) Wedge type of failures are susceptible

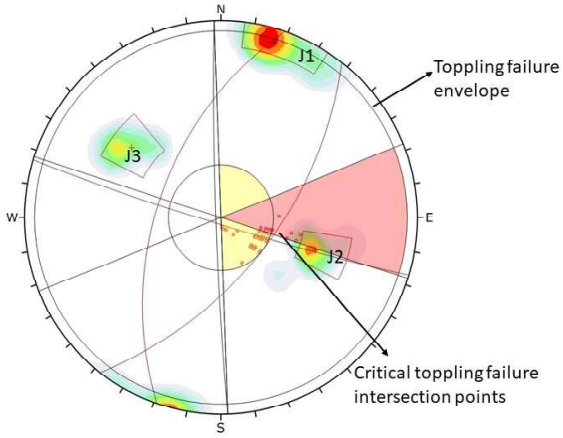

Figure 3c. Toppling failures from the eastern high wall

The Rock Mass Rating (RMR) and Slope Mass Rating (SMR) on the basisof field data and kinematic analysis are given in Table 1. Even though the RMR class for the slope is fair the SMR value is fairly low indicating unstable and prone to failure slopes.

Table 1. Rock Mass Characterization of high wall slope

West Wall			**East wall**		
RMR	SMR	**Stability condition**	RMR	SMR	**Stability condition**
71	16.2	Very Bad	67	38.1	Bad
71	19	Very Bad	69	38.9	Bad
71	27.5	Bad	68	37.9	Bad

ROCKFALL TRAJECTORY SIMULATION

The cross-section of the most vulnerable segment for rock falls along the eastern high wall slope was considered for rockfall trajectory simulations using the rigid body model. The height and slope angle were approximated based on field data and the slope profile was kept uneven as per existing slopecondition to model and observe the rock falls behavior as accurately as possible during block movements. Initially, the model slope is validated and parameters were back-calculated through the past rock fall event by considering the actual block sizes and end locations of blocks from the well-defined detachment zones at various locations along the slope profile. These measured end locations in the field were set as the boundary limits for block run-out and detachment zones were set as seeders at various location sprior to compute the model. The upper portion of the high wall is marked as a potential zone for block detachment due to the increased aperture of the extension joints. The other two seeder zones are considered along the intersection of two joint sets forming wedge-shaped blocks day-lighted in the slope. The modeled slope and results of the rockfall analysis are shown in Figure 4 along with seeder locations. Because of steep to negative slope profile, the detached rock blocks are more open to free fall and bounce impacted at the base than rolling or sliding (Figure 4).

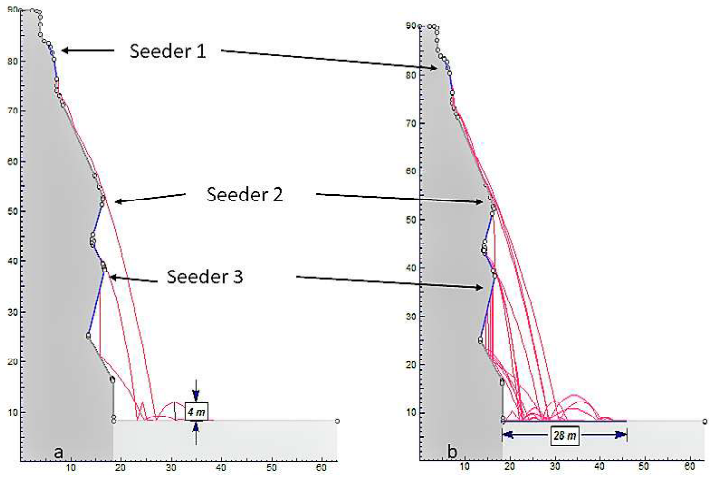

Figure 4. Simulated model showing seeder locations, rockfall trajectory, block impact locations, and run-out distances considering (a) Single block and (b)5 blocks per seeder and associated maximum end-point locations.

The size and shape of the detached rock block are of great importance to predict the rockfall characteristics such as bounce height, overall run out path, and total kinetic energy[1]. Upon back analyzing of past rockfall events, slope surface parameters were finalized (Table 2) by duplicating the field scenario considering the rockfall end locations (Figure 4a). The block sizes and shapes have also been considered in the analysis which is given in Table 3. After settling the input parameters, simulation was done by taking five blocks per seeder simultaneously (Figure 4b). The analysis suggests that the output parameters such as impact location, bounce height, and run-out distances are highly governed by the relative position of block detachment along the slope profile. Figure 4 shows the runout path of the blocks from each seeder which suggests that the maximum distance covered by falling blocks is nearly 28m. It signifies that the safe working distance for men and machinery during mining operations will be no less than 28m in such steep and high-wall mining environments.

Table 2: Input parameters of slope surface used in rock fall simulations

Parameters	Clean hard granitic bedrock	Fractured bedrock at the base
Normal Restitution	0.53	0.3
Tangential Restitution	0.99	0.8
Dynamic Friction	0.58	0.58
Rolling Friction	0.29	0.29

Table 3: Block shapes considered for rock fall simulation

Shape	Illustration
Super ellipse^1:1	
Super ellipse^2:3	
Super ellipse^5:6	
Super ellipse^1:2	

The run out paths for lower most seeders are less than 28m due to the rough ground surface. The bounce height of the falling blocks is 4m i.e. the blocks will attain a height of approximately 4m after their first impact. The maximum total kinetic energy of the simulated blocks is observed to be 63kJ at 10m from the slope profile (Figure 5). Whereas, the simulated blocks are stopped in maximum frequency before 20m, as suggested by the graph of block path end location (Figure 6).Total kinetic energy and rock path end location plots provided in Figures 5 and 6will assist to

determine the capacity, size, and location of the rockfall protection barrier to install. A rockfall protection barrier should be placed at the location where the lowest total kinetic energy is predicted.

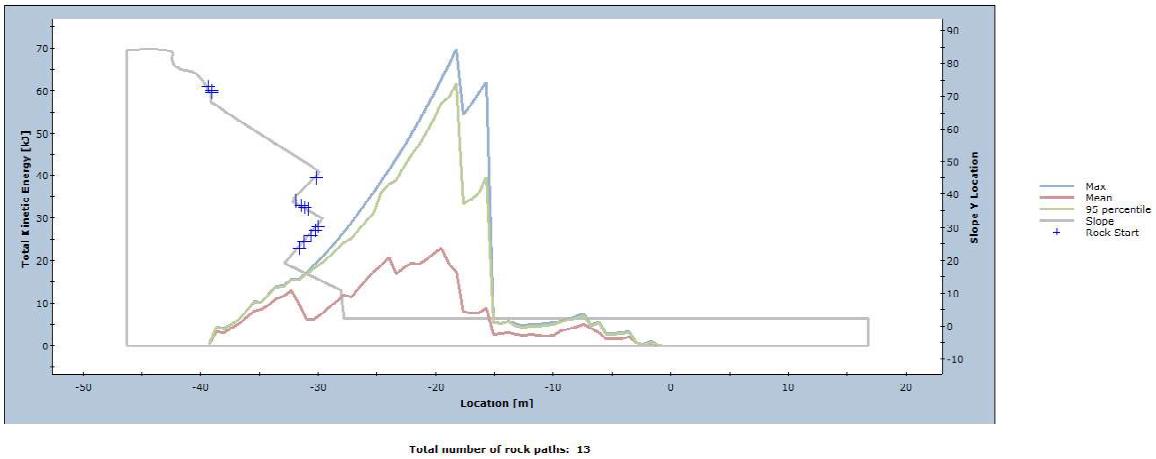

Figure 5: Variation of total kinetic energy and mean kinetic energy along the slope profile

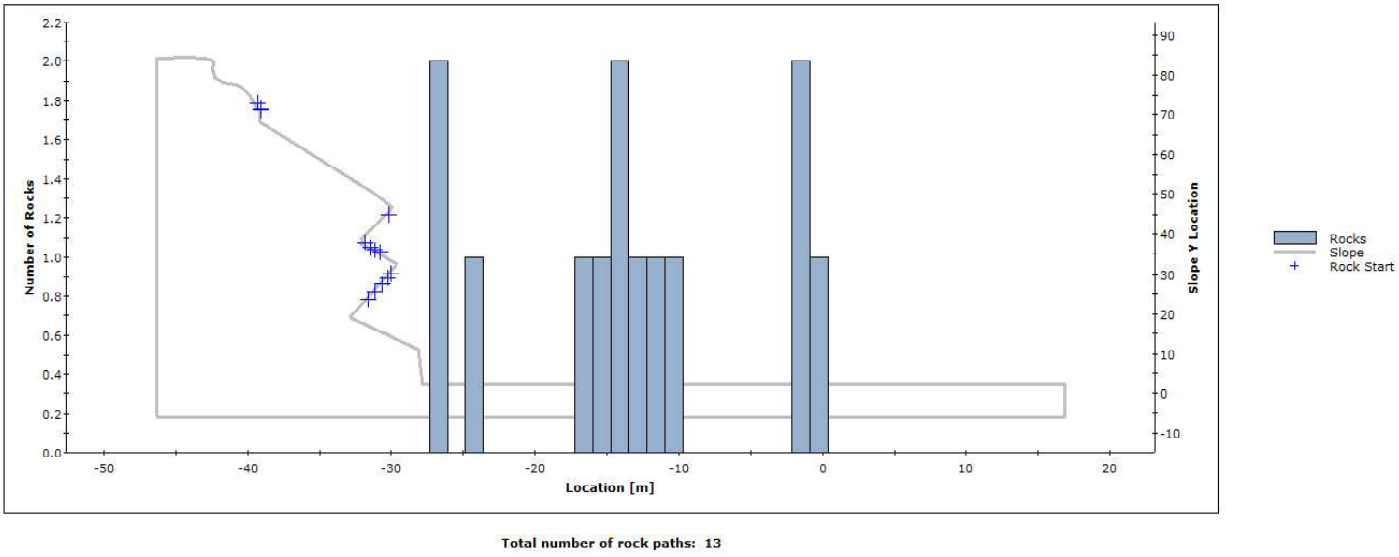

Figure 6: Distribution of rock fall block path end location with respect to slope profile

SUGGESTED MEASURES IN VIEW OF FINAL HIGH WALLS

Mining through proper benching of the final high wall in Dadam Stone Mine is constrained due to the narrow patch of the mining lease area. High steep slopes at the mining lease boundary are formed to maximize production from the available lease area. To counter rock fall hazards and minimize their effect, the high wall is optimized through benching with a bench height of 20m and berm width of 8m (Figure7) in existing slope conditions. Upon simulating the rock fall scenario in the suggested optimized slope geometry, the risk of rock fall is significantly reduced without the installation of any protective barrier. All the detached rock blocks are arrested within the berm. The proposed bench geometry to reduce the rockfall risk account for only about 24m of forest land at the base while maintaining the minimum width for any machine operation over the berm.

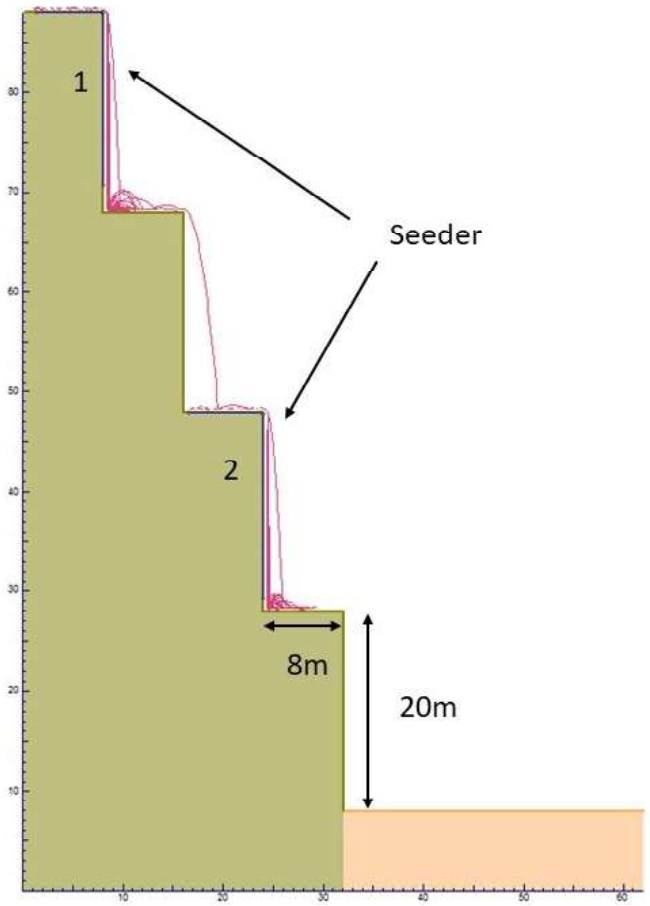

Figure 7: Optimized bench geometry to reduce the rock fall risk

CONCLUSIONS

The mining lease boundaries of Dadam quartzite Mine is sequestered in small patches surrounded by the protected forest area. To maximize the production from these narrow patches, downward excavation is the easiest way thus leaving behind high steep slopes. These steep high walls are at hazardous for rockfalls posing high risk to miners and machinery. Therefore, the present study addressed the rock fall problems associated with these high walls by evaluating the rock fall characteristics such as kinetic energy, their velocity, bounce height, and endpoint locations of the falling blocks. These parameters are found controlled by block dimension, volume, and the location of detached rock blocks. The size and shape of in-situ potential rock blocks directly related to prevailing joint frequency of blasted rock mass. Rock fall trajectory simulation has been done using slope and block properties, helps to understand the degree of rockfall hazard associated with these high walls followed by kinematic and SMR analysis. Study suggests that the detachment location of block is key factor to quantify the rock fall hazard govern by mostly free falling of the blocks. To counter the risk associated during mining operation, an optimized bench geometry has been proposed in view of existing constrained mining environment.

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Recent Developments in Arena of Indian Energy Front- Step Towards "Atmanirbhar Bharat"

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ABSTRACT

The demands and aspirations of India's billion-plus citizens drive the country's energy needs. India's import dependence has grown as domestic fuel output has fallen behind demand growth. As a result, India's energy security has been a source of concern. We believe that India's energy security must be considered from the perspective of the country's unique history. It must also take into account issues like accessibility, price, and environmental sustainability.

India's flexible goal on renewable energy, goal of 500 GW green energy by 2030 dropped. It also did not include the commitment to reduce one billion tonnes of carbon emission by 2030, as stated earlier at the COP26 conference, held in Glasgow in November last year. Giving itself the flexibility of 50% power from non-fossil fuel sources by then in its commitments to the United Nations Framework Convention on Climate Change (UNFCCC). This keeps India's options open for new coal-based power plants in the projected 820 GW total capacity, if excess demand cannot be met from green fuels.

INTRODUCTION

India dropped its target of establishing 500 GW of renewable energy capacity by 2030, giving itself the flexibility of 50% power from non-fossil fuel sources by then in its commitments to the United Nations Framework Convention on Climate Change (UNFCCC). This keeps India's options open for new coal- based power plants in the projected 820 GW total capacity, if excess demand cannot be met from green fuels.

The Cabinet approved India's updated Nationally Determined Contribution (NDC) to be communicated to the UNFCCC. The updated NDC proposes about 50% cumulative electric power installed capacity from non fossil fuel-based energy resources by 2030, dropping the 500 GW absolute target committed at COP26. It also did not include the commitment to reduce one billion tonnes of carbon emission by 2030. An official statement issued after the cabinet meeting reiterated India's long-term goal of reaching net zero by-2023.

CAPACITY TO DEPEND ON POWER DEMAND

The updated NDC has a flexible approach towards renewable energy generation that in reality depends upon power demand If the demand for power is high, the generation should be high, rather than setting rigid targets.

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" The industrialised countries have been using fossil fuel for their growth for the past many decades. Our first requirement is to make sure there is enough power available for growth. There is not going to be any compromise on that and halting new thermal power projects. India's current installed power capacity is 404 GW, consisting of coal-based 204 GW (50%), renewable energy sources 114 GW (28%), and hydro 47 GW (12%). Nuclear power generation capacity is 7 GW, gas-based power 24 GW, and lignite and diesel-based 8 GW.

Installed Power Generation Capacity

	MW			% share		
	Current*	Mar-27	Mar-30	Current*	Mar-27	Mar-30
Coal	2,08,214	2,38,150	2,66,911	54.9	38.5	32.7
Gas	24,957	25,735	25,080	6.6	4.2	3.1
Hydro	46,209	63,301	71,128	12.2	10.2	8.7
Nuclear	6,780	16,880	18,980	1.8	2.7	2.3
Renewables	92,970	2,75,000	4,35,155	24.5	44.4	53.2
Total	**3,79,130**	**6,19,066**	**8,17,254**	**100.0**	**100.0**	**100.0**

*As of end-February 2021, estimated by CEA

The Central Electricity Authority has forecast that the country's reliance on coal will drop from 53% in 2021 to 33% in 2030, whereas solar and wind together will make up 51% from 23% in 2021. Coal contributes about 67% of the energy generation.

This might brainstorm that, meeting new demand of energy requirements by coal based energy and standing commitment to reduce one billion tonnes of carbon emission by 2030.

ATMANIRBHAR BHARAT ABHIYAAN

Honourable Prime Minister of India in his 75th Independence Day speech has mentioned that India will have to pledge to become energy independent before its 100 years of Independence. At present India is heavily dependent on imports for its oil and gas needs. For the steel making process through blast furnace route requires coking coal which is mostly imported from Australia, USA and other countries. Hydrogen produced from Syn gas will also help in meeting the energy need of the country. In the past, number of efforts has been made to gasify coal in India.

In order to achieve 100 MT coal gasification projects in India by 2030, Ministry of Coal has taken several steps. All coal companies have been advised to appoint a nodal officer and to prepare an action plan for gasifying at least 10% of their coal production. Two years back, CIL included gasification as a major component of its diversification agenda, others being solar manufacturing and aluminium. Since then, it has already sought bids under BOO for three gasification projects, while two more are on the anvil, adding up to use of 10 million tonnes of coal per annum. The envisaged gasification products can be used as fuel and feedstock in downstream industries.

4 projects for coal to clean energy conversion to help achieve 100 MT coal gasification by 2030

Conversion of coal to clean energy with private sector capital investment of Rs 30,130 crore will help in achieving the target of 100 million tonnes (MT) coal gasification by 2030. Finance Minister Smt. Nirmala Sitharaman in her budget speech 2022-23 announced setting up of four pilot projects for coal gasification and conversion of coal into chemicals required for the industry will be set up for technical and financial viability".

❖ This 100 MT coal gasification will happen in three phases.

1. In the first phase from 2020- 2024 — four million tonnes (MT) of coal will be gasified and around Rs 20,000 crore will be invested for the same.
2. In the second phase — from 2020-2026 — 6 MT of coal will be gasified which will involve an investment of Rs 30,000 crore.
3. In the Third phase from 2020- 2024 four million tonnes (**MT**) of coal will be gassified and around RS. 20,000 crore will be invested for the same.

COAL GASIFICATION PRODUCTS: SECTORAL POTENTIAL

Chemicals and Petro- chemicals 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:

a) Methanol
b) Olefins – (Primarily - Ethylene and Propylene)
c) DME, Acetic Acid and Formaldehyde

The units will produce methanol, ammonia, ammonium nitrate and urea.

India currently imports close to 20% of its ammonia and ammonium nitrate consumption primarily from Turkey, Russia, and Bulgaria for fertilizer industry.

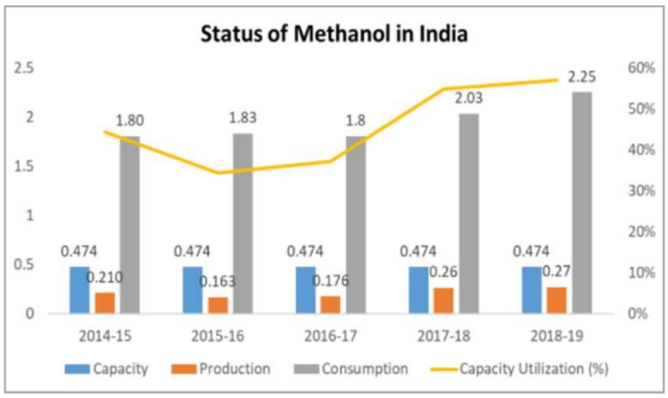
A) Methanol

Natural gas to methanol is an established process, however, coal is also being used to produce methanol in some parts of the World, mainly China. India having abundant reserves of coal can produce methanol from coal.

Conversion Efficiency of Coal to Methanol: It is estimated that 2.7-3 tons of coal would be required to produce 1 ton of Methanol. Therefore, 5-6 MT of coal would be required to produce around 2 MT of Methanol. Also, methanol can be used as a feedstock to produce Olefins, DME and Acetic Acid.

POTENTIAL OF METHANOL CONSUMPTION

M15 Fuel: BIS has notified M15 fuel for automobile sector wherein 15% methanol can be blended with Gasoline. In addition to the present domestic methanol consumption, about 5-7 Million tonnes more Methanol, which is the main product from coal gasification is majorly import driven in India with 90% of the demand being met from Iran and Saudi Arabia. According to coal Ministry's estimates, $50BN is the foreign exchange for chemical and petrochemical products in India, as natural gas imports grew at a compound annual growth rate (CAGR) of 5.89% during last decade.



can be utilised in M15 fuel with 30 million Tonnes of consumption of gasoline.

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.

OLEFINS (PRIMARILY- ETHYLENE AND PROPYLENE)

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.

DI-METHYL ETHER(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*ƒ* 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

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

Ammonium Nitrate (AN)

Ammonium Nitrate is an important constituent for manufacturing of explosives in open cast mines and at present there is an import of about 2.5 million tonnes of AN. Most of the domestic manufacturers are importing ammonia and producing ammonia through imported Natural Gas and these plants are situated on the western part of the country. The consumption centers are in the eastern part and are more inclined to imported AN received from Vizag port. Department of Chemicals may formulate a strategy for production of AN from domestic sources.

CHALLENGES

Coal Gasification utilises chemical property of coal and as such availability of consistent quality of coal for the entire project life is an important factor. There are many other challenges for the successful running of surface coal gasification projects which can be summarised as:

(i) Availability of coal having gasification potential and of consistent quality as a feed stock is utmost important. There should be an appropriate linkage policy for this purpose.

(ii) The quality of coal available in India is mostly of low rank high ash coal. Technology for conversion

of high ash coal to syn gas is one of the major challenges. There is a need to develop indigenous technology suited to Indian coal.

(iii) Capital requirement for setting up of these plants is high and huge capital will be required to achieve the mission. Further, due to uncertainty and dependence on foreign licensors for Syn Gas conversion, the cost of various products produced domestically may not be at par with the imported products. Specially methanol produced from Coal may not be competitive with methanol produced from Natural Gas.

(iv) The lack of experience in the domestic sector for SCG is also a challenging factor. This is mostly because there is little expertise in domestic sector for coal gasification.

(v) Infrastructure requirement such as land, water, electricity will play an important role in establishing SCG projects. Further, development of market for various products and transportation cost from point of production to consumption centre will also be important.

(vi) Use of M15 fuel as transport fuel, blending of DME with LPG and establishing Syn Gas to ethanol conversion technology will be key in achieving the Mission.

(vii) The coordination between various stakeholder Ministries such as P&NG, Chemical and Fertilisers, Steel, Coal, Power etc. is also important for the success of various SCG projects.

CONCLUSION

India's Energy Security is largely depend on coal which along with the fossil fuels is at centre stage of global debate over global warming and climate change. The Paris agreement and the subsequent COP26 stands India's commitment to reduce carbon footprint as a responsible global citizen however the task is changing multi ferrous activities towards accepting these changes is imperative and a journey towards that is fought with such actions like, different forms of CCT, Alternative sources of power and adopting advanced technologies towards substitution of different energy sources to reduce the carbon footprint. All these actions must be in alignment with the increasing demand of power and other fuel resources. Simultaneously with fulfilling the commitment of India to achieve net zero carbon emission by 2070. And most of the feed stock feed stock for secondary industries are mostly dependent on imports by coal gasification we can provide to industries and become self-reliant a way towards ATMANIRBHAR BHARAT ABHIYAAN:

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Clean Coal Technology

Aman Kumar* Ayush Kumar* Nulu Jagadeesh* Manish Kumar*

ABSTRACT

Coal preparation is key to the realization of a clean coal technology. It acts as a bridge between producing mines and customers. A strategic plan for sustainable coal preparation has been created. There are different factors that determine the characteristics of quality of mined coal. The dilution takes place due to: geologic, mining and mine supervision. Raw coal quality deteriorates during mining. If dilution is restricted at this stage, there is a great deal of relief in the coal preparation plant. Control of dilution during surface and underground mining has been separately dealt with. The introduction of a new system of grading by gross calorific value has paved the way for non coking preparation to become more rational. Clean coal technology through precombustion, combustion and post combustion is discussed in this chapter and the zero waste approach is advocated. The growing implementation of clean coal technologies will also accelerate the use of coal as a primary source of energy.

Coal is an extremely important energy source, providing 39% of the world's electricity. But the burning of coal also has a huge impact on the environment—it releases about 9 billion tons of harmful carbon dioxide into the atmosphere every year, contributing to global warming. The coal industry is developing new "clean coal" technologies that aim to cut down on these emissions while maintaining coal's low cost. Some clean coal technologies purify the coal before it burns. One type of coal preparation, coal washing, removes unwanted minerals by mixing crushed coal with a liquid and allowing the impurities to separate and settle .Other systems control the coal burn to minimize emissions of sulfur dioxide, nitrogen oxides and small particles. Wet scrubbers remove sulfur dioxide, a major cause of acid rain, by spraying gas with limestone and water. The mixture reacts with the sulfur dioxide to form synthetic gypsum, a component of drywall .Low-NOx (nitrogen oxide) burners reduce the creation of nitrogen oxides, a cause of ground-level ozone, by restricting oxygen and manipulating the combustion process. Filtration devices remove small particles that aggravate asthma and cause respiratory ailments by charging particles with an electrical field and then capturing them on collection plates.

INTRODUCTION

Clean coal technologies are several generations of technological advances that have led to more efficient combustion of coal with reduced emissions of sulfur dioxide and nitrogen oxide. The U.S Department of Energy (DOE) administers the CCT program to encourage and support public/private partnerships to research, develop and demonstrate clean coal technologies that ultimately can be brought to large-scale commercial deployment. In the first generation of CCT, private industry was required to provide half of the funding for each project, but historically contributed significantly more. The clean coal technology program has resulted in more than 20 new, lower cost, more efficient and environmentally compatible technologies for electric utilities, steel mills, cement plants and other industries.

Energy and Environmental Benefits of CCT

Power plants being built today emit 90 percent less pollutants (SO2, NOx, particulates and mercury) than the plants they replace from the 1970s, according the National Energy Technology Laboratory (NETL). Regulated emissions from coal-based electricity generation have decreased overall by over 40 percent since the 1970s, while coal use has tripled, according to government statistics. Examples of technologies that are deployed today and continue to be improved upon include.

Fluidized-bed combustion

Fluidized bed combustion (**FBC**) is a combustion technology used to burn solid fuels .In its most basic form,

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fuel particles are suspended in a hot, bubbling fluidity bed of ash and other particulate materials (sand, limestone etc.) through which jets of air are blown to provide the oxygen required for combustion or gasification. The resultant fast and intimate mixing of gas and solids promotes rapid heat transfer and chemical reactions within the bed. FBC plants are capable of burning a variety of low-grade solid fuels, including most types of coal, coal waste and woody biomass, at high efficiency and without the necessity for expensive fuel preparation (e.g., pulverising). In addition, for any given thermal duty, FBCs are smaller than the equivalent conventional furnace, so may offer significant advantages over the latter in terms of cost and flexibility.Limestone and dolomite are added during the combustion process to mitigate sulphur dioxide formation. There are 170 of these units deployed in the U.S. and 400 throughout the world.

Integrated Gasification Combined Cycle (IGCC)

Integrated gasification combined cycle technology is considered to be one of the clean coal technology associated with the generation of power by using syngas in gas turbines and also recycling the exhaust from the gas turbines for forming steams and using the same steam in steam turbine to generate additional power. An **integrated gasification combined cycle** (**IGCC**) is a technology using a high pressure gasifier to turn coal and other carbon based fuels into pressurized gas—synthesis gas (syngas). It can then remove impurities from the syngas prior to the electricity generation cycle. Some of these pollutants, such as sulphur, can be turned into re-usable by products through the Claus process. This results in lower emissions of sulphur dioxide, particulates, mercury, and in some cases carbon dioxide. With additional process equipment, a watergas shift reaction can increase gasification efficiency and reduce carbon monoxide emissions by converting it to carbon dioxide. Heat and pressure are used to convert coal into a gas or liquid that can be further refined and used cleanly. The heat energy from the gas turbine also powers a steam turbine. IGCC has the potential to improve coal's fuel efficiency rate to 50 percent. Two IGCC electricity generation plants are in operation in the U.S.

Flue Gas Desulfurization

Also called "scrubbers," and removes large quantities of sulphur, other impurities and particulate matter from emissions to prevent their release into the atmosphere. Most FGD systems employ two stages: one for fly ash removal and the other for SO removal. Attempts have been made to remove both the fly ash and SO in one scrubbing vessel. However, these systems experienced severe maintenance problems and low removal efficiency. In wet scrubbing systems, the flue gas normally passes first through a fly ash removal device, either an electrostatic precipitator or a baghouse, and then into the SO absorber. However, in dry injection or spray drying operations, the SO is first reacted with the lime, and then the flue gas passes through a particulate control device. Another important design consideration associated with wet FGD systems is that the flue gas exiting the absorber is saturated with water and still contains some SO. These gases are highly corrosive to any downstream equipment such as fans, ducts, and stacks. Two methods that may minimize corrosion are: (1) reheating the gases to above their dew point, or (2) using materials of construction and designs that allow equipment to withstand the corrosive conditions. Both alternatives are expensive. Engineers determine which method to use on a site-by-site basis.

Low Nitrogen Oxide (NOx) Burners

Reduce the creation of NOx, a cause of ground-level ozone, by restricting oxygen and manipulating the combustion process. Low NOx burners are now on 75 percent of existing coal power plants.

Selective Catalytic Reduction (SCR)

Selective catalytic reduction (SCR) is a means of converting nitrogen oxides, also referred to as NO_x with the aid of a catalyst into diatomic nitrogen (N_2), and water (H_2O). A reductant, typically anhydrous ammonia (NH_3), aqueous ammonia (NH_4OH), or a urea ($CO(NH_2)_2$) solution, is added to a stream of flue or exhaust gas and is reacted onto a catalyst. As the reaction drives toward completion, nitrogen (N_2), and carbon dioxide (CO_2), in the case of urea use, are produced. Achieves NOx reductions of 80-90 percent or more and is deployed on approximately 30 percent of U.S. coal plants.

Electrostatic Precipitators

An electrostatic precipitator (ESP) removes particles from a gas stream by using electrical energy to charge particles either positively or negatively. The charged particles are

then attracted to collector plates carrying the opposite charge. The collected particles may be removed from the collector plates as dry material (dry ESPs), or they may be washed from the plates with water (wet ESPs). ESPs are capable of collection efficiencies greater than 99 percent. An ESP is primarily made up of the following four components: gas distribution plates, discharge electrodes, collection surfaces (either plates or pipes) and rappers. The gas distribution plates consist of several perforated plates which help maintain proper flow distribution of the entering gas stream. The discharge electrodes are divided into fields. Most ESPs have three or four fields in series; however, very large units may have as many as fourteen fields in series. Discharge electrodes are energized by a single transformerrectifier (T-R) set power supply. The energized electrodes create ions that collide with the particles and apply the electrical charge to the particles contained in the incoming gas stream. The collection plates or pipes provide the collection surfaces for the charged particulate matter. The rapping system is responsible for removing the collected particulate matter from the collection surfaces. Remove particulates from emissions by electrically charging particles and then capturing them on collection plates.

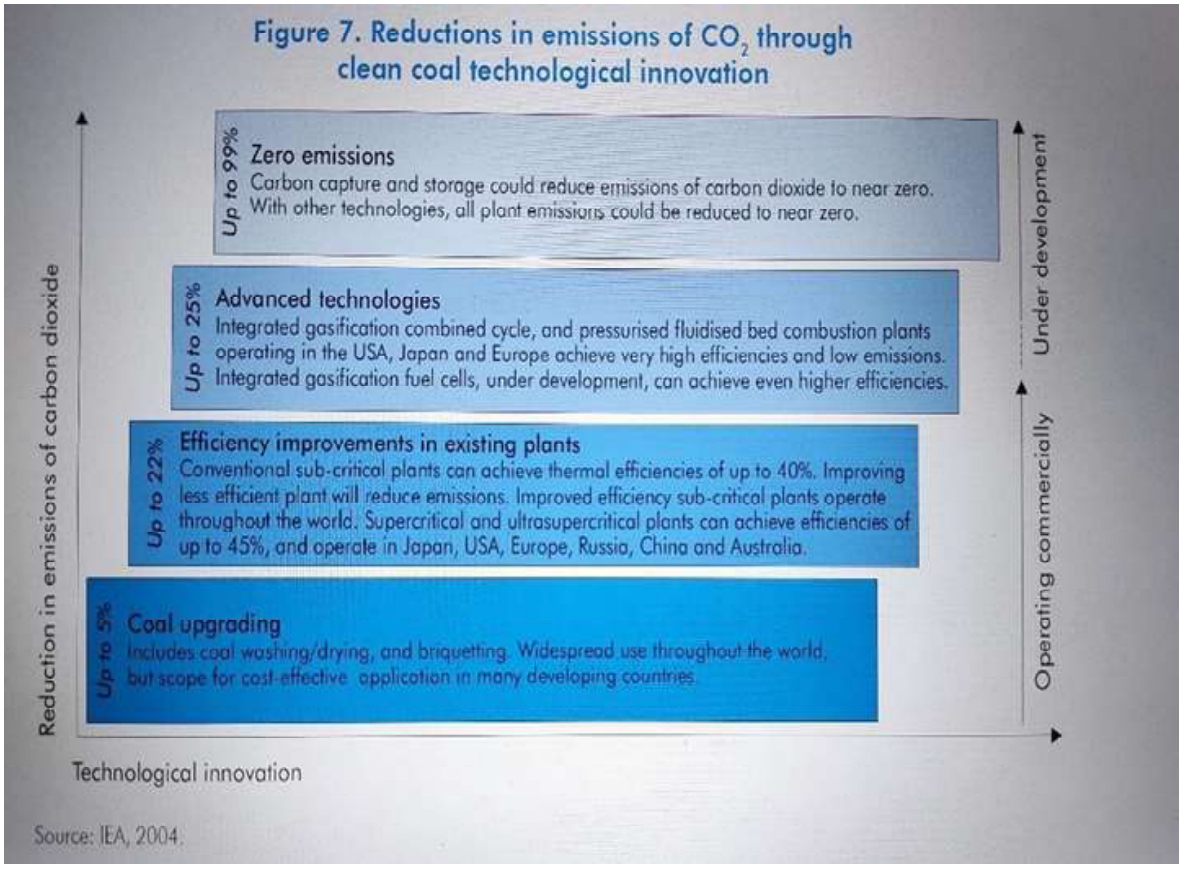
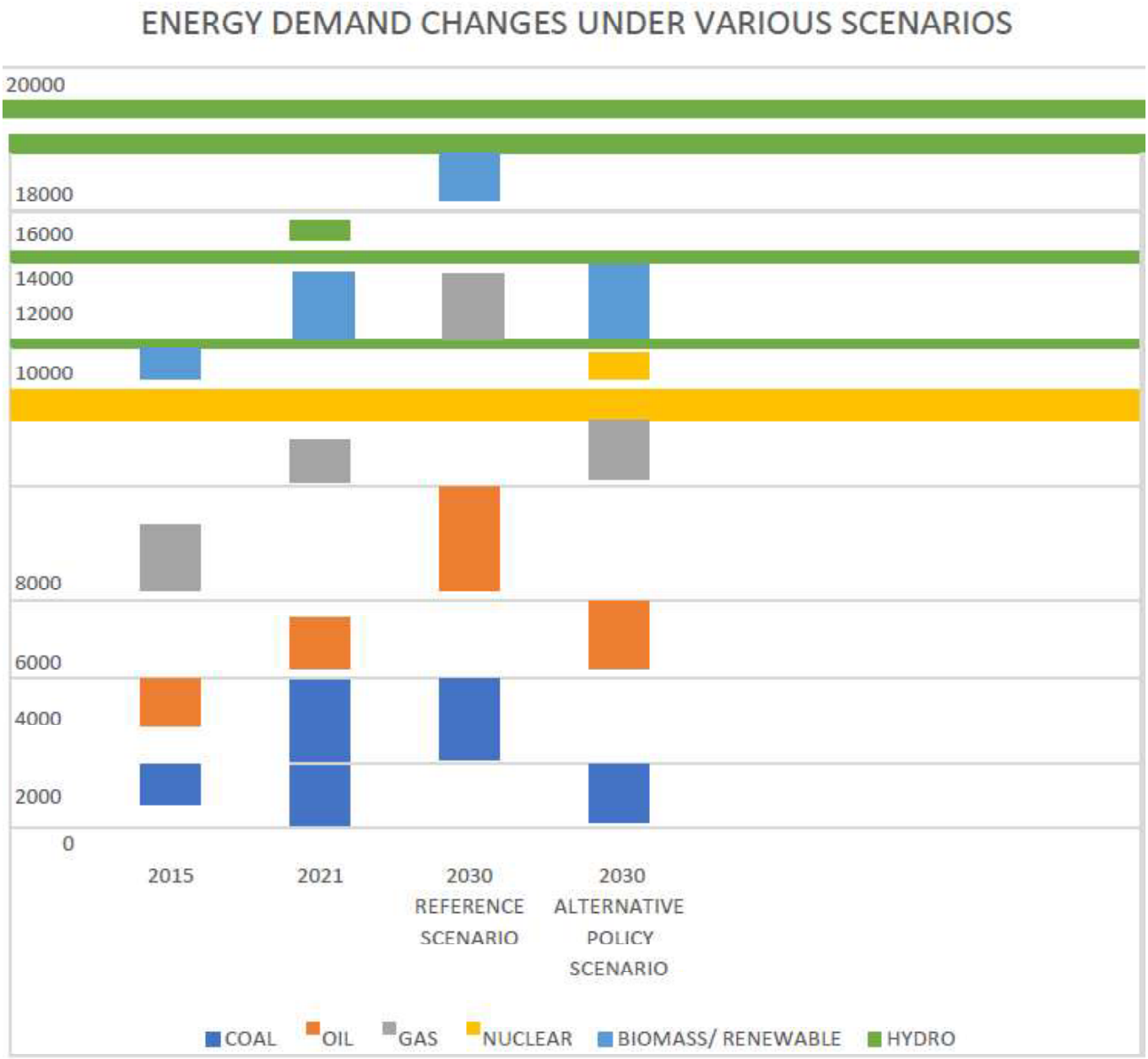


Figure 7. Reductions in emissions of CO_2 through clean coal technological innovation

THE NEED FOR COAL

As the IEA has noted in recent statements, only a portfolio of cleaner fossil fuels together with energy efficiency measures, nuclear and renewable energy can provide the price stability, supply security and widespread availability needed over the next few decades for the developed world to maintain its prosperity and for the developing world to fuel its economic growth and alleviate poverty (IEA, 2007a and IEA, 2007b).

Moreover, the push for development to alleviate poverty continues to place priority on economic growth and the concomitant urbanisation and mass infrastructure development that characterises rapidly growing Asian economies. The need for new ports, roads, railways, airports and housing drives increased demand for electricity, steel and cement which are traditionally reliant on coal to fuel their production.

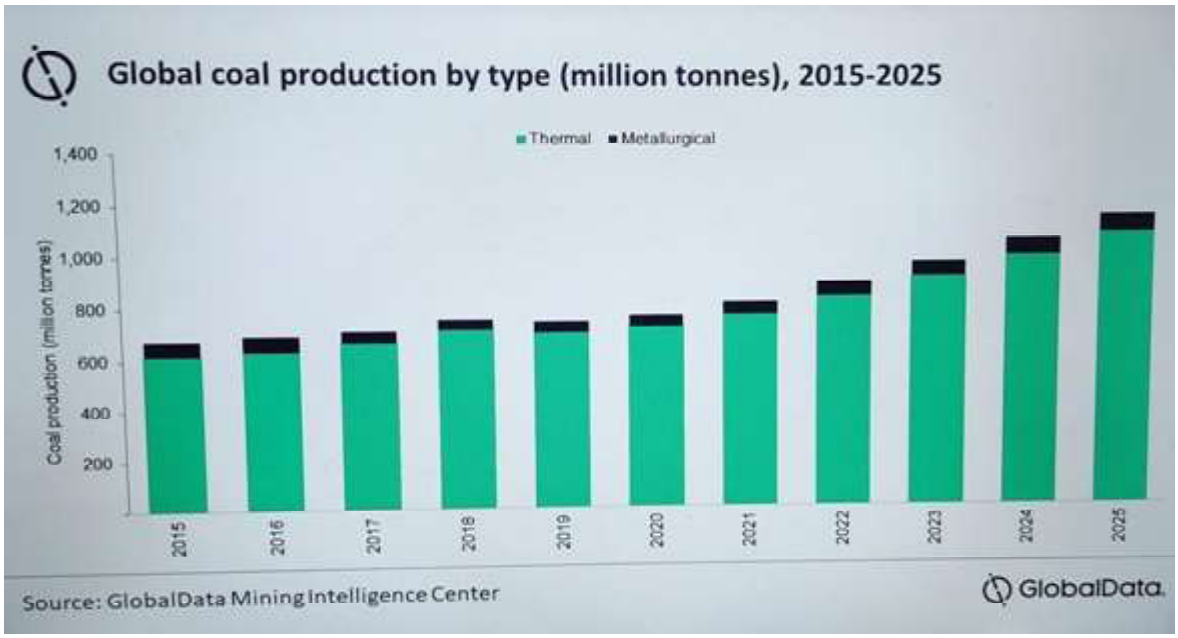


COAL CONSUMPTIONS

Coal is the most important and abundant fossil fuel in India. It accounts for 55% of the country's energy need. The country's industrial heritage was built upon indigenous coal. Commercial primary energy consumption in India has grown by about 700% in the last four decades. The current per capita commercial primary energy consumption in India is about 350 kgoe/year (Kilogram of oil equivalent per year) which is well below that of developed countries. Driven by the rising population, expanding economy and a quest for improved quality of life, energy usage in India is expected to rise. Considering the limited reserve potentiality of petroleum & natural gas, eco-conservation restriction on hydel project and geo-political perception of nuclear power, coal will continue to occupy centre-stage of India 's energy scenario. Indian coal offers a unique eco friendly fuel source to domestic energy market for the next century and beyond. Hard coal deposit spread over 27 major coalfields, are mainly

confined to eastern and south central parts of the country (See Coal Reserves).The lignite reserves stand at a level around 36 billion tonnes, of which 90 % occur in the southern State of Tamil Nadu.

Some 26% of primary energy needs are met by coal and 37% of electricity is generated from coal, compared with 23% for natural gas. Coal is the world's most abundant and widely distributed fossil fuel source. Globally about 2000 GWe of coal-fired generation capacity is operating and another 500 GWe is expected online by 2030. However, each year burning coal produces over 15 billion tonnes of carbon dioxide (CO_2), which is released to the atmosphere, most of this being from power generation Development of new 'clean coal' technologies is attempting to address this problem so that the world's enormous resources of coal can be utilised for future generations without contributing to global warming. Much of the challenge is in commercialising the technology so that coal use would remain economically competitive despite the cost of achieving low, and eventually 'near-zero', emissions. The technologies are both costly and energy-intensive.



"Global Data expects coal production in India to grow at a compound annual growth rate (CAGR) of 9% to reach 1.2Bnt in 2025, meeting the Indian government's target of 1Bnt. However, covid-19 will present some short-term challenges to this estimation," says Vineeth Bajaj, mining analyst at Global Data .The sharp increase in new covid-19 cases since the beginning of March 2021 and fresh lockdowns across key coal-producing states (such as Odisha, Chhattisgarh, Madhya Pradesh, Maharashtra, and Telangana) have hampered India's coal operations .Despite this, Bajaj believes there was a slight recovery in coal offtake in April 2021, indicating a revival in demand over the coming months .While power demand is growing in the country, coal is being gradually phased out of power generation over environmental concerns ."In 2020, around 73% of the electricity in India was generated from coal. However, India has environmental commitments to reduce carbon emissions to 50% by 2030. As a result, the share of coal-fired electricity generation is forecast to fall to 70.6%, while the share of renewable rises from 2.9% in 2020 to 4.2% in 2025."

MAKING BHARAT AATMANIRBHAR THROUGH CLEAN ENERGY

One clear lesson from the global energy crises precipitated by the Russia-Ukraine war is that transitioning away from geographically concentrated fossil fuel resources to more equitably distributed renewable power may lead to a more stable global energy market. In India, where extreme power blackouts have been fanning the flames of a looming energy crisis, power demand is surging even as summer heat makes new records every year.

Already heavily dependent on oil imports, India is being pushed into the untenable position of importing more fossil fuels even as prices worldwide have been skyrocketing. Inflation is only rising, disproportionately impacting food budgets of low income communities, such as those in rural areas. To achieve India's development goals, transitioning to a clean energy-based economy is crucial. Recognizing this, India has been working strategically toward this transition in several ways that could be further strengthened.

Development of new 'clean coal' technologies is attempting to address this problem so that the world's enormous resources of coal can be utilised for future generations without contributing to global warming. Much of the challenge is in commercialising the technology so that coal use would remain economically competitive despite the cost of achieving low, and eventually 'near-zero', emissions. The technologies are both costly and energy-intensive.

As many coal-fired power stations approach retirement, their replacement gives much scope for 'cleaner' electricity. Alongside nuclear power and harnessing renewable energy sources, one hope for this is via 'clean coal' technologies, such as carbon capture and sequestration, also called carbon capture and storage (both abbreviated as CCS) or carbon capture, use and storage (CCUS). It involves the geological storage of CO_2, typically 2-3 km deep, as a permanent solution. However in its *Energy Technology Perspectives 2014* the International Energy Agency (IEA) notes: "CCS is advancing slowly, due to high costs and lack of political and financial commitment." In Energy Technology Perspectives 2020, CCUS is fairly low profile, and in the Sustainable Development Scenario about 2 billion tonnes per year is captured from coal burning by 2070 (of 10 Gt/ year total). In 2020 about 40 million tonnes of CO_2 per year was being captured and sequestered from all sources, with about the same CCS capacity under construction.

The clean coal technology field is moving in the direction of coal gasification with a second stage so as to produce a concentrated and pressurised carbon dioxide stream followed by its separation and geological storage. This technology has the potential to provide what may be called "zero emissions" – in reality, extremely low emissions of the conventional coal pollutants, and as low-as-engineered carbon dioxide emissions.

This has come about as a result of the realisation that efficiency improvements, together with the use of natural gas and renewables such as wind will not provide the deep cuts in greenhouse gas emissions necessary to meet future national targets.

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Mineral Industry Contribution in Context to Aatmanirbhar Bharat

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ABSTRACT

India is emerging among the largest economy of world. Aatma Nirbhar Bharat is a mission to make India globally competitive in economic strength. The fast growing population, urbanization, industrialization will require increase in energy demand. Energy consumption in India is increasing at a rate of 4.6% approximately at every year. Make India campaign is way to industrialization to keep pace with the world's growth scenario .PM of India has stressed upon to become exporter of mineral than to be a importer in mineral abundant India. Measures are being taken by making industry friendly reforms in mining industry. About 95 minerals are mined in India. Aatma Nirbhar Bharat may bring resilient, and self reliant India by improving condition of mineral industries. There will be major cut in import of coal by commercialization of coal Industry. One important threat is to be kept in mind that mining of coal has to be undertaken from underground by research and mechanization, to avoid sudden crisis. Major coal reserve lies underneath earth. Indian power system is expected to be increased by four times its size, so is the requirement of fuel industry also. Development of technology and its equipment manufacture also requires independency in achieving the mission.

INTRODUCTION

Mineral industries play important role in Indian economy. The GDP contribution of mining industry varies from 2.2% to 2.5 %. If it is considered by the GDP of total industrial sector its contribution is 10 to 11 %. Total power generation of India was 1378.525 billion units during 2020-21, including renewable energy sources. Coal based generation was 950.751 billion units. It amounts to 69% of total power generation. Coal is also required in, cement, fertilizer, sponge iron, aluminum, and in other industries. Environmental issues are threat to use of coal in world scenario. The world over many countries is moving away from coal but in the Indian context is different. Coal is preferred energy fuel in India because of its abundance, availability and affordability. Ministry of coal has overall responsibility to promulgate policies and strategies in respect of exploration and development of coal reserves. The role and position of coal and mineral production in India are as under (Table 1).

Table 1: Contribution of Production of Mineral in India

Mineral	Year	Position in world
Mica sheet	2012	largest in world
Iron ore	2015	4th
Alumina	2015	4th
Chromite	2015	4th
Bauxite	2019	5th
Zinc	2019	5th
Manganese	2019	7th
Lead	2019	7th
Sulphur	2019	7th
Titanium	2019	11th
Phosphate	2019	18th
Gypsum	2019	16th
Salt	2019	3rd
Graphite	2019	5th
Uranium	2019	11th
Coal	2019	3rd

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Contribution of production of coal in India is given below

Production of coal (MT)	
2020-21	716.08 MT
2021 -22	778.19 MT
2022-23	356.058 MT (till august)

Import of coal (in MT)

Coal	2020-21	2021-22	2022-23
Coking coal	51.20	57.16	15.175
Non coking coal	164.04	151.77	51.993
Total	215.25	208.93	67.169
Coke	2.46	2.48	.713

Target of coal ministry is to minimize import of thermal coal to make Indian Aatmanirbhar in the sector. Coal production aim is to achieve domestic coal production to 1.2 billion tones by FY23-24. India is self-sufficient in many minerals like bauxite, iron ore, and zinc ore. It is deficient in some major minerals like magnesite, manganese ore, copper ore, lead ore and rock phosphate.

Steps taken by Government to boost production of coal and mineral

Under coal mines special provision act 2015, 107 coal mines have been allocated, 47 mines allocated through e –auction 60 allotted to government companies. About 48 coal mines have been allotted to regulated power sector, 22 mines to non regulated power sector i.e. iron and steel, cement and captive power and 37 mines for sale of company. Approx. 500 mining blocks are to be offered through auction process inviting investment into coal sector. In 1994 mining sector was opened to private domestic and foreign investors to explore and exploit iron ore , copper , manganese , lead , chrome ore , zinc , sulphur, molybdenum , gold , tungsten, diamond and platinum group of minerals.

In 2000 mining sector was opened upto 100 % foreign direct investment through the automatic approval route. Many foreign companies entered India till 2010, the reason being none of the states issued exploration licenses – reconnaissance permit and prospecting permit to any company till introduction of the new mines and minerals (Development and regulation) act 2015.

The participation of FDI in India from April 2000 to September 2021 was 0.54 % of 561 billion total FDI inflows during this period. RIO Tinto exited in 2017 from Indian mining sector. It abandoned its well explored Bunder diamond mines project in M.P. So to promote investment attractiveness self reliant India campaign has opened door to attract more investment through transparent and internationally competitive policies. MMDR act 2015 gave scope to motivate the private sector to invest and explore.

In another measure distinction between captive and non-captive mines was removed. It allowed easy transfer of mining leases. These changes may promote investment in the sector.

India has entered into agreements with countries like Afghanistan, Australia, Bangladesh, Bolivia, Brazil, Chile etc in sharing latest technologies for exploration and mining. KABIL Khanij Bidesh India Limited may promote Economic cooperation. AI- ECTA Australia India Economic cooperation and trade agreement is one of strategic bilateral partnership to get high quality mining technology, equipment and services to the Indian miner with expertise in exploration, environment preservation, skills and mines safety. This is a way ahead to self-reliant India.

But past Experience of Indian mining Industries and its failure makes us to think that unless the indigenous development of technology in India is promoted and facilitated self reliant may not sustain long. Increase in coal production from open cast mining has substantially increased, but in long term we are to think for sub surface coal mining, which requires its own time to produce coal. We are to learn and adopt world class technology to expand world class production capacity in our mines.

Coal /mineral industry vis a vis Aatma Nirbhar Bharat

Aatma Nirbhar Bharat is right call by our prime minister. The objectives of reforms in coal industries to achieve self reliant goals are defined below

- o They will bring transparency, ease of doing business and ensure that natural resources are used for national development;
- o Would help India gain access to high-end technology for underground mining used by miners across the globe.
- o This will speed up the process of implementation of projects, simplification of procedure and benefit all the parties in areas where minerals are located.

- This would open up the sector to players outside steel and power as well as remove end-use restrictions.
- It will create an efficient energy market and bring in more competition as well as reduce coal imports.
- Sectorial reform for mining of minerals will boost growth, employment and bring state-of-the-art technology, especially in exploration.
- Large mining investment would build employment and ignite demand in critical sectors including mining equipment and heavy commercial vehicles
- If multinationals decide to invest, the country could profit from the infusion of sophisticated mining technology, especially for underground mines.
- The reforms are also aims at lowering environment impact.

It is difficult for us to reduce our oil and natural gas imports, which accounted for $120 billion or so in imports in 2019, we can definitely ramp up domestic coal production.

Coal gasification and liquefaction are encouraged. Bidders will not require any previous experience in coal mining — they simply have to put up sufficient deposit money. Mining plan approval will be provided in 30 days, rather than 90 days.

Revenue share is the bidding parameter and 100 per cent Foreign Direct Investment (FDI) is allowed through the automatic route. Coal pricing will be determined through a transparent National Coal Index that will be determined for different grades of coal.

Some of India's richest coal reserves lie in the Karanpura coalfield that runs right across Hazaribagh constituency. In the last few years, the epicenter of coal production in India has started to shift from Dhanbad to Hazaribagh as the Jharia coalfield gets depleted, and the Karanpura coalfield is brought into production. As a result, we have had to handle all the challenges associated with a rapid ramp-up of coal production in agricultural areas.

Land acquisition reforms and land utilization

Identifying rightful landowners and paying them fair compensation is probably the greatest challenge that we face on the ground. Land records are still not fully digitised and remain subject to endless disputes and litigation. Additionally, there is significant fraud and criminal activity associated with land records. It is also necessary that jobs generated in these mines be given to local people. Only very specialised jobs requiring unusual skills should go to outsiders. Moreover, mining companies must, through their CSR activities, make all possible efforts to train local people for the full range of jobs available— from operating mining equipment to handling accounts. Once mining starts, a host of difficult issues require continuous administrative and political handling. Villages have to be resettled in other areas to enable coal mining. Handling coal-related road and rail traffic soon becomes difficult. New roads have to be built; conveyor equipment, railway sidings, railway over and under bridges, and other infrastructure become necessary to prevent coal traffic from making normal life difficult. Coal dust spreads everywhere, leading to loss of agricultural production and many health problems. Criminal syndicates and extortion rackets get involved in mining and transporting activities. Deforestation and environmental damage have to be strictly controlled.

Commercial coal mining is vital to building an Aatmanirbhar Bharat. The auction process will lead to energy security for the country and enable us to take advantage of our rich coal reserves. Further, unleashing private sector participation will result in rapid investment, job creation, and increase in government revenue.

The government's roadmap seems pretty clear-go in for a large scale exploitation of coal and other mineral reserves, letting in private sector and FDI to scale up, gaining material traction, even while keeping cumbersome environmental questions at bay with the soon-to-be amended Environment Impact Assessment (EIA), no matter the storm of opposition that it may spark or the long term impact of pollution.

Land bank and land use

Land bank formation of unused land of coal mines needs to be expedited. This is becoming menace for illegal mining and criminal activities. Development of unused land for agricultural purpose by deploying agricultural scientists will also help in increasing cultivating land, fruit bearing land and water reservoir for irrigation. The purpose of land use should be well defined while handing over such land to land less. Huge land of abandoned coal mines are also to be earmarked and used purposefully. This will create job opportunity to many.

Relevant legal provisions related to the reforms in mining

The relevant provisions, Acts, Ordinances and Rules regarding the coal sector reforms are as follows

- **The Mines and Minerals (Development and Regulation) Act, 1957** This Act provides for the production and management of Union regulated mines and minerals. It claimed that it would be convenient in the public interest for the Union to take charge of mining policy and mineral production extent hereinafter provided.

- **The Coal India (Regulation of Transfers And Validation) Act, 2000** This Act empowers the Central Government to direct the transfer of the land, or of the rights in or over land or in reference to a coal mine, coking coal mine or coke oven factory, owned by Coal India Limited or a subsidiary company by any subsidiary of Coal India Limited or any other particular activity and validating such transfers of such property or assets.

- **The Coal Mines (Special Provisions) Act, 2015** This Act provides for the assignment of coal mines and the transfer of rights, title and interest in and over property and mining assets in accordance with mining leases to successful bidders and allocated parties with a view to ensuring consistency in coal mining projects and coal production and facilitating the optimal use of coal resources in line with national requirements, interest and for matters connected therewith or incidental thereto.

- **Mineral Laws Ordinance, 2020** On 10th January, 2020of the Mineral Laws (Amendment) Ordinance 2020 was promulgated to amend the Mines and Minerals (Development and Regulation) Act 1957 and Coal Mines (Special Provisions) Act 2015.

The Ordinance completely opens up the coal sector to commercial mining. It also plans to wipe out limits on end-use involvement in coal mine auctions. It permits coal mining by any organization existing in sectors apart from steel and electricity, and the Act on 13th March, 2020.

- **Coal Blocks Allocation (Amendment) Rules, 2020-** On 18th May, 2020; the Ministry of Coal issued a notification, which was an amendment to the Coal Block Allocation Rules, 2017. The notification was issued in exercise of the powers under the Mines and Minerals (Development and Regulation) Act, 1957. The amendment brought about some changes in the methodology for auction of coal and lignite mines/ blocks for sale of coal / lignite on revenue sharing basis and tenure of coking coal linkage

All the aforesaid legal provisions were introduced to give shape to the newly announced reforms on 16th May, 2020, for the Aatma Nirbhar Bharat.

Sustainable and Responsible Mining

Coal use has a serious threat to environment, but it is related with the growth and development of country. Coal is one of the most significant resource for advancing human civilization.

In fact, coal mining has been instrumental in the Industrial Revolution and has helped economies and societies take their present shape. Coal mining is important fossil fuel to lift millions out of poverty.

India represents 17% of the global population but its historical cumulative emissions are only 4% and the country's current annual greenhouse gas emissions are only about 5%. India has abundant reserves of mineral resources and the mining sector is not only the industrial backbone, but also one of the leading employment generating sectors in the country. The sector has potential to boost India's growth and has an indispensable role to play in making India Aatma-Nirbhar. Therefore, the effects of mining on the environment and on biodiversity need to be counterbalanced with environmentally-sustainable activities so that mining can continue to contribute in building a New India.

Amrit Mahotsav and mining industry

As we celebrate Azadi ka Amrit Mahotsav, mining activity needs to be geared in a environmentally sustainable way. The nation's mining PSUs has demonstrated stellar performance of excavating minerals and assuring mineral security to the nation. They have also undertaken several initiatives to restore the ecological balance. Ministry has announced in the most recent annual budget for the year 2022-23, 4 pilot projects for coal gasification and conversion are in the pipeline.

The PSUs under the Coal Ministry are diversifying into green mining alternatives and have made an investment

plan of almost Rs. 2.5 Lakh crore by 2030 in new business areas, clean coal technologies and new mine development projects.

Not only this, CIL is also venturing into renewables sector and planning to soon become a 'Net Zero Energy' company. Its recent decision to form 2 subsidiaries is an extension of this ambition. Another PSU, NLC India is the first CPSE in the country to achieve solar power generation capacity of more than 1 GW. All these steps indicate how our coal companies are fighting the climate war, something for which they have always been held guilty. Being on track with climate consciousness, India has no reason to single out coal, which is among the key sources of energy for the nation. India has a balanced energy basket and remains dependent on coal for power generation.

District mineral foundation and its role

What needs to be understood and acknowledged is that in India, coal is much more than just a source of energy. Coal is also a binding factor of an integrated ecosystem that is socially and economically dependent on it – for all developmental purposes. While the states rich in coal reserve deposits derive an indispensable part of their revenue from coal, the livelihood of people in districts surrounding the mining areas are completely dependent on coal usage and the revenue generated thereof. The huge corpus of funds in the District Mineral Foundation constituted under the Pradhan Mantri Khanij Kshetra Kalyan Yojana is mainly responsible for the development of areas in the mining states. With amendment in 2021, local MPs, MLAs and MLCs have been made member of DMF governing council to ensure local participation and participative development of mining affected regions. The total amount collected in DMF as on 31 March, 2022 is Rs. 61868 crores.

Environment Management

Apart from diversifying into clean energy, coal and lignite PSUs have also set an ambitious target to green almost 2400 hectares of land this year. This will be achieved by planting 60 lakh saplings of local species in and around coalfield areas. Till now, Coal/Lignite PSUs have planted more than 100 million trees/saplings. These companies are distributing more than 10 lakh seedlings amongst locals and are also taking up hi-tech cultivation and development of grasslands in the mining areas. The overall impact of these activities would be huge, considering the vast ecosystem these companies maintain.

Ministry of coal is taking firm steps at the policy level. It is also taking steps for resolution of persisting issues in the critical coal and mining space.

Coal gasification and coal bed methane

Coal Gasification/Liquefaction will be incentivized through rebate in revenue share

- Will result in significantly lower environment impact
- Will assist India in switching to a gas-based economy
- Infrastructure development of Rs. 50,000 crore
- For evacuation of enhanced CIL's target of 1 billion tones coal production by 2023-24 plus coal production from private blocks
- Includes Rs 18,000 crore worth of investment in mechanized transfer of coal (conveyor belts) from mines to railway sidings
- This measure will also help reduce environmental imp
- Coal Bed Methane (CBM) extraction rights to be auctioned from Coal India Limited's (CIL) coal mines
- Ease of doing business measures

ROLE PLAY OF AATMA NIRBHAR BHARAT

Aatmnirbhar Bharat Abhiyan in India or Self-reliant India is the new ray of hope in the form of a scheme initiated by India's Government. The Aatmnirbhar Bharat scheme lays the foundation stone for the long-term reformation and growth in the Indian Economy's crucial sectors that would lead to raise per capita GDP in the hour of crisis. Aatma Nirbhar Bharat Abhiyan in India is like a dream come true for plenty of business setups, migrants, vendors, indigenous families, etc. The Aatmnirbhar Bharat Abhiyan in India has played a cosmic role in the lives of suppressed sectors and people and has been a great success in converting the time of crisis into opportunity. The scheme has proved to be a blessing in disguise for most business organizations and people tremendously affected by the pandemic. The primary reason behind launching the strategy was to pursue those policies that are efficient, competitive, long-lasting, and resilient. The scheme resulted from India's efforts, which could sense the atrocities suffered by the majority of Indians and came up with this thought to revive the people's distorted lives.

Opportunity and creation for employment

The coal mines auction process will lay strong foundation for energy security in the country by producing additional coal providing large scale employment and huge opportunities for likely from Coal India in FY 23-24 and meet full requirement of domestic thermal coal.

CONCLUSION

Indian economy and development are related with development of mineral industries. The reform initiative in mineral industries, coal sector reforms may bring a competitive market for investors. Industry will flourish with new advance technology, in safety and mass production in days to come. It will eradicate age old technology, with adoption of new advanced technology. Import of coal will turn to export of coal. Intent of reform in coal Industry is a need of day considering the socio-economic condition of India. The country has to depend on coal in future also. The challenges are there but it can be resolved. The dream of self-reliant India is to come true in perspective of governments existing concern, reforms and steps. This will create employment and hope for mining industries in days to come. Mining Industries will also flourish.

Coal reserve needs to be explored further. Sustainable development is also to be kept in mind. Renewable energy, clean energy, are to be promoted as an alternative source of energy. Mechanization is need, but development of equipment manufacturing in country need to promoted.

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India Towards Low Carbon Emission

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ABSTRACT

In recent years, the environmental problems caused by excessive carbon emissions from energy sources have become increasingly serious, which not only aggravates the climate change caused by the greenhouse effect but also seriously restricts the sustainable development of many leading economies of the globe. An attempt is made in this paper to highlight briefly the key measures which are being taken by India to reduce carbon emission in the near future.

INTRODUCTION

The Union Cabinet chaired by the Prime Minister Shri Narendra Modi, has approved India's updated Nationally Determined Contribution (NDC) to be communicated to the United Nations Framework Convention on Climate Change (UNFCCC).

The updated NDC seeks to enhance India's contributions towards achievement of the strengthening of global response to the threat of climate change, as agreed under the Paris Agreement. Such action will also help India usher in low emissions growth pathways. It would protect the interests of the country and safeguard its future development needs based on the principles and provisions of the UNFCCC.

India at the 26th session of the Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC) held in Glasgow, United Kingdom, expressed to intensify its climate action by presenting to the world five nectar elements (Panchamrit) of India's climate action. This update to India's existing NDC translates the 'Panchamrit' announced at COP 26 into enhanced climate targets. The update is also a step towards achieving India's long-term goal of reaching net-zero by 2070.

Earlier, India submitted its Intended Nationally Determined Contribution (NDC) to UNFCCC on October 2, 2015. The 2015 NDC comprised eight goals; three of these have quantitative targets up to 2030 namely, cumulative electric power installed capacity from non-fossil sources to reach 40%; reduce the emissions intensity of GDP by 33 to 35 percent compared to 2005 levels and creation of additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover.

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As per the updated NDC, India now stands committed to reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level and achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030

Renewable methanol accelerating progress toward a carbon-neutral world

Today, the world is seeing unprecedented momentum to fulfil clean energy potential as several countries make ambitious efforts to achieve their net zero carbon goals. A versatile energy product, methanol can play a crucial role in reducing greenhouse gas (GHG) emissions when produced renewably. Carbon dioxide (CO2), treated as waste rather than a resource, can be recycled to produce low-carbon methanol. Capturing CO2 emissions, hydrogenated with green or recovered hydrogen to produce methanol, offers decarbonising economies a sustainable fuel and chemical feedstock that accelerates the transition towards a carbon-neutral future and circular economies.

Status of Methanol in India

India is at a nascent stage in methanol production and usage, but it has a large potential given its wide applications. There are 5 main producers of methanol in India – Gujarat Narmada Valley Fertilizer & Chemicals limited, Deepak Fertilizers, Rashtriya Chemicals and Fertilizers, Assam Petrochemicals and National Fertilizers Limited.

Methanol blending

Methanol (CH_3OH) & DME (CH_3OCH_3) can be blended with gasoline and diesel, or can completely substitute the latter fuels respectively giving us an opportunity to reduce our dependence on imported crude oil. India has already set itself an ambitious target of 10% reduction in import dependence of oil & gas by 2022 in comparison with 2014-

15 levels which can get quite well with the use of methanol and DME as alternate fuels. High methanol blends offer significant vehicle efficiency improvement – potential of 25%. This also offers an opportunity for the railway engines to run on methanol/DME blends. Moreover, India envisages to roll out a massive water transportation system under the aegis of its flagship Sagarmala project where 40 MT of steel capacity is expected to be set up in coastal areas and around 80 MT of coal would be transported through waterways. Therefore, in order to check the pollution caused by diesel run ships, methanol and DME powered ships would not only be cost effective alternatives but would also produce far less pollution.

Initiatives taken by the Aviation Industries

· Air India, AirAsia India and Vistara (Tata Group Airlines) joined hands with the Council of Scientific and Industrial Research - Indian Institute of Petroleum to collaborate and work together on the research, development and deployment of sustainable aviation fuels (SAFs). The impact of continued use of petroleum-derived fuel for aviation is considerable with greenhouse gas and carbon emissions being of significant concern across the globe. The International Air Transport Association (IATA) has committed to achieving net-zero carbon emissions from their operations by 2050 in line with the objectives of the Paris agreement to limit global warming to 1.5 degrees Celsius.

According to IATA, the aviation industry's net-zero carbon emissions target is focused on delivering maximum reduction in emissions at source, with the adoption of Sustainable Aviation Fuel (SAF) contributing around 65 per cent of the reduction in emissions, in addition to innovative new propulsion technologies, and other efficiency improvements.

Initiatives taken by the Automobile industry

Automobile manufacturers are taking several steps like increasing use of renewable energy and pushing suppliers to cut their emissions in a bid to reduce carbon footprint, but the biggest challenge for them will be tackling the tailpipe emissions from the vehicles they sell. Let us see the latest statements on low carbon emission by some of the Heads of Automobile industries :-

- Maruti Suzuki has scaled up captive solar power generation from 1 MW four years ago to 26 MW now, said Rahul Bharti, executive director, corporate affairs at Maruti Suzuki.

- M&M has taken it a step further by fixing an internal carbon price when making business decisions, said Rajesh Jejurikar, executive director for auto and farm sectors, Mahindra Group. While assessing a new project, the company will consider a price of $10 per ton of CO2 that is estimated to be generated. This ensures that less expensive but more polluting options do not trump those that are cleaner but more expensive. "At M&M, we identify climate change risk to our business and stakeholders and build a strategy with a mitigation action plan," he said

- Tata Motors' fleet partner BluSmart saved 5,500 tonnes of CO2 in a year. EV startup BluSmart, which counts the likes of Jio-bp and Tata Motors among its strategic partners, claims to have saved 5,500+ tonnes of CO2 on the roads of Delhi-NCR in a year. On the BluSmart ride-hailing platform, 25 tonnes of CO2 were saved each day, which is equivalent to planting 1,000 mature trees, stated the company.

Anmol Singh Jaggi, Co-founder and CEO, BluSmart said, "Our focus is to solve the pollution challenges of megacities like Delhi-NCR and improve the quality of life of people living in such places. EVs are responsible for considerably lower emissions over their lifetime than conventional (internal combustion engine) vehicles."

"We have experienced the cost of EVs declining while the range has been on a steady rise. Now anyone can consider buying an EV and reap the benefits," he added

4 major projects to achieve 100 MT coal gasification by 2030

Conversion of coal to clean energy with private sector capital investment of Rs 30,130 crore will help in achieving the target of 100 million tonnes (MT) coal gasification by 2030. Finance Minister Smt. Nirmala Sitharaman in her budget speech 2022-23 announced setting up of four pilot projects for coal gasification and conversion of coal into chemicals required for the industry will be set up for technical and financial viability".

This 100 MT coal gasification will happen in three phases.

· In the first phase from 2020-2024 — four million tonnes (MT) of coal will be gasified and around Rs 20,000 crore will be invested for the same.

- In the second phase — from 2020-2026 — 6 MT of coal will be gasified which will involve an investment of Rs 30,000 crore.

- In the third phase — from 2022-2030 — 90 MT of coal will be gasified and Rs 3.6 lakh crore will be invested for the same.
  5 PSU'S to set up manufacturing units to increase coal gasification capacity
- To help achieve the centres target of having 100MT of coal gasification capacity in the country by 2030, five PSU will set up manufacturing units.
- PSU'S are CIL, BHEL, GAIL, IOCL (INDIAN OIL CORPORATION LIMITED), NLC (NYVELI LIGNITE CORPORATION).
- The units will produce methanol, ammonia, ammonium nitrate and urea.
  India currently imports close to 20% of its ammonia and ammonium nitrate consumption primarily from Turkey, Russia, and Bulgaria for fertilizer industry
- Methanol, which is the main product from coal gasification is majorly import driven in India with 90% of the demand being met from Iran and Saudi Arabia. According to coal Ministry's estimates, $50BN is the foreign exchange for chemical and petrochemical products in India, as natural gas imports grew at a compound annual growth rate (CAGR) of 5.89% during last decade.

Promoting Renewable - Moving towards net zero carbon

In order minimize the carbon footprints of mining and to progress towards the goal of net zero carbon emission, coal/lignite companies are keen on promoting renewables. Coal companies are going for both roof top solar and ground mounted solar projects. It has also been envisaged to develop solar parks in some of the reclaimed mining areas.

As on 31.03.2021, Coal/lignite PSUs have installed solar capacity of about 1445 MW (including roof top solar of ~ 4 MW) and wind mills of 51 MW. During next 5 years it is planned to install additional 5560 MW of renewable capacity.

Coal India Limited (CIL) has already installed 4.83 MW of solar power plants including 2 MW of ground mounted solar projects. Coal India, a fossil fuel producer has aligned itself and is committed to become a Net Zero Energy Company and is in the process of implementing 3 GW solar power program by 2023-24.

One of the notable renewable projects of NLCIL has been installation of Solar Power Plant in Port Blair & South Andaman - integrated with 8 MWhr Battery Energy Storage System (BESS) for smoothening the Solar Power export to the grid. Due to this plant, substantial portion of the day peak requirement of Port Blair & South Andaman will be met through solar power. This will bring down annual diesel consumption & also reduce carbon footprint. NLCIL Wind Mills 51 MW at Kazhuneerkulam, Tirunelveli district in the State of Tamil Nadu. The first wind turbine generator was commissioned on 29th August 2014 and 31 wind turbine generators have been commissioned till July 2015.

In line with the goal of Atmanirbhar Bharat, Coal India Limited is setting up a Wafer Manufacturing Plant to strengthen the indigenous supply chain for ensuring availability of solar panels.

CONCLUSION

It is true that India's energy security mainly depends upon fossil fuels like coal but the initiatives which are being taken in our country (as discussed in this paper) to reduce carbon emission and at the same time find suitable renewable fuel which can be used as prime source of energy. We are at the nascent stage but I am sure that we will be the fastest growing country in the world which will control carbon emission.

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Role of Innovation and Mechanization in Mining Industry - A Step Towards Atma Nirbhar Bharath

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ABSTRACT

21st century is the period of innovation and evolution of technologies in the field of exploration and mining. India is not far behind to accept and adopt the new technologies to compete with the rest of the work to ascertain its position in the global market. This paper represents the need and various innovations, mechanization in various regions in mining industry to fulfil the demands of various industries and to make a way for the sustainable development. India produces as many as 95 minerals which include 4 fuel, 3 atomic, 10 metallic and 23 non-metallic minerals and 55 minor minerals (including building and other materials). Out of a total land area of 3.2875 million sq. km, Geological Survey of India (GS identified 0.571 million sq. km. For smooth operations of hazardous mining operations where safety plays an important role and to enhance production & productivity the training, skilling, and for updating with latest technology, innovation is the need of hour and requires continuous efforts for improving the mechanization. Nowadays, mining companies are stepping forward to collect, store, and utilize the data about mining operations to improve their knowledge and business insights and to be able to drive automated mining operations. mining in India needs to be accelerated in view of ambitious projects, such as "Make in India", "Made in India" leading to an "ATMANIRBHAR BHARATH" India as immaculately envisaged by our illustrious and visionary Hon'ble Prime Minister Shri Narendra Modi ji.

INTRODUCTION

Mining is considered as the backbone of the economy and also an old industry. So as an old industry does not mean to adopt traditional methods. In general, we observe the mining industry is less technologically advanced in comparison to other industries like biotechnology, communication etc. But the reality is different. Mining has the scope of innovation which brings the better efficiency, safety and environmental and social integration in any adverse situation. Innovations in mining are difficult and challengeable because we mined the non-renewable resources which are present beneath the surface where unknown and unreceptive conditions get in the way of exploration and extraction. Technological innovations in mining industry provide the smarter exploration of the minerals, more efficient mining, safer working conditions and more environmentally responsible industry. Mining industry is grappling with many challenges such as availability of skilled work force, productivity improvement, safety, and environmental issues, etc. This is driving companies to integrate mining operations from pit to port and leverage the available technologies to get the maximum benefits out of it. Typically, enabling sustainability across operations involves three factors, namely, economic, environmental, and social. The mining industry is constrained by environmental and social factors as it must adhere to guidelines and various government regulations. In fact, leading mining companies are adopting advanced technologies with the required infrastructure, business, and technical capabilities to reduce cost and boost safety and productivity. Mining operations produces vast amount of data in its entire value chain from Pit to Port, and that too in various formats and being handled by numerous applications deployed by the organization.

EXPLORATION

Adequate reserve and resource base is the key for any mine to enhance ore production on sustainable basis to generate revenue. To estimate the ore reserve, waste, geological conditions, tenor and to decide the workings and to determine the life of the mine is done by EXPLORATION.

The mineral industry value chain begins with mineral exploration and ends with economical exploitation of mineral resource/reserves. The outcome of Geological exploration is the main basic input for further mine planning and designing.

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3D Land scanner Survey instrument

To meet the requirements of exploration and mining sector, the latest survey instruments like total station, DGPS, robotic total station, land scanner and aerial drone survey equipments for obtaining specific aerial data of mining sites for boosting productivity, planning, safety, inventory management beside serving the purpose of mine surveillance as per the latest IBM guidelines.

DGPS Survey instrument

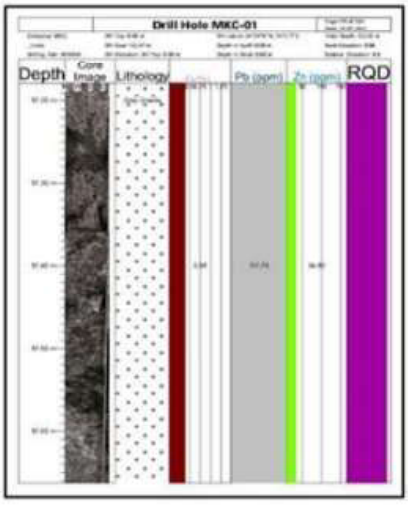
Software like ERDAS Imagine and ENVI are being used for satellite imagery analysis and ARC GIS to create maps and analysis for spatial data acquisition. Further software like Geosoft Oasis, Montaj for geophysical data processing and interpretation is being used. Although, Time Domain Electro-Magnetic geophysical survey instrument is the newly introduced geophysical survey instrument to identify the deep seated concealed ore bodies up to 1000m depth, with the introduction of advance high speed drilling rigs in the field with capacity explore deep seated mineral deposits up to 1500 m depth from the surface. The accuracy of the drilling path is being continuously monitored by advanced magnetic and nonmagnetic borehole deviation probe with 3D visualisation of the surveyed borehole path.

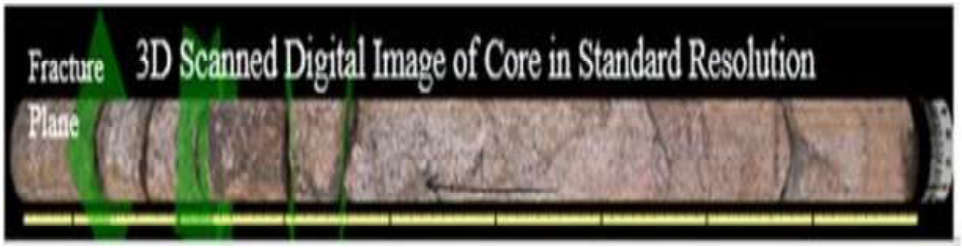
Lakhs of meters of borehole core is continuously generated in the country. Each meter contains valuable geological information which is generally lost after preparation of core samples for analysis. The preservation of half core samples cannot store the entire information that a full core may have. Storage space is another constrain. In this scenario a core scanner instrument with a high resolution camera is introduced. It captures the three dimensional information and can create a digital core library with amalgamation of the geological and chemical information. So, by adopting new technologies in exploration process, accurate results of the ore deposit can be obtained and by proper study of the results planning and working can be done.

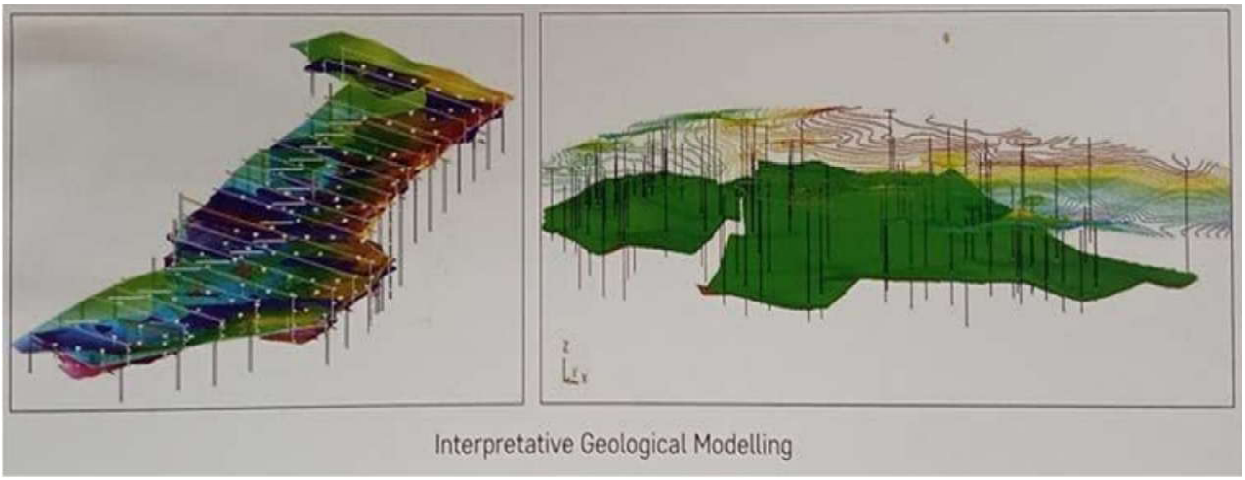
PLANNING

Modern mining software plays a vital role in our day-to-day operation, from exploration to rehabilitation this software has greatly improved the quality of design as well as productivity. Use of step plans, sections and LVS and drill design of TC05 have majorly contributed to effective planning. Softwares used in the exploration reads data from the tests and by interpreting the data obtained a suitable plan can be made as per our requirements. As these plannings are made from conducting various studies thus ensures safety while working and leads to the proper usage of ore deposits that increasing the life of the mine and output. As the size of the mine increases the difficulty in managing the movement of machinery and vehicles will become difficult and by adopting the latest technologies to monitor the movements of vehicles and machinery planning of movement becomes easier and hence higher efficiency can be achieved.

Core Scanner Instrument Installed in MECL Laboratory







Interpretative Geological Modelling

DRILLING :-

DRILLING plays a crucial role in mining industry in terms of core recovery, drilling for blasting and for supporting in u/g mines so, the latest technologies which are proven efficient in today's world should be adopted.

In state of art in Drilling technology & Innovation, an underground based MCR machine has been deployed at surface for exploration drilling to explore lead-zinc rich ore body at shallow surface. Drilling data statistics suggest avg. 2.10m/Hr production achieved through MCR while surface rig produce 1.38m/Hr.

The pre-determined path for bore-hole is an innovative method to control its deviation. Motorised Directional drilling (MDD) is the technique of controlling the direction and deviation of a drill hole to follow a predetermined path. In line of advance drilling techniques exploration using a Motorised Directional Drilling (MDD) Technology for rapid growth of R&R. This technique directly helps the exploration team to reduce cost, time & drill hole planning with respect to achieve business plan. To reach the production targets in mining industry , there is always a need to increase production drilling in mining industry.

Case study:- Sandvik DL421 is an electro-hydraulic, long hole drill rig engineered for large-scale production drilling in underground mines. This versatile rig has been designed for vertical and inclined plane rings and fans, as well as parallel long production holes and long single holes with a diameter of 64 to 115 millimeters (2 ½ to 4 inches), and a depth of up to 54 meters (177 feet). As it is operated digitally it ensures greater safety and there will be a less chance for the human errors and returns greater output.

Fig. 4 Drill site view of UG rig deployment at surface

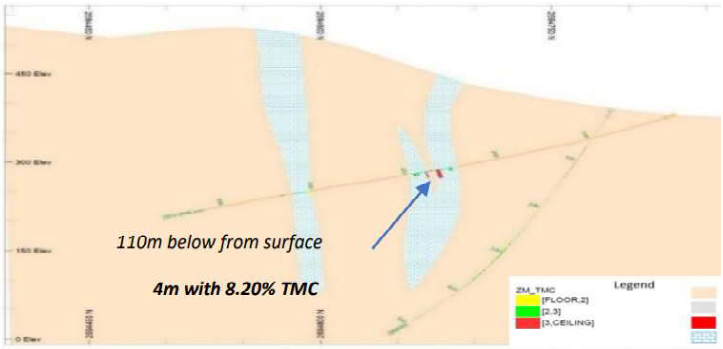


Fig. 5 Geological section of hole drilled by shallow level by UG rig at surface

SURVEYING

Remote sensing and GIS studies are used for mineral targeting. Based on the requirement of the study and the project area satellite imageries are procured from NRSA and wide ranges of softwares may be utilized to achieve the results. Remote sensing study is used for the preparation of a composite geological map with structural mapping and alteration zones and to delineate probable mineral prospect zones for targeted mineral commodity. The spectral analysis is employed to target the mineralization area. After Digital Elevation Model (DEM) is used for visual interpretation, analysis of topography, landforms, drainage extraction and lithology. Based on the requirement of the study, ERDAS Imagine and ENVI 5.5 and SRI-Arc GIS 10.8 software utilized to achieve the results.

Borehole deviation survey instrument

The advanced survey instruments like total station, DGPS, Robotic total station, 3D land scanner and aerial drone survey equipment's for obtaining specific aerial data of

mining sites for boosting productivity, planning, safety, inventory management beside serving the purpose of mine surveillance as per the latest IBM guidelines.

COAL MINING

In today's world coal plays a vital role in power generation. This role is set to continue in decades to come. Coal currently fuels 40% of the worlds electricity generation and will continue to do for next few decades until the non renewable sources of energy could not generate the equivalent amount of energy requirement. In India almost 71 % of the coal produced is consumed for power generation.

As we know that coal is being mined by opencast methods and as well as underground methods. There is a lot of scope for the mechanization in opencast mines as there are no problems such as strata control, ventilation, explosions etc. As we know the majority of coal in India is produced from opencast mining continuous efforts should be made for improving the mechanization to increase the productivity and to meet the today's requirement. The main operation in the production is loading and transportation. To get more efficient productive hours HEAVY EARTH MOVING MACHINERIES are being introduced in loading and transportation operations. The latest machines like BUCKET WHEEL EXCAVATOR, DRAGLINE, SHOVEL, SURFACE MINER, HIGHWALL MINER, HIGH CAPACITY DUMPERS are being used to make the working hours more productive.

UNDERGROUND COAL MINING

To mine the coal situated at greater depths the only way is underground coal mining. In Indian context BORD AND PILLAR method is more popular and hence the scope of continuous miner technology is enormous. On the other hand LONGWALL mining is yet to make a serious inroad in Indian underground coal mines so far because of several factors but presently the need for its large scale introduction has become imperative in the context of expanding our coal mining in deeper deposits more than 350m in depth in consideration of higher level of better quality coal from greater deposits efficiently and also from the point of environmental implications. Although these are not new to the industry and these are the only methods to extract the deeper deposits continuous efforts are being made to make it more effective and productive. The techno economical parameters are being improving. To get the better quality of coal which are situated at very deep from the surface and to make environment friendly mining as well as to make a way to the reduction of carbon emission the underground mining is a need of hour contrast in coal mining industry. When a number of mines in world arena is producing 10 million plus tons of coal from many individual mines, India must strive to establish a production level of 2.5-3.0 million tons from individual Longwall mines at present to gradually pick up with the world standard.And this is the direction towards which the Indian coal mining industry is taking confident strides today. To make a steps towards the sustainable mining and for fulfilling the projects like ATMANIRBHAR BHARATH mechanization and innovation of new technologies are necessary.

Continuous miner technology is the most acclaimed MPT world wide with B&P method of mining. Latest innovations in machineries like BOLTER MINER which is being utilised

in development of longwall and also in bord and pillar faces to cut down the time for roof bolting and provides faster rate of advancement. In longwall mining, Longwall Visual Analysis (LVA) is a software package developed by LVA Pty. Ltd., Sydney and is in use over 15 mines in Australia. The use of this software is to continuously monitor shield pressure and shearer position in long wall mines. The software shows an online real time chart of data including shield leg pressures and shearer position in long wall mines (Hoyer 2011). The software shows online real-time charts of data including shield leg pressure, loading rates and yield frequencies. The software is mostly used in Australia, the developer had used early warning system of long wall weighting events and warning of information cavities through CRI (cavity roof index). This provides much safer conditions for working and helps in effective planning of longwall panel and reduces the risk of accidents.

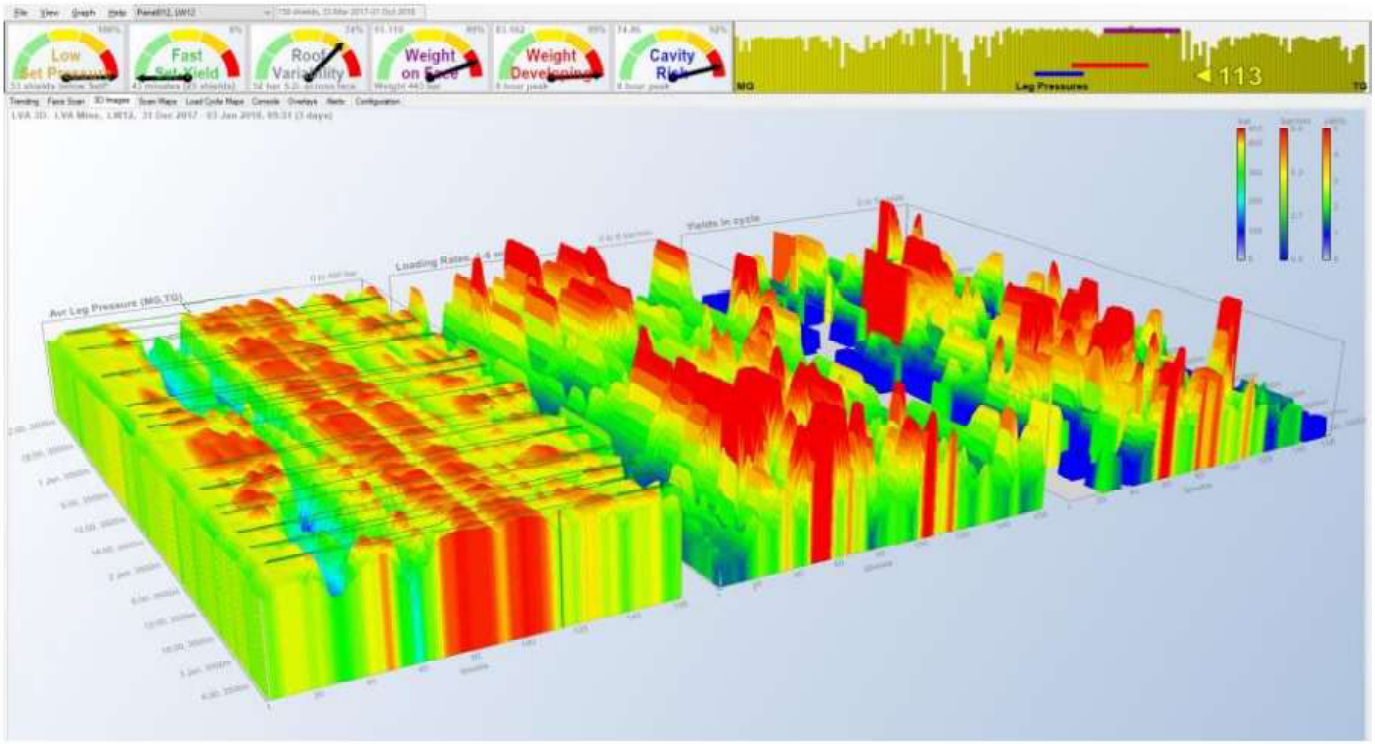
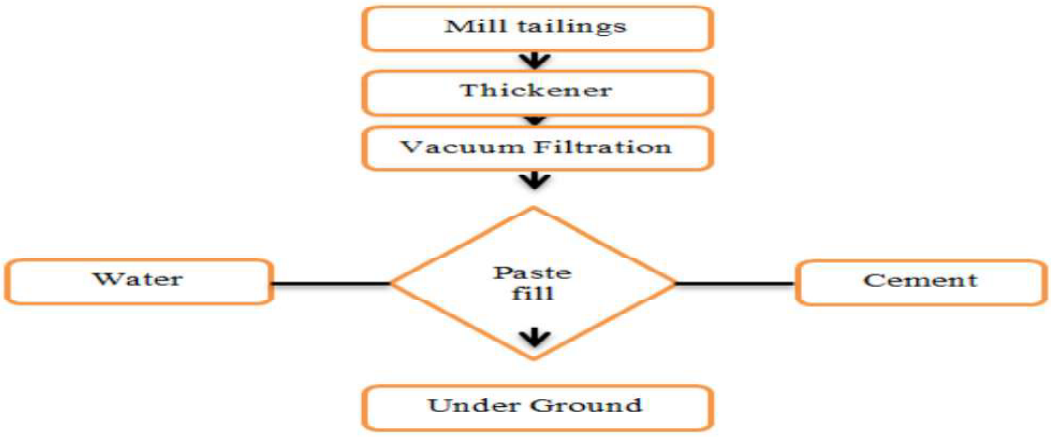


Fig 2: real-time monitoring using LVA of strata conditions.

UNDERGROUND METAL MINING

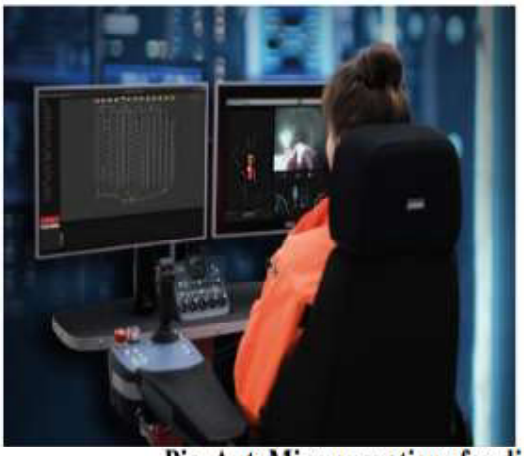
The recovery of underground hard rock ore bodies often involves the use of mine fills. The type of mine fill depends on the mining methods and sequences. Where later recovery is dependent on stability of exposures of earlier placed fill, cement and/or cementitious materials are added to the fill. Once such fill type is paste backfill. However, the use of paste backfill to maintain ground stability involves some difficulties related to the complexities of its behaviour and their engineering properties. These complexities are due to the continuous evolution of the properties of cemented fill during placement, consolidation, and hardening due to the hydration of binder agents. There should be a thorough knowledge of the engineering properties before they are being sent to underground for filling. Paste backfill is well established in many mines in the world and significant cost savings and operational benefits have been realized, compared to other methods of fill. The application of paste fill could significantly reduce the cyclical nature of mining, improve ground conditions, speed up production and greatly reduce environmental costs related to tailings management on the surface (Hassani & Bois, 1992).



Paste back fill preparation system

INNOVATIONS IN SAFETY

Mining deals with hazardous situations. It is well-established that that there is a strong correlation between improved safety performance and the impact on production and financial performance of a mining operation. Both the workforce and the community at large have expectations mining companies safe working environments is a critical expectation from a mining company's workforce and from society at large. This also demonstrates that the company is honouring the values expected of a modern, significant mining company. So latest technologies have been emerging in mining industry in various aspects from ppe kits to operation of machinery.



Pic. AutoMine operations for distant control rooms for LHD , LPDT, Surface drills

Artificial Intelligence and Machine Learning are prime technologies that could help the mining industry, due to the remote mine sites, the hazardous nature of the work, and the high costs of labour and transport. Indeed, AI & ML have found uses in mineral exploration, smart sorting of minerals and ores, demand forecasting, autonomous machinery, etc. Applications of AI & ML are relatively new in mining, and the full potential of these advances need to be realized.

In particular, there are four themes that are expected to be central to the mining industry over the next decade are Autonomous (self-independent, self-directed equipment's), emission less power agnostic vehicles, digitally connected and advance analytics-based systems. Mine automation promises several benefits, mainly increased fleet utilisation, improved working conditions and safety, increased production, reduced maintenance costs, as well as optimised tramming speeds and smoother equipment operation. Increased fleet utilisation

ensures constant performance level enhancements and optimum use of the workforce.

Teleremote Equipment Operation

The operators have been given training about the machineries operated by them in training centres digitally. In many companies remote operated machineries and tele monitoring systems have being adopted so that the operators can work safely. Digital ppe kits have been given to workers to moniter their moments and in mines like uranium where the workers are exposed to radiation a thin plates is given to workers to carry with them during workings and these plates are checked for radiation exposure of person during their workings.

CONCLUSION

The mining industry needs continuous improvement in all the operations right from the exploration stage to the ending stage of the mine to meet the market demands. Innovative technologies should be adopted in all the stages. It makes the mining operations more productive, more efficient, and enhances safety and leads a way to the proper use of minerals in a sustainable way. The increased need of minerals in today's world can only be fulfilled by adopting the innovative technologies and mechanization. By implementing the new technologies reduces the risk of hazards and multiplies the factor of safety. Thus to support the ambitious national projects like "ATMA NIRBHAR BHARATH" mining need to be accelerated with new innovative technologies.

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9. LATEST TRENDS IN STRATA AND SUPPORT BEHAVIOUR MONITORING IN LONGWALL PANNELS - A CASE STUDY-SINGAM JAYANTHU AND RAJDEEP DAS (National Seminar & Exhibition" Role of Innovations & Technology in turn around Mining Industry" Aug.26-28, 2022)
10. TRAINING AND SKILL DEVELOPMENT IN MINING SECTOR-SANJAY SHARMA. (National Seminar & Exhibition" Role of Innovations & Technology in turn around Mining Industry" Aug.26-28, 2022).

Alternate Fuels for Mining Machinery

Anubhansh Shrivastava*

ABSTRACT

Performance and Emission of harmful gasses is a big problem in Underground Mining as well as Open cast Mining . As we know , the Heavy Earth Moving Machines work with Diesel engines which are not much efficient and also produce a lot of CO2 which evidently increases the ventilation cost in terms of Underground Mining . The Alternatives to diesel power is few and most compare poorly with the power of diesel . Compressed air is one of the common source of power for Underground Mining and is still practiced exceptionally well in some areas too . The major option is Electric power which is applied in three ways ; trolley , cable and battery electric . The best advantage of these power sources is that they don't emit any type of harmful gasses or substances into the external environment.

Hydrogen is the most expected alternate fuel which has kept high hopes of engineers on replacing the Diesel . A special technique of fuel management has overcome abnormal combustion issues oftentimes seasoned with hydrogen fuel. A diesel was converted to a spark-ignited hydrogen engine and Hydrogen engine-fuel system is being developed as an alternative for powering Underground Mining machinery. Using hydrogen fuel also have some pollutants from the combustion process and those are the oxides of nitrogen which can be filtered out by using a lean fuel-air mixture which makes it the cleanest fuel available with less than 10% of nitrogen oxides in the exhaust system.

CIL also have come up with replacing it's diesel-run heavy mining equipments like dumpers with LNG kits in a bid to significantly reduce carbon emission and save around INR 500 crore annually.

Some big companies like Komatsu India has also given out its bio fuel compatible models. They have also started securing order for large-scale mining equipments .

We are expecting more of some alternate fuels in the future to replace these power sources such as Nuclear powered engine , but it will take a lot of time to develop .

Keywords- Performance ; CO2 emission ; Alternate Fuels ; Hydrogen powered engine ; Environmental health.

INTRODUCTION

Diesel has remained the main fuel for Mining machinery since the first machine was introduced to mining in India . Diesel provided machines with large horsepower engines and gave mining a boost in production and economic means . It made the mining process a lot easier than before and it also cut off a lot of manpower which saved the mine owners a nice amount of funds . According to Petroleum Planning and Analysis Cell (PPAC) India consumed 7.71 billion liters during March in 2022 , out of which mining machinery alone consumed around 4.3 billion liters.

The rapid use of diesel engine is increasing the pollution and damage cause by the mining activities and also increasing the cost of mining . So to overcome these drawbacks of use of diesel engine , the evolution from diesel fuel to renewable fuels or any other alternate fuel is started.

Flowchart given below will show the classification of forms of energy available for the mining machinery or are expected to be consumed to operate in the mines in upcoming future.

Combustion of diesel produce some pollutants that can have adverse effect on health and mine environment. Common pollutants include carbon monoxide (CO), unburned hydrocarbons (HC), nitrogen oxides (NOx) or particulate matter (PM). These pollutants are emitted due to some non ideal process during combustion such as combustion of engine lubricating oil, incomplete combustion of fuel, combustion of non-hydrocarbon components such as fuel additives , reaction between mixture components under high temperature and pressure, and more. The total concentration of pollutants in the exhaust gases from diesel engine emission is about tenths of one percent.

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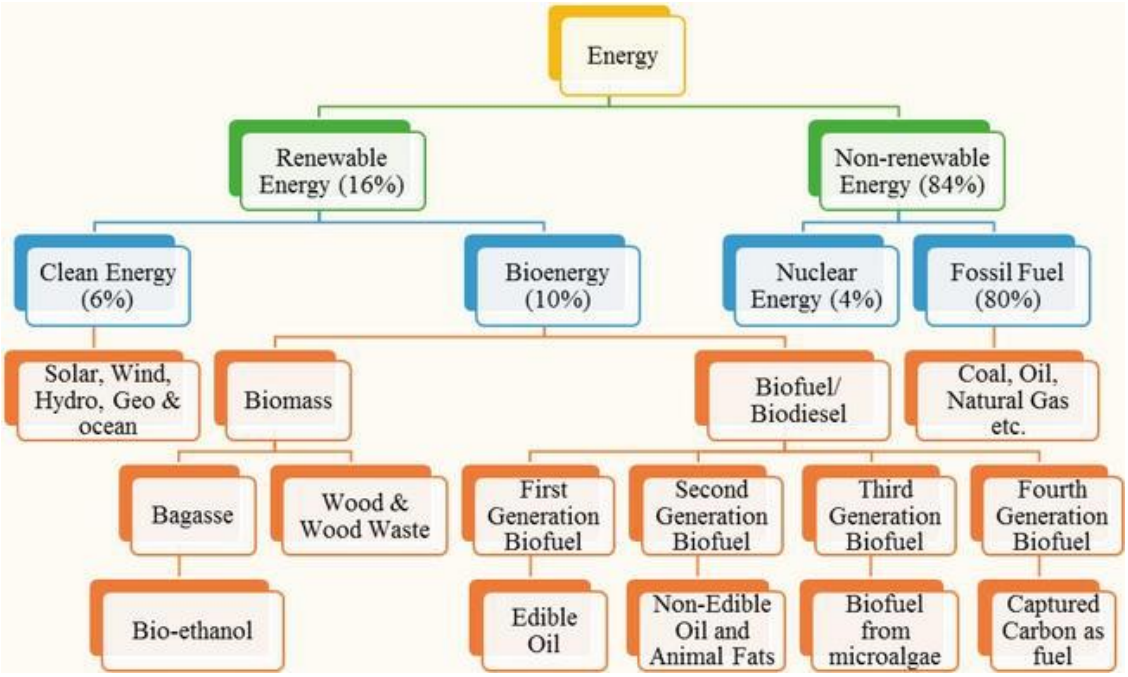

Alternative fuel engines have inherently lower harmful emissions, including toxic pollutants or contaminants compared to diesel fuel engines. Alternative fuel vehicles reduce impacts on global warming, air quality, public health and the environment. The fact that use of Alternative fuels should be encouraged more because it affects the mine environment a lot more as well as affects the mine economy. As the maintenance and cost of fuel is lower compared to diesel or gasoline.

Alternative fuels come from different sources and one of them is renewable sources of energy , which provide great energy efficiency in the development of fuels as well as reduce reliability on finite sources of energy. The only drawback that comes out from the side of alternative fuels is that the fueling infrastructure for many alternative fuels is only now being developed.

HYDROGEN

Compared to other fuels , Hydrogen have a higher energy content present in itself which produces heat and water when combusted with oxygen at high temperature and pressure. Hydrogen is odorless, colorless gas which have a lower density (0.0898 kg/m^3) then gasoline and that's why it also requires more storage space for a vehicle to run for the same distance on hydrogen.

The hydrogen's wide flammability limits makes its use suitable for a wide range of air fuel mixture. The fuel economy is improved when operated at lean mixtures where complete combustion takes place with very few residues. Hydrogen have high auto-ignition temperature, it's is suitable for a spark ignition engine however a low auto-ignition temperature fuel is required to initiate combustion for its use in a diesel engine. Hydrogen have high diffusivity and flame speed which results in faster combustion at a constant volume.

Nearly 95% of hydrogen is produced from fossil fuels since it's not available in its gaseous state. It is pushed out of the earth due to its low density and it exists only in the combined form in natural resources such as fossil fuels, natural gas, coal, and water which results in higher production cost and a large amount of emissions are produced if it is not economically and abundantly produced from renewable sources.

Some common methods which are used for the production of hydrogen are gasification of biomass, electrolysis of water, and gas reforming. Biomass comprises of algae, crops residue, switchgrass, animal waste, forest residue, and municipal waste. In the process of gasification, the hydrogen, carbon monoxide, and carbon dioxide is converted from carbon-rich material at a temperature greater than 700°C in the presence of oxygen or water vapour.

In electrolysis, hydrogen and oxygen is formed by passing an electric current through water making the process of electrolysis the highest energy consumption process for production of hydrogen. Other methods of forming hydrogen are splitting of water using solar, microbes, and high-temperature thermochemical water splitting.

USE OF HYDROGEN AS A FUEL IN COMPRESSION IGNITION (CI) ENGINES

This section describes the operation and performance characteristics of compression ignition engine when operated in dual fuel mode with hydrogen. The efficiency of the engine is higher due to the good heat transfer characteristics of hydrogen which increases the combustion temperature.

In the early 70's a group of people (Homan et al.[85] and Ikegami et al.[87,88]) discovered that the hydrogen ignited by injecting a small amount of pilot fuel into the swirl chamber of the engine. The engines operation range is varied based on the use of low or high auto-ignition temperature fuel. When the engine is supposed to be operated with low auto-ignition temperature fuel such as diesel, Vegetable oil, and biodiesel, the hydrogen is either inducted in a carburetor or injected within the manifold or the intake port.

When the low-ignition temperature fuel also known as pilot fuel is injected into the combustion chamber , hydrogen should be injected through the port for better performance of engine and reduction of emission compared to use of carburetor or manifold injection. The real problem with the hydrogen induction is that at high loads the engine performance is limited due to knocking. A method named Exhaust Gas recirculation (EGR) has been proved effective for NOx reduction and for suppressing knocking in hydrogen dual fuel engine but it also results in the increase of harmful emissions.

Natural gas is another option to be used as an injected fuel in a dual fuel engine but due to slow rate of burning if natural gas the engines efficiency is low followed by high emissions. The engine's performance can be improved by using hydrogen as a supplement to natural gas as well as it reduces the emission.

Biodiesel was also blended with hydrogen by many researchers to use it as a pilot fuel in a hydrogen-fueled dual fuel engine. Palm oil methyl ester was blended with diesel and the blend was used as a pilot fuel in a single-cylinder dual fuel engine where hydrogen was used as an injected fuel. Waste cooking oil also produces biodiesel which can be used as a pilot fuel to a hydrogen dual fuel engine.

BIODIESEL

Biodiesel is the gaining more attention because of its non-toxicity and biodegradable nature. It can easily substitute petroleum diesel for power generation and motive power without needing any major modifications with low emission of sulfates, chemical matters and aromatic compounds which harm the mining environment. The anuual production of biodiesel around the globe touched 28 Billion liters.

A total variety of 350 oil-bearing crops were identified from which biodiesel is produced efficiently. They are picked on the basis of climate change, soil conditions, methods of cultivation, location of the field, and harvesting. The biodiesel is also formed from several edible resources such as rice bran, palm oil, sunflower, soybean, rapeseed, coconut, and peanut. To gain these resources it is felt that deforestation and reduction in cultivatable land for the plantation purpose is being done which lead to the damage of soil resources.

Some other possible feedstocks for the generation of biodiesel are several nonedible oils, greases, animal fats, and waste cooking oils. Contamination with foreign particles and collection of waste cooking oils is tough due to its scattered resources. Even having these variety of feedstocks it is believed that, they don't provide with the right level of energy requirements.

Different method to produce biodiesel and other fuels are

transesterification, pyrolysis, forming microemulsions, and blending with other fuels.

BIODIESEL AS A FUEL

Biodiesel will be used in heavy mining equipments under the B10 formula is issued by Rida Mulayana , the Director General of New Energy, Renewable Energy and Energy Conservation of the Ministry of Energy and Mineral Resources.

The Government issued that the Biodiesel B20 formula is safe for usage in heavy mining machinery. They recorded no problem in the engine after running all the tests and they still haven't declared the final conclusions. The Government will supervise the blending of the biodiesel B20 so that it can perform well and there is no accidents. Biodiesel helps in utilizing existing diesel engine technology to meet reduced levels of emissions and enhance existing exhaust after treatment devices. The contamination tanks made of stainless steel are accepted with the same handling procedures used for Petroleum diesel.

Komatsu India private limited (KIPL), a subsidiary of Komatsu Ltd, Japan have started launching their vehicles with biodiesel compatibility such as dump trucks, dozers, wheel loaders, hydraulic excavators, motor graders, and wheel dozers. They are signing a Full Maintenance Contract (FMC) which states the machine operation up to ten years. The equipments were deployed in the month of May 2022. The first set of Hd785-7 dump trucks with biodiesel (B20) compatibility is delivered.

PROPANE-POWERED EQUIPMENT

Another new gasoline alternative is turned out to be propane as it was used to power pavers from a long time. For example BW 120 AD-5 LPG tandem drum roller of Bomag is designed in Diesel, electric and as well as Liquid petroleum gasoline (LPG). LPG burns clean and without any emission particles that's why LPG-powered rollers is in areas where emissions are critical and exposure to exhaust particles are lower than other sites.

LPG is cheaper in cost compared to diesel and gasoline , so initial cost and operating cost decreases over time. These equipments are around 21% more Powerful and it produces less carbon dioxide (15%), Nitrous oxide (95%), and fine dust (15) as compared to equipments with diesel engines and are much more efficient.

Coal India the biggest producer of Coal in India claimed that they will replace it's Diesel-run heavy equipments like dumpers with LNG kits. CIL is retrofitting 2 x 100- tonne dumpers with LNG kits to test and analyze the efficiency and performance while transporting coal in the mines. Which is supposed to reduce carbon emission and save around INR 500 crore for CIL annually.

Rawmatt Industries installed a private Liquefied Natural Gas (LNG) storage and dispensing facility and LCNG dispensing facility in Nagpur, Maharashtra to support CIL to adopt LNG for its mining operations They have tried to convert hundreds of transit buses and several cars to CNG with the help of Nagpur Municipal Corporation (NMC) and observed the decreases in vehicular emission and adopt green vehicles.

A Memorandum of Understanding (MOU) was signed between Shell Energy India Pvt Ltd and a Gujrat based company named INOXCVA for partnering and developing the market for LNG supply by road from Shell's LNG terminal in Hazira, Gujrat. In April 2021, to service the growing demand of LNG in India , INOXCVA signed a Memorandum of Understanding with Mitsui & Co Pte Ltd a Japanese

based company for partnering by sharing technical and commercial expertise. Over 100,00t of LNG is distributed to the customers by INOXCVA and it's 35 facilities across the country by its own tanker fleet under its brand "GoLNG" , they spread and logged over 6.5 billion kilometers all over the country propagating the use of LNG as a clean and environment friendly source of energy. Contribution and development of LNG as a fuel for Mining trucks, marine engines, rail engines by INOXCVA should be well acknowledged.

PRODUCER GAS

Producer Gas is made of dry biomass such as wood, rice husks, charcoal, and coconut shell. These materials have to go under the process of gasifying for the production of producer Gas. Heat is the major factor in the process of gasification which helps to break down the solid biomass and then it is transferred into the gasification system which includes a container filled with gasification agents such as oxygen, air, and water vapour and a reactor.

The following table shows the calorific value obtained when we use different type of agents in the gasification process,

Gasification agents	Calorific values
1. Oxygen	10-15 MJ/Nm³
2. Air	4-6 MJ/Km³
3. Water vapour	13-20 MJ/Km³

These gases will then be used to as a feedstock for the production of methane and methanol. Biodiesel also plays an important role in the process of igniting the producer Gas in the dual fuel CI engine when it is inducted with air into the cylinder.

DIMETHYL ETHER

Dimethyl ether (DME) is considered to be the simplest form of ether having chemical formula CH3OCH3. It can be identified by its physical properties such as it burns with a blue flame, it's colorless, nontoxic, and highly flammable with a slightly narcotic effect and can be used as a liquid fuel when the gas is kept under pressure. The two similar methods used for the production of DME are dehydrogenation of methanol and direct conversion of Syngas. DME can be produced from both fossil fuels and renewable energy sources.

Production of Bio-DME by using renewable sources is more costly relative to diesel so the second method is preferred more, which is production of DME using direct conversion method. During this direct conversion method, Syngas produced can be used for the production of DME and methanol using suitable catalyst. The first step includes the use of pure oxygen for the partial oxidation of coal and biomass or conversion to Syngas by either reforming natural gas using steam. In the second step Syngas produces methanol with the help of a copper based catalyst. In the third step DME is formed from dehydrogenation of methanol with the help of alumina or zeolite based catalyst. Then the product obtained is then purified as it will contain some amount of methanol nad water in it.

The advantages of DME are as follows,

1. It produces low smoke as it has a high contact of oxygen in it and absence of any bond between carbon atoms.
2. Its physical ignition delay is less because of its high cetane number.
3. Its auto-ignition temperature is low.
4. Its boiling point is low which is responsible for the quick evaporation of fuel spray.

The disadvantages of DME are as follows,

1. It has low viscosity and lubricity which causes leakage and rough surface of the fuel system
2. Its calorific value is less, so the amount needed to produce same amount of power is more.
3. As compared to diesel , it have a lower bulk modulus of elasticity.

USE OF DIMETHYL ETHER AS A FUEL IN CI ENGINE

This section of the paper describes the use of DME in a diesel engine on the basis of its combustion , efficiency and exhaust emissions. DME can be used in a engine as a neat fuel when it is blended with diesel, bio-diesel, or LPG.

The heat release and combustion pressure with DME-fueled engine are came out to be higher than diesel. It was a direct injection single-cylinder diesel engine with a multiple hole injector. The DME blend provided us with lower ignition delay and higher indicated mean effective pressure with a reduction in the percentage of NOx emission and carbon dioxide emission with higher exhaust gas recirculation rate.

To operate a diesel engine with DME it's fuel injection system should be redesigned to handle it's low viscosity, lubricity, lower heating value, and elasticity. Field testing of a prototype DME truck was completed by Volvo and Oak Ridge National Laboratory.

CONCLUSIONS

The fossil fuels are limited and are depleting rapidly so it is necessary to use alternative fuels to keep on the working of the Mining industry. The number of benefits alternative fuels provide are overshadowing the cons of other fossil fuels. Alternative fuels provide social empowerment, energy security, and employment generation. That's why the exploration of other alternative fuels should be carried on , on a large scale.

There have been a lot of challenges in the operation of engines with the current alternative fuels such as cost, feedstock, specialized engine system and so on. There were more challenges in the production of alternative fuels as the process are complex and we have to always look for the new methods to decrease the cost and time required. Specialists are employed for the production of alternative fuels which have appropriate knowledge of physical, chemical, thermodynamics qualities of the alternative fuels.

It will take a lot of research and exploration in the alternative fuels criteria to completely replace fossil fuels such as Diesel. Both the options have their own cons and pros, with alternative fuels we have a safer future with low pollution and clean emissions with the same amount of work done. Some alternative fuels have very promising qualities and have high potential to change the working of the engine which will lead to emission free future. For now we know that we can use the diesel engines with the blends of alternative fuels which won't affect the performance and will help us to create a greener environment.

To make India self sufficient in the production of alternative fuels, Government has started a "Make in India" and "Atmanirbhar Bharat Abhiyaan" to enhance the efforts for lowering the making cost, and tackle the challenge coming on the way of replacing diesel with alternative fuels more efficiently. Memorandum of understanding or cooperation Agreement is signed with CIL and other customers to make it happen and come into action as soon as possible.

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Coal Gasification

Shreeya Julme*

A 50% revenue share concession can be made available only if the successful bidder utilises coal generated in its own plant(s) or a processing facility of its holding, subsidiary, affiliate, or associate for coal gasification or liquefaction on annual basis, or tries to sell coal for gasification or liquefaction.

This is subject to the requirement that at least 10% of the planned coal production for that year, as per the agreed mining policy, be consumed or sold for gasification or liquefaction. This initiative has been launched in order to achieve energy self-sufficiency.

ABSTRACT

Coal gasification is the process of producing syngas—a mixture consisting primarily of carbon monoxide (CO), hydrogen (H2), carbon dioxide (CO2), methane (CH4), and water vapour (H2O)—from coal and water, air and/or oxygen. According to the US Department of Energy, coal gasification is a thermo-chemical procedure wherein the pressure and heat of the gasifier disintegrate coal into its chemical components. The resulting "syngas" is mostly carbon monoxide (CO) and hydrogen, with some other gaseous substances thrown in for good measure. Historically, coal was gasified to produce coal gas, also known as "town gas". Coal gas is combustible and was used for heating and municipal lighting, before the advent of large-scale extraction of natural gas from oil wells.

In current practice, coal gasification is an in-situ method wherein oxygen is infused into the seam together with water and ignited at high temperatures, causing coal to partly oxidised into hydrogen, CO, carbon dioxide (CO2), methane (CH4), and hydrogen sulphide (H2S). Large-scale coal gasification installations are primarily for electricity generation (both in conventional thermal power stations and molten carbonate fuel cell power stations), or for production of chemical feed stocks. The hydrogen obtained from coal gasification can be used for various purposes such as making ammonia, powering a hydrogen economy, or upgrading fossil fuels.

Ex-situ reactors are designed to simulate the gasification process above the ground's surface. Sulphur in coal is transformed to H2S and trace volumes of carbonyl sulphide during the gasification process (COS). Alternatively, coal-derived syngas can be converted into transportation fuels such as gasoline and diesel through additional treatment, or into methanol which itself can be used as transportation fuel or fuel additive, or which can be converted into gasoline.

Acid gas removal technology can easily and cost-effectively discard these sulphur compounds. There is no scrubber sludge produced by coal gasification plants, which necessitates careful and expensive disposal. The majority of the wash water is reprocessed, and residual waste waters from gasification plants can be treated effectively.

As a result, coal gasification is regarded as a cleaner coal technology when compared to coal combustion.

Furthermore, coal could be used to generate a range of products using clean coal innovations such as hydrogen, methanol, and fertilisers via coal gasification. Carbon fibres and plastic composites made from coal power plant ash/residue.
Keywords- Coal Gasification ; Syngas ; Power stations ; Fuel additive.

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SHREEYA JULME

INTRODUCTION

Coal, being one of the fossil fuels is burned for heat, contribute a quarter of world's primitive and elementary energy and two-fifth of its electricity. It is the most Eco rich considerable and essential fossil fuel in India. In line with the World Energy Model (WEM) presented by International Energy Agency (IEA) the absolute fundamental energy demand through coal, attained 3750 MT in 2017 and its growth rate will diminish a lot in the forthcoming 10-20 years. The coal production in India hit 730 MT in the financial year 2019-20 (provisional) and 716 MT in financial year 2020-21 (provisional, despite of sinking demand which was affected due to covid-19 pandemic. In India about 55% of the total fuel source for power along with Ignite is represented by Thermal Power itself and it consume a total of 80% of the coal produced.

The first rate Assets of gaseous fuels concerning environmental fortification and accessible transportability, in addition with their wide spectrum of uses as energy sources and chemical crude elements for commodities signify that their importance for the world's energy economy will go on increasing in the future. Nevertheless coal will persist as the major fundamental energy in the subsequent few decades.

Coal gasification, as the name suggest is the process involving conversion of coal into gas which is used in illuminating and heating purposes. It includes thermochemical modification of coal into a combustible gas. The method gives consideration to the conversion of carbonaceous basic material such as petroleum, petroleum Coke, coal or Biomass into hydrogen and carbon monoxide.

Coal gasification as a power generation innovation is prevailing immense popularity due to easy, accessible and handy Global availability of raw material (coal) as well as positive environmental and ecological concerns affiliated with this technology above other combustion innovations and technologies.

The process of gasification can be established in a separate area by providing necessary facilities or can occur in coal mine itself. Coal gasification is the capital innovation in attaining pure and productive utilisation of coal gasification entails opposed multi-burner CWS gasification, GE coal water slurry (CWS) gasification, GSP pulverized coal gasification, shell pulverized coal gasification and SE pulverized coal gasification. These technologies effectively enhance coal utilisation and productiveness and diminish sulphur (SO2), Nitrogen dioxide (NO2) and carbon dioxide (CO2) emissions.

Despite the fact that commercialized gasifiers are extensive all over the world, persistent fundamental study is essential to meet the technical demands covering carbon conversions, nozzle and refractory lifetime, slagging issues and the corresponding syngas purification. Additionally via thorough fundamental study investment and functional expenses of the actual plant will be miniaturised additionally.

HISTORY

In early 19th century fuel gas was first produced commercially from coal. Due to War of 1812, the British impact in America was clearly obvious from the fact that just five years later the gas light company of Baltimore became America's first gas company although the usage

of coal gas was lighting didn't become common practice until the year 1865. The first fixed grade producer was introduced in 1839. Mond gas was a producer gas generated from coal rather than coke created by Ludwig Mond in 1850s.

The non-luminous flame of blue water gas (BWG) makes it ineffective for illuminating applications. In 1850s, process for making producer gas and water gas from coke where discovered. This produces a radiant flame when burned due to higher calorific values. To produce water gas, cyclic operation was invented in 1852.
In mid 1800s, coal gasifier were categorized in two

1. Cyclic gas generator same as first used by Fontana
2. Gas producers

BWG supplemented by gases generated by pouring oil into scorching retort is called as carburetted water gas CWG and was developed in 1860s. The 1860s were the golden era of coal gas developments was its tor. Scientist like Kekulé and Perkin cracked the secrets of organic chemistry to exhibit how gas created and its composition. Later this technique was enhanced by Thaddeus S.C. Lowe In 1875.

Soon after the American Civil War in 1875 each and every large area and medium area cities in industrialized American Europe raised coal gas works and gas dissemination interface. The mechanical producer was set up during 1900 to 1920 which now by the time had reached its existing form. By 1930, United States were holding over 11,000 coal gasifiers operators and in early times more than 11 million metric tons of Coal were Gasified annually. The two other German researchers, Fischer and Tropsch Formulated catalyst to reform the hydrogen and carbon monoxide from coal gasifiers gas to hydrocarbon liquids. Since coal was initially gasified prior when the gases were diminished to liquids.

Cheaper natural gas and oil replaced coal gas from many of its former user countries in the world except in South Africa and some developing countries soon after the Second World War. The oil crisis of 1970s stimulated rehabilitated concerns in diverse alternative coal consumption technologies, like coal gasification and coal liquefaction, as a mode of substituting Petroleum Resources Such as oil and natural gas. In many parts of world along with Canada, coal resources are so huge that gaseous and liquid fuels from coal could progress towards being feasible alternative fuels if conventional resources Gallop low.

Many coal gasification processes had been developed soon after the first oil crisis in 1973. The accessibility relationship between oil and coal and its modified price increased firm motivation in coal gasification technology. Nevertheless, the revert of ample and budget oil supplies has efficiently kill the market expansion commercial possibilities of these technologies.

Coal gasification came out to be dominating technique in the countries such as United States from 1880s two 1950s.

PROCESS

Gasification is partial oxidation process. Term partial oxidation defines less oxygen is utilized in gasification process rather than combustion of same amplitude of fuel. Only 25 to 40% of theoretical oxidant (either air or pristine oxygen) generally utilized for gasification to engender adequate heat for the gasification of remaining unoxidized fuel, engendering syngas.

CHEMISTRY

The result of chemical reactions can be different depending upon conditions and feedstock used. In comparison with conventional combustion gasification process typically consists of combustion reaction in which only one-fifth or one-third of theoretical oxidant is used. This process of oxidation is known as "Partial Oxidation". Carbon monoxide and hydrogen with minor elements of completely oxidized carbon dioxide our main combustible products of the process.

The Combustion Reaction:

1. $H_2 + ½ O_2 \longrightarrow H_2O$ (- 242 MJ/Kmol)
2. $Co + ½ O_2 \longrightarrow CO_2$ (- 283MJ/Kmol)
3. $C + ½ O_2 \longrightarrow CO$ (-111 MJ/Kmol)

This basic combustion reactions are done under normal condition of gasification process. Other considerable gasification reaction comprises of:

4. $C + 2H_2 \longrightarrow CH_4$ The Methanation Reaction (-75MJ/Kmol)
5. $C + CO_2 \longrightarrow 2CO$ The Boudouard Reaction (+172 MJ/Kmol)

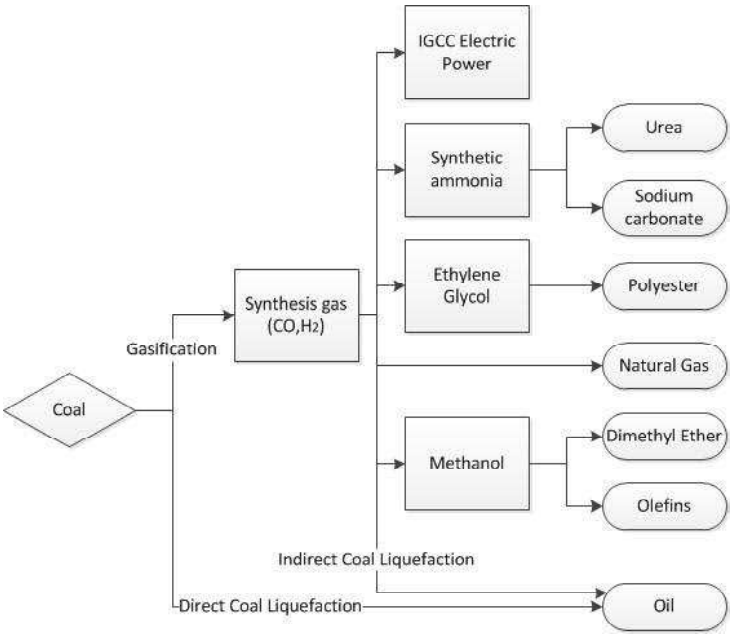
6. $C + H_2O \longrightarrow CO + H_2$ Water-gas Reaction (+131 MJ/Kmol)

These reaction is possible under high carbon conversion conditions. These are heterogeneous reactions which can be curtail into two homogeneous gas reactions of water gas shift and steam methane Reforming.

7. $CO_2 + H_2O \longrightarrow CO_2 + H_2$ Water Gas Shift Reaction (-41 MJ/Kmol)

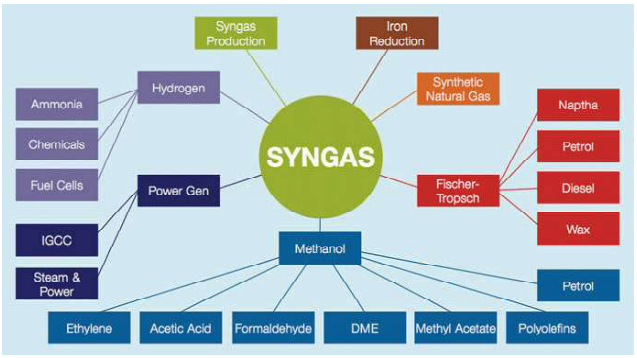
8. $C + H_2O \longrightarrow CO_2 + 3H_2$ Steam Methane Reforming Reaction (+206 MJ/Kmol)

These reactions has major contribution in determining final gas composition termed as syngas. The amount of sulphur, nitrogen and chloride is minute and have insignificant impact on syngas component of H_2 And CO.



SYNGAS

Syngas or synthetic gas consists of hydrogen and monoxide present in diverse proportion. Basically it also holds some quantity of carbon dioxide and methane. Syngas is typically used for manufacturing methanol and coal. Being combustible gas, it can be used as fuel. In past times, it was used in replacement of gasoline.



SYNGAS COMPOSITION

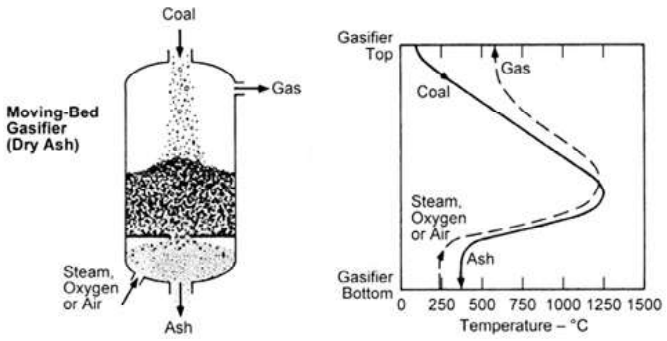
The constitutions of syngas may differ, depending upon the feedstock used and gasification method engaged for the production. Generally, syngas comprises of 30 to 60% of carbon monoxide (Co), 25 to 30% of hydrogen (H_2), and minute composition such as 0 to 5% of methane (CH_4) and 5 to 15% of carbon dioxide (CO_2). Additionally it also contains negligible quantity of water vapour, sulphur compounds, hydrogen sulphide H_2S, carbonyl sulphide (CoS), and eventually some ammonia and alternative evidence contaminants.

Classifications of coal gasification technologies

The coal gasification technologies are categorized on the basis of gasifiers used operational characteristics and design of the gasifier. These categories are as follows:

1. Moving Bed or Fixed Bed Dry Bottom (FBDB)
2. Fluidized Bed (Back mix reactors)
3. Entrained Bed (plug flow reactors)

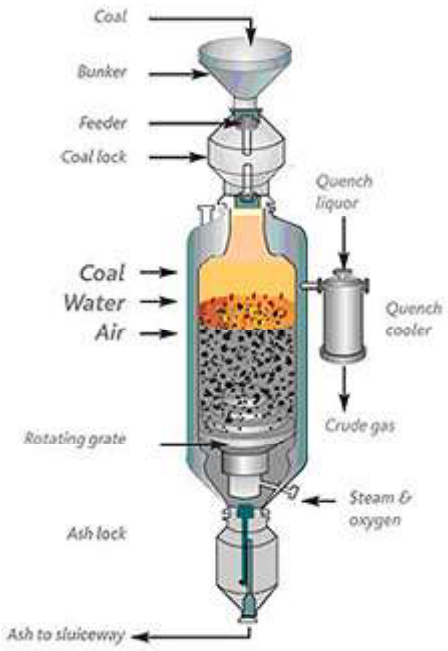
Moving Bed /Fixed Bed type gasifiers



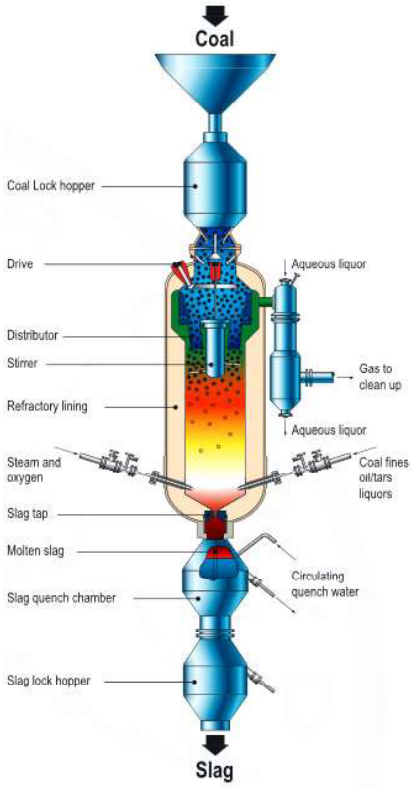
Moving Bed gasifiers are operated in two different modes

1. Dry Ash
2. Slagging

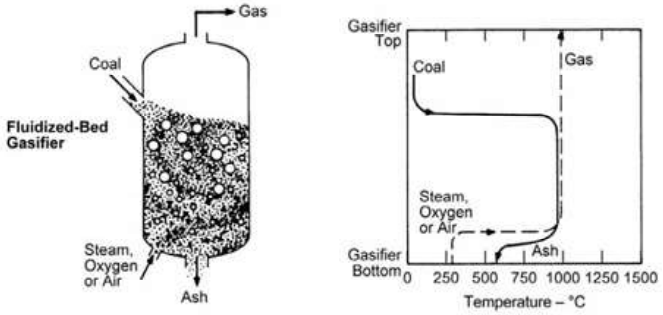
Dry gasifier



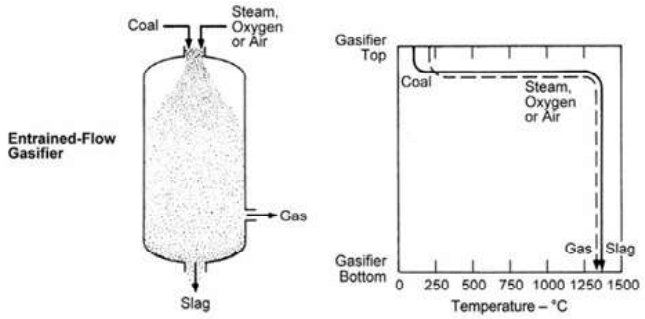
Slagging gasifier



Fluid Bed Type Gasifier



Entrained flow type



Underground Coal gasification

Coal based energy productions are slowly bringing impacts on industrial world. These techniques is utilizes for extraction of energies in an inaccessible industry. It involves introduction of steam and oxidant directly in coal seam and illuminated via various procedures. Reactions takes place between coal, steam, and oxygen producing a combustible synthetic gas (Syngas) which is used in generating electricity or using it as raw material for other manufacturing processes. This technique is used to transform the coal existing beneath the earth directly into gas. This is achieved by drilling holes from surface till the existing coal seam beneath the earth surface. Nextly, steam and oxidizing agent are processed further in a sufficient and required amount to achieve gasification to generate synthesis gas, mixture of carbon monoxide, hydrogen, and methane in diverging ratio relying on preferable state.

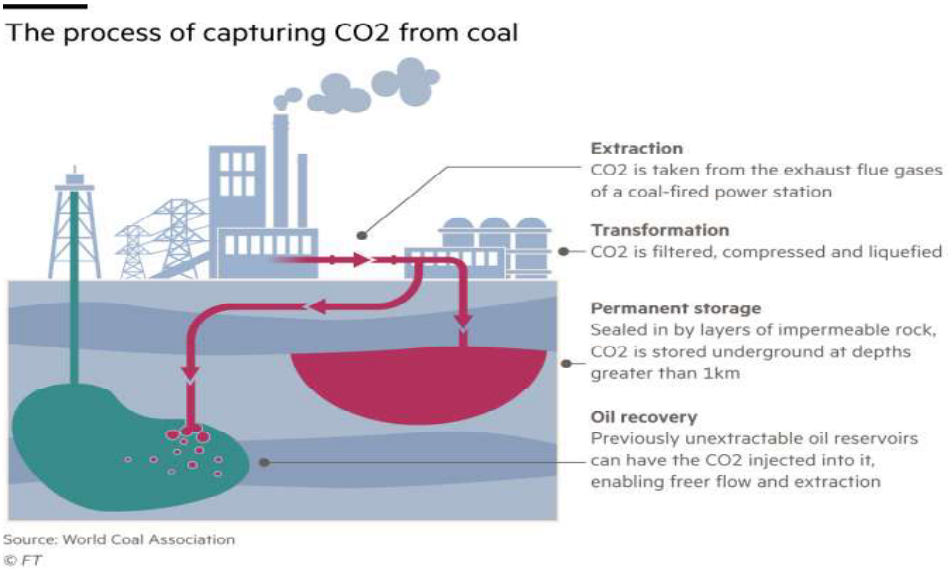
Coal capture technology or Coal capture and storage.

Carbon capture and storage (CCS) is a method to diminish emission of carbon to tackle down the serious issues of global warming. CCS implicates of capture carbon dioxide (CO_2) from the production area. Then it is carried back to its manufacturing area through ship or through pipeline. These are then stored in a storage site which basically should be of size 0.62 miles (1km) or more beneath the ground.

Characteristics of UCG

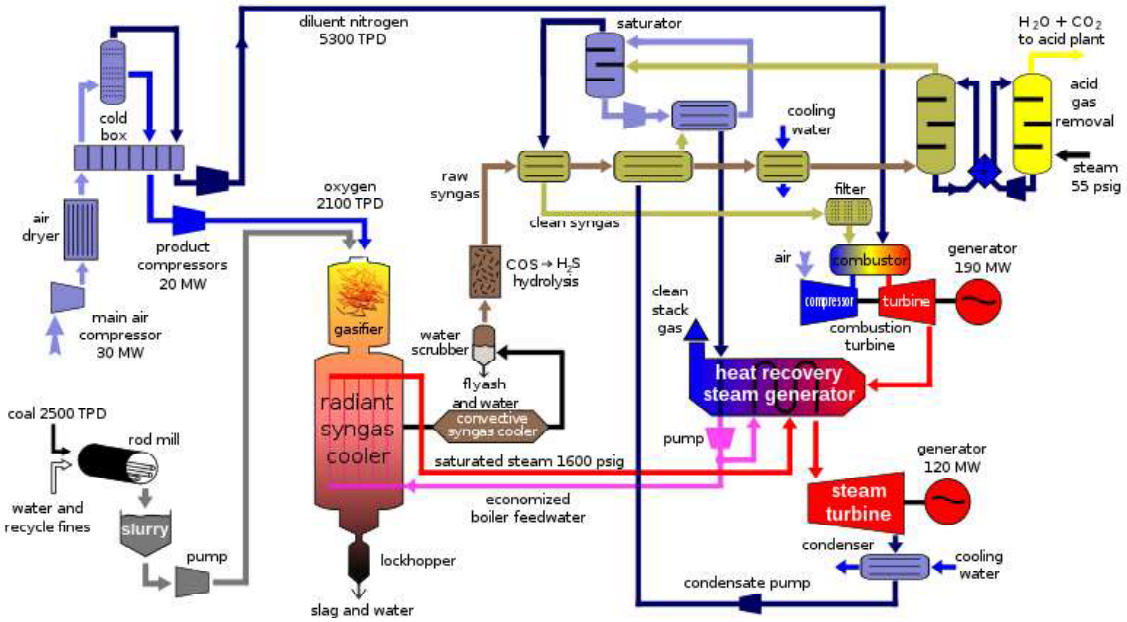
Sr. No	Factor	Requirement	Reason of Importance
1	Depth of Coal	200-400m	Stability to CG process, pressure plays a positive role, increasing pressure decreases heat reduced and increases gasification efficiency
2	Thickness of Coal	>3m	Thinner seem effects the quality of gas due to the heat lost to the surrounding rocks, uneconomical
3	Coal Rank	Lignite and sub bituminous is more suitable than higher rank coal	Lignite sub bituminous how high reactivity then bituminous due to high porosity, surface area and ash content. They shrink and crack up on heating, thus helping product gas to flow. Bituminous tends to swell
4	Gasifying Agent	Air, steam or oxygen	What sort of make sure you are using will decide the calorific value of produced gas, generally using oxygen gives higher calorific value gas
5	Types of Overlying and Underlying Strata	Firm and tight rock mass (like shale)	To reduce heat and gas lost
6	Hydrogeological Conditions and Geological Structure	Lack of Fissures, faults, aquifers	Stability of UCG operations, prevent water quality degradation

Source- Minetech, Volume 42, No 3, July-sept., 2021



Integrated Gasifcation Combined Cycle (IGCC)

"Integrated Gasification Combined Cycle" is termed by the abbreviation "IGCC". IGCC being one of the popular technology to purify the gasification products and remove the acidic compounds before entering gas turbines attached to power generators. IGCC also offers us to use coal with low ash melting point. IGCC is considered to take over the problem of acid rain due to combustion fuel gas exiting from turbines have very low amount of acidic species and peculates. IGCC is being the considerable technology for the confirmed who can't handle their greenhouse gas emissions but have to switch to a different energy source with low carbon dioxide emission.



Characteristics of IGCC

1. High Power production ability:

• Carbon dioxide emissions, essential requirement of sufficient fuel for the production and power generation expenses can be reduced.

2. Border range of felicitous coal types:

• The technology sanctions us to utilize low-grade coal, which is not congruous for conventional coal-fired power stations. This enables us to compete against resource-opulent countries and awaits us truncate fuel expenses.

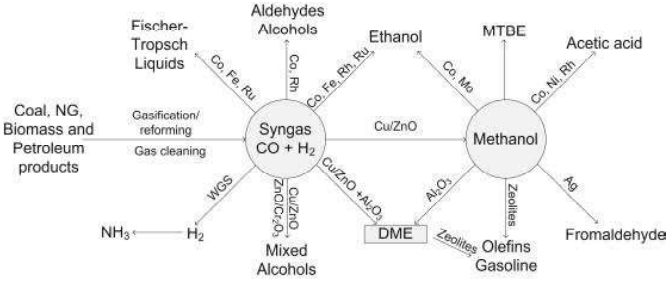
3.Eco convivial characteristics:

• IGCC technology minimizes the SO2, NO2 and soot emissions relative to the amplitude of potency endangered as compared to conventional coal-fired thermal power technologies.

• Plants involving in IGCC technology emits Glass-like slag. Which truncates the volume of emissions by a moiety. In addition, the slag can be recycled to engender convert or sub-base course materials.

By-products of Coal Gasification

- Methanol
- Ethanol
- DME, Acetic acid and Formaldehyde
- Olefins
- Fertilizers fertilisers and NH3 based products
- Urea
- Di-ammonium Phosphate (DAP)
- Ammonium Nitrate (AN)
- Hydrogen



Global Experience

Coal gasification technology is around us for 200 years. It is the best choice for clean production and other energy forms. The global coal gasification market is anticipated to strike around 3,89,825 MW by 2026. The world is increasingly leaning towards integrated coal gasification combined cycle (IGCC) power plants gaining positive opportunities.

China

The outcome of IGCC can assist the economy of China looking for future. Coal is the major source of energy in almost every area in China. Currently China claims for 90% of its ammonia production through coal gasification. China is looking forward to boost the consumption of large scale coal to SNG projects and scale up versatile coal to oil technologies projects which would hold and support the gasification technology and Chinese Economy.

United States

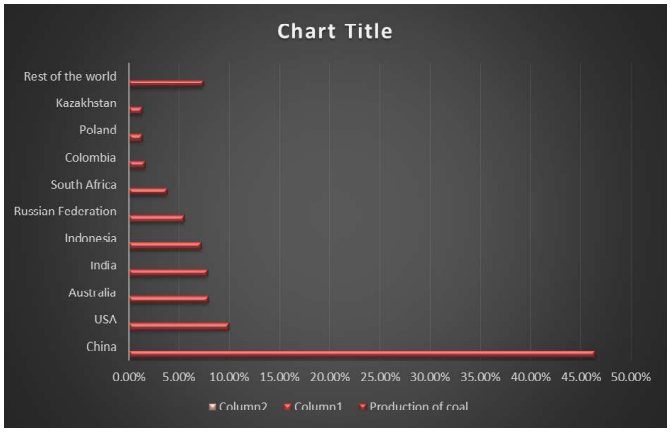
The natural gas market in US has beaten the revolution of shale oil and gas resulting in the producing price of electricity utilizing natural gas was lower than for coal.

Including ample reserves of oil and gas, enough production of oil and gas are descending the cost of renewables such as solar and wind.

There are very little chances that US is ready to gasify coal in future, since natural gas delivers much inexpensive and Industrially established choice for the particular.

Japan

As per the Ministry of Economy, Industry and Trade (MEITY), Japan will abort the non-beneficial older coal plants by 2030. But also will proceed with utilization of ultra-supercritical and IGCC plants. Japan hold two IGCC plants with total capacity of 800MW and recently one of the plant has added with a capacity of 543 MW. For this reason, Japan didn't shunt the coal gasification projects alike US.

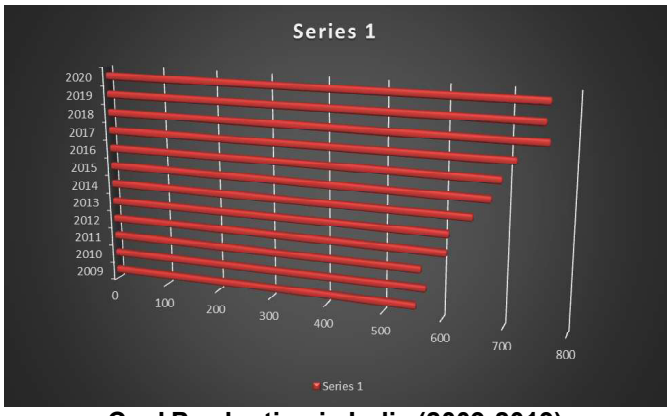


Top 10 Coal Producing Countries

Talking about India

Coal resources in India

The proved reserves of coal of the whole world are 1074 BT and India hold the 4th largest reserves of coal with 10% of global reserves. India was placed at third position for production as well as consumption of electricity in 2020. About 622.63 million metric tons of coal is produced in 2022 by coal India. In 2021, China, India, Indonesia, United States of America and Australia were the countries holding top positions in terms of production (by volume). Where India stood second (by volume) with a total coal production of 766.9 million tons.



Coal Production in India (2009-2019)

Experimental methodology

Methodology means presenting or expressing new experimental of applicable methods or producers. The purpose is to get with betterment of industry as well as

get with the better version of currently Present method. The method should be ideally applicable or worthy in terms of practical application.

RECOMMENDATIONS

SR. NO	NAME OF MINING COMPANY	NAME OF MINE	NAME OF MINE/SEAM	RECOMMENDATIONS	OTHER RECCOMENDATIONS
1	MCL	TALCHER, BHUBANESHWARI OCP	SEAM 2	HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
2	MCL	TALCHER, BHUBHANESHWARI OCP	SEAM 3	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
3	MCL	TALCHER, JAGNNATH	SEAM2	MEMBRANE LINED HIGH TEMPERATURE EFG	WASHING/BLENDING WITH LOW ASH. CAN ALSO HANDLED IN MBG and FBG
4	MCL	TALCHER, KANIHA AREA	SEAM 2	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
5	MCL	TALCHER, BALRAMM	SEAM 2	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
6	MCL	TALCHER, BHARATPUR	SEAM 2	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
7	MCL	TALCHER, ANANTA OCP	SEAM 2	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
8	MCL	TALCHER, LINGRAJ OCP	SEAM 2	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
9	MCL	TALCHER, LINGRAJ OCP	SEAM 3	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
10	MCL	TALCHER, HINGOLA	SEAM 8	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
11	MCL	IB VALLEY, LAKHANPUR OCP	LAJKURA SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
12	MCL	IB VALLEY KULDA OCP	LAJKURA SEAM 2 (ORIENT)	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
13	MCL	IB VALLEY KULDA OCP	LAJKURA SEAM 2	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
14	MCL	IB VALLEY, BELPAHAR	IB SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
15	MCL	IB VALLEY, RAMPUR	TOP-BOTTOM COMPOSITE SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
16	MCL	IB VALLEY	SAMALESWARI OCP	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
17	MCL	IB VALLEY, LAJKURA	LEVEL 1 TOP SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
18	MCL	IB VALLEY, LAJKURA	LEVEL 2 BOTTOM SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
19	CCL	ASHOKA MINES	LOWER DAKRA SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	AFTER WASHING/BLENDING WITH LOW ASH FEED IN MBG WITHOUT WASHING/BLENDING WITH LOW ASH FEED IN FBG
20	CCL	URIMARI MINES	UPPER BALKUDRA SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG

21	CCL	URIMARI MINES	LOWER BALKUDRA MINES	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
22	CCL	NORTH URIMARI MINES	ARGADA A+B SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
23	CCL	MAGADH MINES	ONE BOTTOM SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	AFTER WASHING/BLENDING WITH LOW ASH FEED IN MBG. FBG CAN BE OTHER OPTION.
24	CCL	AMRAPALI MINES	ONE COMBINED SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	AFTER WASHING/BLENDING WITH LOW ASH FEED IN MBG. FBG CAN BE OTHER OPTION.
25	CCL	PURNADIH MINES	LOWER MIDDLE DAKRA COMBINED SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	AFTER WASHING/BLENDING WITH LOW ASH FEED IN MBG. FBG CAN BE OTHER OPTION.
26	ECL	MOHANPUR MINES	SEAM A	MEMBRANE LINED HIGH TEMPERATURE EFG	AFTER WASHING/BLENDING WITH LOW ASH FEED IN MBG. FBG CAN BE OTHER OPTION.
27	ECL	CHITRA MINES	CHITRA SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
28	ECL	JHANJHRA MINES	R-V SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
29	ECL	KOTTHADIH MINES	R-VI SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG
30	ECL	SONEPUR BAZARI	R-VI SEAM	MEMBRANE LINED HIGH TEMPERATURE EFG	CAN ALSO HANDLED IN MBG and FBG

Source: National Coal Gasification Mission- MoC

Indian efforts in coal gasification

In 1960s many strains were given to introduce coal gasification in India. At the past times, Sindri hold a fertilizer plant that was utilized for coal gasification process and now the plant is closed. And from many years, Jindal Steel and Power Limited JSPL is working on a gas based DRI plant with domestic coal. The main focus of gasification plants are for their contribution for India using high ash domestic coal. In 2020, ministry of coal Shri Pralhad Joshi Stated that India's ambition is for 100 million tons MT coal gasification by 2030. Investment concerned with it was worth over Rs 4 Lakhs Crores. All coal gasification companies were asked to select a special officer for gestation of executive plan for gasification of minimum 10% of coal production.

Coal gasification plants in India

Jindal Steel and Power Limited (JSPL)

World's first Direct Reduced Iron (DRI) plant was set up by Jindal Steel and Power Limited which focused on coal gasification by using coal which they were already using for steelmaking in Angul District of Orissa . The syngas project Initiated from 2007 and commissioned by M/s JSPL In 2014. A pilot plant in Trichi was set up by BHEL which produced 6.2 MW power but handling high ash coal was problematic . For coal to methanol production, M/s Thermax has also installed a pilot plant in 2014 with DST funding under the patronage of NITI Aayog in Pune.

Ongoing coal gasification projects in India

Talcher Fertilizers Limited (TFL)

Talcher fertilizers limited (TFL) is a joint venture of GAIL (India) limited, Rashtriya Chemicals and Fertilizers limited (RCF), Coal India limited (CIL) and Fertilizers Corporation of India limited (FCIL) will be installing a megaproject based on urea located at Talcher in Angul District of Orissa. The TFL board confirmed coal gasification technology of M/s Air products (earlier M/s shell) for suggested plants. A mixture of coal and pet coke in 75:25 ratio will be used to manufacture ammonia and urea.

Dankuni coal to methanol plant

Under diverse lead of CIL, both DCC and ECL has introduced coal to methanol plant of 2050 MTDA (0.676). From ECL, Sonepur Bazari Mines will feed about 1.5 MT coal to the plant. And similarly from the DCC, raniganj coalfield will be feeding coal of about 1.35 MT to the plant.

Other proposed projects

CIL has also introduced four various coal gasification projects in ECL, SECL, WCL and CCL in which methanol, ammonia, ammonium nitrate and urea are anticipated to produce.

Central coalfield limited CCL is seeking suitable circumstances for diversification of new business of coal to chemical domain by production of syngas through utilization of coal from north karanpura coalfield. The plant having conditional expenditure of raw coal of ash content 34% in tune of 8650 MTPD (metric tons per day) for the production of 80,000 Nm^3/ hr of syngas.

SECL has visualized installation of coal gasification plant under CIL neighbouring to mahamaya mines on the basis of BOO, and around 1.35 MMTPA (G-4) Coal will be utilized for the production of 2200 MTPD of ammonia. For this mahamaya mines will be providing coal to SCG plant.

WCL has also identified coal to ammonium nitrate plant. CIL and its subsidiaries will be using ammonium nitrate as explosives. It will be further processed Fuel oil for production of ANFO. For this project Niljai Mines (G-) Has been selected and around 0.7 MMTPA of coal will be utilized for production of 2000 MTPD of ammonium nitrate.

UCG Development in India

YEAR/PERIOD	WHERE	IMPLEMENTING AGENCY	REMARK
Mid 80's	Merta Road Lignite deposit	CMPDI/CIL with technical support from USSR	1) Data were generated and the area was found suitable for pilot scale studies 2) The project could not be pursued further on apprehension of contamination of groundwater (as per UCG S&T completion report)
Sep' 05	Barmer, Rajasthan	GAIL with service provider Ergo Exergy	GAIL signed MoU With government of Rajasthan in Sept 5 For pilot I GCC project of 5 MW to be completed by 2009 (as per GAIL UCG brochure)
3rd November, 2005	MoU Signed between CIL-ONGC cooperation in the service, operation, R&D of UCG in coal bearing states of India. Russian experts were appointed by ONGC and some additional data/information generated by CMPDI as per their desire. However the MoU between CIL and ONGC expired in November, 2010 and further progress could not be made in the project .		
18th May, 2007	A note on UCG was approved by MoC (Process to notify UCG As specified end use, necessity for suitable regulatory framework for UCG implementation, CMPDI to identify areas within CIL mining leasehold for UCG)		
12th July, 2007	The GoI Issued a Gazette Notification wherein production of syngas through coal gasification (Surface and underground) and coal liquefaction to be an end use for the purpose of Coal Mines Nationalization Act, 1973.		
August, 2008	A Road Map to develop UCG Technology in India was published by a working group under Principal Scientific Advisor to the GoI which have valuable inputs from all the major stakeholders in UCG development including CMPDI/CIL.		

19th Feb, 2014	GoI Specified production of cement, syngas obtained through coal gasification (Underground and surface) and coal liquefaction to be end use for the purpose of MMDR act, 1957
16th Dec, 2015	The GoI Has approved the policy framework for development of UCG in coal and lignite bearing areas in India
5th Jan, 2016	Constitution of Inter-Ministerial Committee (IMC) For identification of areas for UCG through OM issued by the MoC
Dec 2018	Potential blocks in coal and lignite were identified and considered in the IMC For the commercial development of UCG preferably by PSUs. Identified coal blocks for UCG development are in Wardha Valley Coalfield (Jogapur-Sirsi), sohagpurCf (Maiki (North)-Maiki-Merkhi, Pathora, Chainpa), Tatapani-Ramkola CF (Reonti-West), Singrauli Coalfield (Bandha) and Godavari Valley (Yelendu-SCCL)
13th Nov, 2019	A workshop on "Prospects of Underground Coal Gasification (UCG) in India" organized at New Delhi. Dr. V K Saraswat, member – NITI Aayog, Secretary (Coal), Additional Secretary (Coal), Adviser (Projects), MoC, other senior officials from Ministry of Coal & former Adviser (Project) MoC and representatives from industries (coal and lignite), scientific organizations and international UCG experts from Skochinsky's Institute of mining SIM Moscow and Ergo Exergy Technologies Inc. Canada were participated actively.
Dec 2020	A Coal block i.e., Kasta (West) block Raniganj Cf under Eastern Coalfields Limited area has been identified to undertake pilot scale UCG projects under R&D model. It has been envisaged to develop UCG at Kasta West First in pilot scale and after that commercial scale UCG plant will be developed.

Source- Minetech, Volume 42, No 3, July-sept., 2021

Indian strategy for the future of coal gasification

In August 2020, Coal minister Shri Pralhad Joshi has announced a vision of 100 MT Coal Gasification by 2030 with expenditure of 4 Lakhs crores. Mostly, coal produced in India is consumed by thermal power plants for power generation. This initiative was taken for the purpose of making India self-sufficient to accomplish Government of India's "Make In India" and "Atmanirbhar Bharat Abhiyan" as well as to progress towards being a low cost producer. And the three phases of executing gasification project are as follows:

Phase 1 (2020 to 2024)

This phase identifies development of dankuni coal complex and Talcher fertilizer plant.
Investment: Rupees 20,000 crore along with four MT coal input.

Phase 2 (2021 to 2025)

Development of four projects-Utkarsh, Shilpanchal Pariyojna, Mahamaya SCG and Ashoka SCG.
Investment: 24000 crore along 06 MMT coal input.

Phase 3 (2022 to 2030)

This is an extended part of phase 2, phase 3 will be developed.
Investment rupees 3,60,000 crores with coal input of 90 MMT.

Challenges

- Availability of coal pursuing properties and qualities suitable for gasification is the most essential.
- Conversion of high ash coal to syngas is major challengeable technology.

- Capital investments for these projects are far more than huge.
- Cost of produced products may not rich as compared to the actual cost because it will be domestically produced and not with natural production process.
- This scarcity of involvement of experience in this sector is also a challenging factor which occurs due to less duties in the particular sector.
- Basic structure or framework like land, electricity, and water is essential for establishment projects.
- Managing investment capital, development capital, transportation capital and maintenance capital is also a challenging deal but also and important outlook point.
- Requirement of co-ordination between various stakeholders, companies and other people and industries involved in the success of the projects.

CONCLUSIONS

As the consumption of coal is increased by 700% in the last 40 years, it will continue to become the first preference for India's source of energy. It fulfils about 55% of energy needs of the country currently as of being the most important fossil fuels ever existed. It helped the country from the very past and constantly improved quality of life, enlarged the economy, helping explore new levels of technology and its power.

When there is high demand of chemicals, gaseous and liquid fuels, gasification-based coal conversion techniques are recommended to fulfil the demands. This puts low grade coals to work which are cheaper and don't have much other uses.

India has become the heartland for demonstrating, commercializing, and developing every aspect of incipient coal chemical process chemical and fertilizers technologies. India have done a hefty investment on the research and development of clean coal chemical technologies during the last two decenniums. India have divided the development of Gasification into three phases. Coal Gasification, indirect and direct coal-to-liquid (CTL) processes, and methanol-to-olefins (MTO) techniques are becoming popular rapidly.

Government of India started "Make in India" and "Aatmanirbhar Bharat Abhiyaan" to contribute to the low cost production and encounter the challenges in pricing/ marketing of coal based chemical/fertilizer with the help of CIL and other worthy customers by signing Cooperation Agreement or Memorandum of Understanding.

Latest Trends of Trans-Disciplinary Research Applications for Improving Safety in Mining Industry

Arun Kumar Sahoo* Jitendra Pramanik* Singam Jayanthu** Abhaya Kumar Samal***

ABSTRACT

Mining evolves the cycle of stages which is started from exploration continuing through production and ends with closure of the mine. In every stage of mining process we face lots of risk, hazards to environment and mankind. So minimizing the riskiness of the job and hazards technological innovations are coming forward in the mining industry. Renewal of the innovations is driven by the growth of the demands of the minerals with respect to communities and the environment. Adopting the technological innovations like geophysical methods for exploration of minerals, global positioning system, geographical information system, 3-D models using software etc makes the mining process more productive and reliable. So technological innovations shape the future.

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Analysis of Stability of Bench Slopes in Opencast Limestone Mines – Case Studies

S. Pritiranjan* K. Sridhar* Ashutosh** Singam Jayanthu***

ABSTRACT

This paper presents the overview of slope stability problems, challenges and importance of various approaches including numerical models, empirical approaches etc. Details of the findings of scientific studies on application of slope mass rating and the modifications made in the conventional system of slope mass rating through the project sponsored by the Ministry of Mines -Government of India is also presented. Basic slope design criteria and its application for design of slopes is also illustrated. As a part of the studies, the details of investigations, geomining conditions of study sites, empirical models developed and applied for some of the limestone mines is included in this paper.

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