

# **Signification of Geology, Mining Methodology, Mechanization & Automation for Enhancing Safety, Production & Productivity in Coal Mining Industry**

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## **Abstract**

The abstract should cover the content of the paper. Coal, inspite of the ills of polluting the environmental condition around associated with its use, is recognized to be the main source of energy for many decades to come. The tremendous energy crises during early seventies focused the attention of all the countries of the world on their coal resources, and plans were drawn to increase its production. It has since then naturally necessitated higher inputs in coal mining industry to increase production and productivity, need for improving the level of technology and to strengthen and accelerate its R&D activities in quest of further better technology for the exploration, safe & efficient extraction of coal and application of clean coal technologies for optimum utilization of coal reserves economically & in ecofriendly manner for overall development & growth of the nation and uplift the living standard of its citizens.

The paper highlights significance & inter-relationship of knowledge of geology impacting selection of mining methods under adverse geomining condition, selection of mining equipment, mine planning & designing, importance of proper layout/mine design in coal mine, men & material transportation respectively, engagement of coal face mechanization, automation & computerization, extraction of coal, rock mechanics & application of techniques of strata control and slope stability, ventilation system and structural geology & quality, quantity of coal, telemonitoring of noxious & inflammable mine environment, training, skill/competency development, work culture development, motivational techniques for enhancing safety, production, productivity, efficiency of mining operation for profitability and economic feasibility for sustainability of coal mining industry. Specialized remote guidance technology continuously steers face equipments e.g. longwall mining for

mass production of coal, automatically plotting its position in 3-dimensions, without stopping production as in manual method for correct equipment positioning. Around 60% of Australia's operating coal mines with longwall method of mining have adopted **CSIRO - Commonwealth Scientific and Industrial Research Organisation** (CSIRO worked with industry and equipment manufacturers to develop sensor technology to keep miners safer, and improve productivity) longwall automation technology. The system removes personal from direct hazards and increases safety. Real Time progress can be monitored from anywhere in the world, leading to further efficiency gains, reduced waste of resources. 5-10% increased productivity and maximum cost benefits/profit.

Coal mining practices has been changing fast in recent decades with sophistication in mechanization at coal face and coal/men/material transportation and application of computer controls etc. Manless mining & robotics for safety, mining techniques/methods such as hydro-mining, highwall mining, longwall, slope stabilities/strata control & instrumentation, coal winning in various adverse geomining condition such as greater depth/gradient, extremely thin/thick seam, fiery/gassy, highly water charged deposits/reserves mining, remote sensing for surveying & mapping, adoption of clean coal technologies i.e. coal gasification & liquification, coal convertibility and its alternative uses of coal are clearly visualized to be the emerging technologies in near future for fulfilling its coal requirement to attain self sufficiency in energy requirement.

The aim is to have sound knowledge and correlation of Geology, Mining Methodology/ Techniques, Mechanization & Automation apart from enhancing safety, optimum utilization of available resources, production & productivity in coal mining industry and also ensure that coal can be used as a replacement

for anything that natural gas or oil is used today. Efficient production coupled with environmental safeguards will be key aim of the mining industry in the years ahead. For coal to maintain its importance as a reliable fuel, three things must happen:

- The environmental issues must solve.
- Development of market must be free from artificial barriers.
- Investment in coal resources must be increased.
- Alternate use of coal by conversion into oil and gas.

The Government is funding R&D projects liberally. The coal industry in India is firmly set on the path of growth & modernization and will witness the introduction of many newer technologies/methodology's and automation considering geological structure and characteristics of existence of various coal deposits, metal and ore reserves underneath surface of the earth for exploration, exploitation, beneficiation and utilization of coal.

**Keywords:** *Author Geology, Geomining & Geomechanics, Mechanization, Automation, Mining Methodology & Techniques, Longwall Mining, Productivity, Safety Standards, Continuous Mining, Mass Production & Productivity, Operations, Transportation, Innovations, Efficiency, Economic Feasibility, Computerization, Mining Equipments.*

## 1. Introduction

### A) Geology:

The word, '**Geology**' means science of the earth and deals with the nature and origin of the rocks that constitute the earth. Geology enables a person interested in the extraction of coal/mineral from the earth to locate and utilize accessible deposits of coal/minerals and further enables him to decide the sites most economic for mining or quarrying.

Similarly Geology also includes the study of various natural dynamic and physiochemical processes operating on and within the earth and the impact of these agents and forces involved and evolved in such processes.

**Economic Geology** deals with the study of minerals and rocks and other such material as coal/petroleum/ore of economic value occurring in the crust of the earth that can be economically exploited for the benefit of mankind.

**Mining Geology** is geology as applied to mining practice i.e., for the exploitation of mineral deposits, petroleum and coal reserves of economic importance. Mode of formation of economic minerals, their distribution and response to stresses of fracturing

processes which are some important aspects in which the mining engineer would be greatly interested; such as hardness and presence of cleavage in coal. Study of these geological characteristics would be involved in mining geology.

**Structural Geology** is also important part of geology for safe and economical mining, useful to mining engineers. Structural geology is to study and interpret the structures found in rocks masses. The crust of the earth had never been stationary and there are continuous movement of smaller magnitude taking place along with rapid and forceful movements associated with formation of mountain, mineral and coal deposits. Structural geology aims at the investigation of structural features like folds, faults, joints etc. in the rocks forming the crust and interpretation of their possible mode and mechanism of formation. These structural features have negative impact on grade/quality of coal which incurs loss of crores of revenue due to grade slippage and dissatisfaction of customers resulting in less sale value of coal against the desired project report, percentage of extraction, cost of production, difficulties in mining operation get added up. Risk due to fire, inundation, noxious/inflammable gases and its explosion, weak roof/side strata also affects progress/development under stress, safety of men, machine and causes wastage of other reserves and efforts. The presence of cleavages on other hand increase hydrobreaking productivity eight times. The hydraulic energy consumption in cleated/fissured coal may be half as much as in solid coal. Upthrow faults decreases cost of coal extraction. Structural disturbances on other hand also deplete the quality/grade of coal, impacting its sale value & profitability and increase in litigation matters along with customer dissatisfaction.

### B) Mining Methodology:

When excavating a useful mineral or coal deposit the uneconomic rock or very low grade mineral/low grade coal associated with it has to be excavated and discarded as rejection/dirt/waste in coal mining practice for which various techniques of mining are to be applied using men, machine and various other resources, such as electric energy/fuel for mining equipment and now for more efficiency, safety & economy by way of automation & computerization, explosives etc. depending on the geological set up in the coal seams/minerals existing in the earth and further consideration of **various geo-mining parameter/factors become prerequisite to make a correct choice of mining methods so that coal seams/minerals are extracted and marketed in planned,**

efficiently and economically in eco-friendly manner with due regard to safety, conservation and quality for well being of the mankind.

**Study of structural geology and rock mechanics is very important for deployment of mining method, selection of equipment, strata control and design support system and technology.** Structural geology speaks about coal seams/mineral deposits availability in shape, size, inclination, thickness and line of breaks, its continuous availability and accessibility and application of mining methods for winning the coal/mineral with utmost safety and profitability. **Rock mechanics** deals exclusively with the study of behaviour of rocks (insitu and in laboratories) under loads imposed upon them naturally and artificially, statically and dynamically and in all possible combination of situation. This also implies study of all those factors – geological or otherwise that may be responsible for such observed or expected behaviour of rocks under force fields.

A thorough knowledge of various subjects of geology is essential for mining engineers to decide upon the methods of mining of rocks and coal seam/mineral deposits on the surface of the earth and also underneath. **Unless he has proper knowledge of the structural features of the rock-masses and principles governing the mode of occurrences of mineral deposit/coal seams, he shall never be in position to decide upon the actual method of mining and selection of equipments to be taken up.** The sudden disappearance of coal seams in the mine would be sufficient to put him to great confusion unless he is in a position to follow the effects of folding, faulting, washouts, dykes etc. on rock-beds.

Coal seams are having varying thickness, depth, structures and occur at different depth, overlain by rocks of different contents, characteristics and mode of formation. It follows, therefore that **a method of mining proved successful in one set of conditions cannot be applied for mining of coal seam in different set of conditions.** Hence, it become a prerequisite for mining engineers to have thorough knowledge of mining techniques, economic, structural geology and rock mechanics to make correct choice of the method of mining, to ensure safety and efficiency in mining operations. Further for carrying out extraction in efficient, economic and eco-friendly manner, to ensure higher returns on investment; Mechanization, Automation and Computerization have to be adopted in conventional mining operations which will in turn assist in maintaining safety standards, good industrial relationship, transparency and adhere to organisational ethics, culture and values while attaining the objectives of the organisation.

### **Factors influencing choice of Mining Methods:**

Coal seams have varying thickness, depth/inclination and structures and occur at different depths. It is observed that a method of mining proved successful in one set of conditions cannot be applied for mining a seam in different set of conditions. Hence it becomes a pre-requisite to make a correct choice of method of mining for success. The factors which influence the choice of mining methods are:

- Physical (geological, location of heritage/structural, ecological sensitive/restricted zones)
- Technically feasibility & industrial law & government regulations.
- Economical, financial/non financial, capital/budget availability.
- Social & Political, national/global issues.
- Land acquisition & environmental factors.

### **◆ Physical factors:**

- Thickness & extensiveness of coal seam in strike/dip direction.
- Gradient of the coal seam.
- Depth of the seam.
- Shape of deposit in different directions.
- Structure and geological abnormalities, intrusions i.e. dyke, fold, fault, unconformities washout etc.
- Degree of gassiness & proneness to spontaneous heating.
- Characteristics of floor and roof rocks.
- Hydrogeological conditions/make of water.
- Mechanical properties of coal, grade/quality and market value.
- Level of Mechanization.
- Capital/budget & Rate of return on Investment (IRR).

### **◆ Technical & Economic factors are:**

- Technological development and availability of machines, indigenous technology & spares.
- Geological parameters & technology for coal convertibility & alternate uses.
- Import regulations.
- Economic value of coal mined/budget/IRR, whether it is in abundance or short supply, grade materialization availability of technically skilled etc., and experienced manpower prevailing in country.

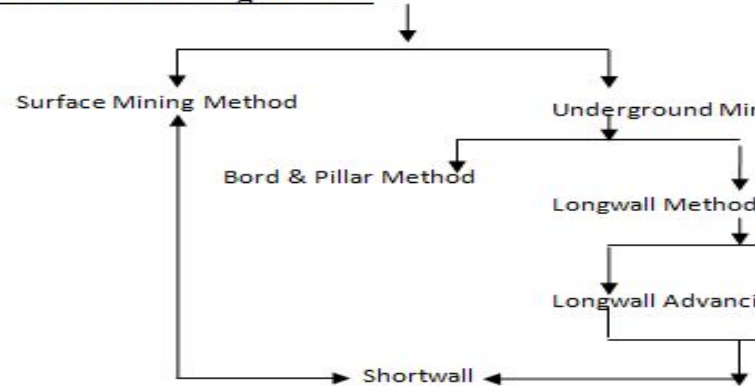
❖ **Land acquisition, social & political factors:**

- Directives & clearance of (MoEF & CC) Ministry of Environment, Forest & Climate Change.
- Restricted/sensitive/forest/wild life zones such as vicinity of national parks, zoos, jungles.
- Clearance from pollution control boards.
- Employment of land oustees and remuneration rate of land to be acquired.
- Land & Rehabilitation Policy.
- Village rehabilitation & expenditure, local politics, villagers resentment & agitations etc., also influence choice of mining methods such as underground or opencast mining.

❖ **Mechanical properties/rock mechanism of coal:**

- Uniaxial, tensile & compressive strength.
- Sulphur, moisture content, hardness of coal, ventilation system/heat exchange methods & comfort workplace and abrasivity influencing drill bit consumption, dust generation & suppression methods.
- Specific energy, mode & consumption also to decide the type of machines that can be deployed for getting coal; use of explosives for blasting to develop and depillar of coal.
- Hydrogeological conditions such as highly water charged strata under pressure e.g. Highly water charged coal seam is not suitable for underground gasification.
- Supporting/strata control technology/methods.

**Basic Coal Mining Method:**



- Level of Mechanization & budget for coal cutting, loading and transportation equally influence the choice of mining method & mine design/layout & percentage of extraction effectively & efficiently.

**C) Mechanization:**

Coal face mechanization had made possible break through in coal mining technology. Starting from manual pick & shovel mining method, coal getting has been generally fully mechanized and in some cases manpower almost completely eliminated, as on remotely operated longwall faces. The current trend is to mechanize all operations e.g. Coal cutting, loading, transportation and support setting for strata control withdrawal and advance of supports so as to achieve 100% mechanization. In India, the current and subsequent plans envisages greater degree of coal mechanization and to improve coal mining technology.

The ultimate aim of mechanization in coal mining is complete flexibility without adhering to rigid cycles and in its fully developed stage; mechanization, comprises, machine cutting and loading of coal, its transport by armoured face conveyor (AFC) and self advancing strata supporting system/hydraulic props at the face. **The factors that influence the type of mechanization are:**

1. **Capital investment capacity.**
2. **Availability of machineries.**

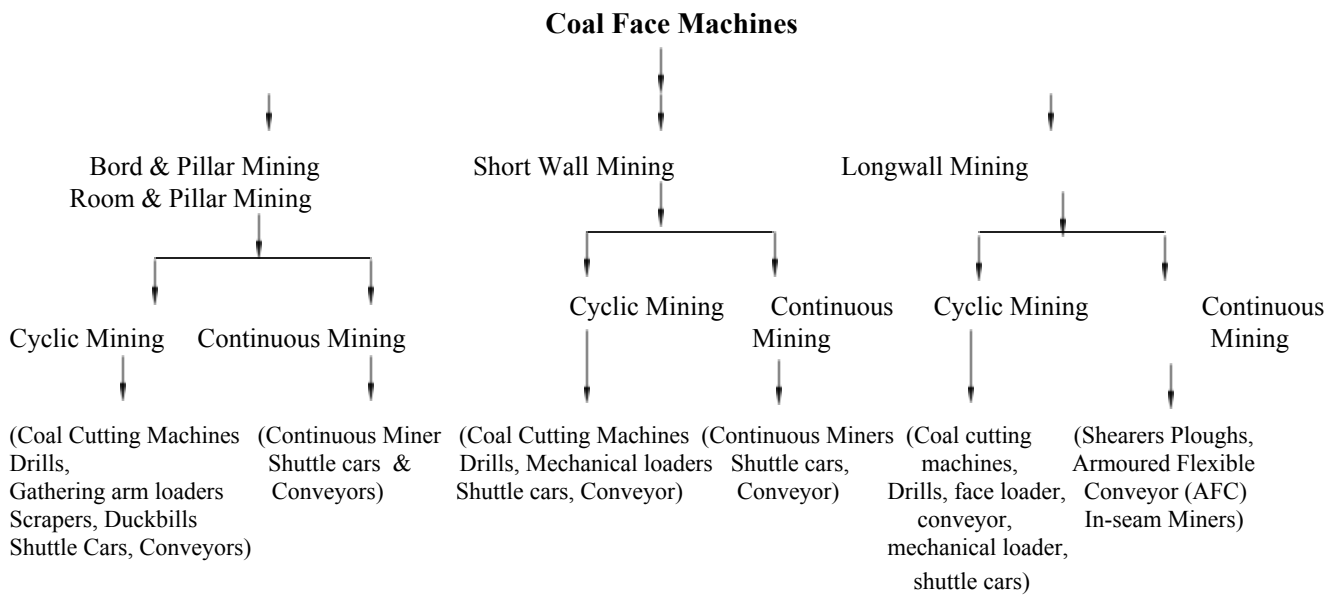
stand still, reduced capacity utilization of relative equipment, wastage of all type of resources and incurring various direct losses which cannot be recovered/made up, as time lost in it is ultimate direct loss.

- Market condition:** Power loading produces more fine coal. One should therefore, must establish good market for the sale of fines.

**Deployment of machineries of different specification or configuration in mechanization alongwith automation & computerization also helps to get coal of required size and grade which impacts growth in profitability and productivity** (output per manshift) and also ensures consumers satisfaction by transparency & timely supply of coal or metallic ore of required size and grade/quality, reduced expenses on litigation matters, harmonious consumer-supplier relationship and plays a vital role in sustainability of the organisation in global competitive market place by retaining existing consumers.

- Geological condition** such as seam thickness and its gradient, cleavages, presence of dirt bands, hardness of coal, igneous pyrite and other hard intrusion like dyke, presence of watery condition, nature of roof & floor and geological abnormalities, e.g. faulting, washout, folds etc.
- Facilities of the mine** i.e. transport system efficiency to deliver produced coal to destination timely. Any breakdown in any stage of chain of transport system, results in all mechanized coal winning operations

**Main type of coal face machines in relation to the method of mining are as follows:**



- Selection of suitable method of work/winning coal depending on physical, technical, economical, social/political, environmental factors etc.
- Cost analysis.

**◆ Steps for achievement of Safety and High Performance/Productivity by Mechanization:**

- Innovative maintenance and spares management systems.
- Training of work force, for skill development/upgradation.
- Compliance of statutory and safety provisions.
- Outbye transportation system – both horizontal and vertical.
- Improved work culture by introducing discipline and incentive scheme.
- Availability of coal faces to be increased by making suitable/proper district layouts and minimizing coal preparation time.
  
- Improvement in machine utilization i.e. availability & capacity utilization percentage by proper maintenance and spares management after analysing the causes of breakdown.
- Reliability of outbye transport system to be increased and lead/travel distance of Load – Haul – Dumper/Side Discharge Loader is to be kept minimum and also lead/lift for dumper shovel combination & inpit crusher and high angle belt conveyor system & similar matching equipments.
- Provision of better working conditions/ventilation in Mine for comfort of workperson & machines overheating & proper heat dissipation.
- Maintaining safety standards & ergonomics for operators.
- Proper distribution of responsibility and accountability.
- Extending some financial power to executives of mine level for motivation.
- Introduction of power support longwall technology.
- Introduction of mass production technology i.e. surface miner for open cast mines with high angle belt conveyor, inpit crushers of high capacity, technically skilled manpower & relevant training modules to create highly skilled & trained work force, continuous miner for underground mines with light duty chain conveyor.
- Modern techniques to retain dedicated and devoted work force, talent hunt & prevent brain drain, development of manpower for succession and change management.
- Introduction of impressive plan i.e. collaboration with the equipment supplies on joint risk and gain sharing basis to improve machine availability, full capacity utilization and ultimately reduced cost of production per tonne of coal.

- Carry out scientific study with geo-engineering approach for better understanding of supports requirements both in terms of design and standard of installation by conducting detailed study of rock quality design (RQD) of roof strata, determination of various physiomechanical studies/properties viz. density, compressive strength, tensile strength, shear strength, impact strength index, Protodyakonov, Young Modules and Slake Durability Index, RMR (Rool Mass Rating) presence of structural features, water seepage, dirt bands of shale & mud/clay, various stresses existing and likely to be induced during active coal extraction process to avoid roof/side fall accidents affecting safety and productivity in underground coal mines and slope stability in open cast mines by proper slope of pit.
- Upgradation of information system for transparency & controls at each stage of operation.
- Development in management techniques, planning process & skills of employees.
- Improvement of resource utilization, store procurement & asset management, waste management etc.
- Development of Business Plan, Operational Plan and introduction of 5-years Rolling Plan.
- Production programme and scheduling.

◆ **Other steps for achievement of High Performance/Productivity & safety by Mechanization:**

- Transport system plays a vital role in determining the production capacity of a mine and the overall cost of operations. Percentage availability and capacity utilization of transport system should be very high.
- Though the production capacity of mine, primarily depends on the availability of working faces, mining technology deployed; it can be constrained by transport, type of man riding system to reach work place & ventilation and uncomfortable working condition and poor work-life balance/organizational culture.
- The transport subsystem plays a major role in this connection. If its capacity is not adequate, the entire coal produced at the face cannot be transported in the stipulated time and the production capacity of the mine will be restricted. On the other hand, an efficient and adequate transport system can handle an increased production from the mine without any difficulty.

- Low production, mismatched mechanization, belt failure/light duty chain conveyor/track failure/breakdown due to improper maintenance, insufficient manpower for repairing, less number of working faces, no regular check/inspection, maintenance and non availability of spares etc. Hence **proper transport planning** is essential and remedial measures are required to increase the availability and capacity utilization of the system.

#### ❖ Causes of failure of Longwall Mechanization in the past in India:

As the limit of economical opencast coal mining is 200-300 mt.depth, the reserves of deep seated coal seams are to be exploited by underground method of mining. But by Bord & Pillar (conventional or semi-mechanization mining) the exponential jump in production is not possible. Secondly, in Bord & Pillar method in deeper coal seams, the size of coal pillar will be large and lot of coal will be blocked in pillars which is contradictory to the national policy of mineral conservation. Conventional support system will also not be suitable. Ventilation problem will be complex with heavy air leakage, difficult to maintain comfortable work place environment for work person. **So for concentrated bulk/mass production from deeper & thicker seams of coal of high quality Longwall Mining with complete mechanization is the only answer.**

Experience of abroad also confirm the above proposition. Using Longwall Technology, China produces 95% of its coal production; U.K. 100% of coal; Germany 100% of coal; USA 35% of total coal production and Australia 75% of its total coal production.

**Though the past experience of Longwall Mining in India is not so encouraging, the technology simply should not be blamed for this. Some reasons for failure identified are:**

1. **Lack of adequate geological information** – regarding coal seams and associated strata, their structure and strength that has led to wrong decision for selection of site for Longwall Mining and further in selection of right kind of equipment, depending on specific geomining condition.
2. **Selection of Equipment:** Procurement only done on bilateral agreement between two countries or as technical/financial aid from developed country to developing country. Sites have been selected later on

and efforts are desperately made to match the geo-mining condition forcefully which were unsuitable for equipment which is not logical.

3. Problem of spares i.e. imported and indigen.
4. Improper selection & **training** of human inputs.
5. Lack of infrastructure & over valuation of grade of coal during project report preparation.
6. Frequent changes in feasibility report or detailed project report.
7. **Improper planning** of coal transportation network/layout.
8. Lag in development of substitute longwall panel for continuous coal production.
9. **Information technology** – Best Longwall panels in world are fully automated with microprocessor based information system which is totally missing in India. Reporting & communication should be fast and precise to enable the operator to take quick decision. Proper reporting helps in **preventive maintenance** also.
10. **Work culture** – Military discipline and dedicated work culture or proper balance of work life culture was missing.
11. Approach towards mechanization half-heartedly i.e. **resistance to change.**
12. Policy failure to develop proper cadre scheme suitable for high mechanization.
13. Apathy in developing proper indigenous spares and equipment for gradual substitution of imported items.
14. Lack of R&D facilities, resulting in insufficient study of rock characteristics and load distribution design, leading to strata control problems in several faces.
15. Policy failure of not adopting mechanization for gradual but en-mass substitution of manual underground mining, but using it only in small patches, without giving proper importance, as a future perspective.

#### ❖ The technological innovation in coal mining which is foreseen is listed below for higher productivity and safety:

- Extended application of open cast mining.
- Extended application of longwall methods, particularly Automated Technology Mining (ATM) faces computerization.
- Increased level of mechanization, comfort working condition & ergonomics tool in machineries.
- Adoption of various techniques of thick seam mining developed abroad.
- Hydraulic mining

- Underground gassification of coal & liquification of coal & its alternative uses.
- Evolution of suitable techniques for the control of strata and subsidence, slope failures and for protection of environment & structures of heritage importance/public utility.
- Development of newer technologies, mechanization, automation, computerization for exploration, information technology, development and winning of coal and metallic ores.
- Increasing application of computer/software in mine planning and remote mining operations.
- Proper procedure, tools, techniques and instrumentation for surveying & determining the actual grade of coal to accurately evaluate techno-economically and feasibility of the proposed project to be opened and also for proper project planning before deciding to open the project which would ensure desired returns on investment throughout the life of project, ensure transparency in business, retain customers and ensure their complete satisfaction.
- Innovative methods of waste management, studies on petrol, diesel, oil, grease, explosive consumption, store management etc.
- Strategic planning to resolve issues arising due to economical, social, political, technological, land acquisition & revenue, industrial disputes, global business competitive market, financial, rehabilitation of villagers & environmental & ecological risks

#### **D) Automation, Computerization, Safety and Efficiency:**

Coal mining system can be made fully automated only when the whole operation is machine dependent, practically with no manpower. In India, though coal face operations are fully mechanized, but operations outbye of the face in the gate roads are considerably dependent on manual operations viz. Supporting gate roads, shifting of bridge stage loader and power pack, dismantling of rails, conveyor belt shortening which are very cumbersome and mostly depend only on labour and supervisors.

For the whole longwall system to give better productivity, it is essential to turn it out into full automatic process, by use of self-advancing 4-legged rectangular chocks installed skin to skin in gate road. It will be integrated system with face support and they will take care of front abutment pressure and will be set at sufficiently high setting load and working with weak roof condition will be easy. Stage loader will be eliminated and Side Discharge Armoured Face Conveyor will discharge

coal directly on gate belt conveyor. Lump breaker will be installed over AFC discharge end. Belt conveyor intake end will be on roller within the chocks; and power pack assembly will be accommodated over the basic frame within the chocks. Thus, the road which was presently required for the movement of power pack assembly may be eliminated from the main gate road. The power pack could be placed over the base frame of gallery chocks, which will move automatically with movement at the face with the gallery chocks. **Therefore, there is no necessity of manpower for attending movement of power pack upon rail and moreover for dismantling of rails for every advancement of the face.** The rail could be withdrawn at a time only at the beginning of face advancement. This will improve running speed of longwall face and coal extraction percentage.

The gallery chocks may be controlled from adjacent chock or remotely from master chock shield. Therefore the automatic control of whole support system gets easier. Thus by application of new system, 80% of manpower may be reduced from present requirement in Longwall gate road and complete automation may be possible with this type of method of extraction. Thus a Longwall panel may be moved safely and efficiently even under adverse conditions of incompetent roof in gate roads. The productivity will be increased significantly as the running time and efficiency of the whole package would be improved in many aspects. Reduction in manpower and with very little additional capital involvement, the overall economy by suggested system will be better. With this system, thus the overall efficiency of the longwall faces may be improved and coal extraction by longwall mining method may turn out to be more economic with increased safety at the gate roads. The economy resulting may be significant in terms of production, productivity, cost per tonne with safety.

**Proper selection of powered support plays an important role in any longwall installation.** Experience of the past longwall faces showed that the failures of any longwall face is mostly linked to improve selection of powered roof support.

So, the necessity for a new planning tool which can check before hand various possibilities of support behaviour during caving and periodic roof fall conditions is very much felt. While different countries might be following different norms for support selection, a ready planning tool is missing in Indian Coal Mining sector.



**A user friendly computer programme is ideal solution.** This will not only reduce the chances of failure but will also take care of the safety aspects of longwall installation, where fatal accident has also taken place. Since powered support cost almost half the longwall package, even damage to supports also can neither be absorbed in terms of money nor in terms of production loss. The computer programming **CLAPS** developed is expected to be an idea/solution for handling such situation. Thus software can handle various combinations of face length, depth, extraction height etc. Thus computer programme is expected to be quite helpful to planners as different combination of variable parameter of longwall installation. Help menu are provided to guide the user, with expected inbuilt ranges. Since longwall installation is capital intensive, the cost of the software will be negligible compared to installation cost; and being user friendly.

For Indian mines to make a move towards maximum mechanization, they should incorporate **Automated Computerised Equipment Monitoring Systems (ACEMS)** to make sure machines are properly maintained operated efficiently, improve percentage of availability and its capacity utilization are as per claim made of **Original Equipment Manufacturers (OEM)**, which will not only enhance consistently production and productivity, but also prevent safety related problems and mining accidents by way of application of reported solid state better technology i.e. Mechanization, Automation & Computerization working with the industry and equipment manufacturer to develop sensor technology to keep miners safer and improve productivity with attainment of **ZAP (Zero Accident Potential)**.

### **Conclusion:**

Thus there is deep correlation between Geology (i.e., economic, mining, structural geology and rock mechanics), selection of Mining Methodology. Mechanization, Automation and Computerization of mining operation to enhance Safety, Production and Productivity in Coal Mining Industry.

Similarly, relation between Economic Geology, selection of **Mining Methods, Mechanization, Automation and Metallurgy with Automation & Computerization** is however very close and somewhat overlapping. **Economic geologists** determines the location, extent, quality/grade and value of coal seams/mineral deposits i.e., ore and non metallic substances while **mining engineers** explore the methods to extract these deposits as safely, efficiently and economically as they can, coupled with mechanization and automation and computerization. **Economic geologist** can successfully co-operate with

mining engineers in predicting the probable difficulties likely to be encountered during mining operation and in solving unforeseen problem. **Metallurgists** are of help in convenient recovery of metal alloys from their ore or high grade coal which are in turn composed of useful as well as useless minerals by application of proper methods of beneficiation; and also in terms of coal mining enhancing the grade/quality of coal to ensure customer satisfaction by supplying them quality and quantity of coal timely as per the fuel supply agreement, thus reducing customer grievances and litigation matter and improve image of the organization in the competitive global market place.

**Coal plays an important role in Indian industrial revolution as well as in the growth of economy and will continue to remain a prime energy resource in the next century too.** This is the right time to analyse the strength and weakness of the industry and to give the right direction under liberalized & globalized economy, overcome, import of coal, poor productivity/performance, ensure optimum deployment of huge burden of manpower, revive huge number of uneconomically feasible old exhaustive mines and also Government policy/regulations to curb subsidy etc.

A balance between domestic coal production and import of coal is to be maintained, enhancement of the activity of exploration of new reserves of coal, maintaining balance between opencast and underground coal production and use of **mechanization, automation, information technology and computerization in a bigger way, is to be integrated in production system.**

Despite significant progress, many challenges still remain including developing sensors and better automation technologies to replace miners operating in hazardous condition, to isolate people from mining hazards and improve productivity.

A miner has to work in hostile and hazardous environment, which increases as mining operation go deeper and deeper into the earth. This causes more discomfort to the workmen which results in reduction in production, productivity and increases the risk to the life of work-person. Use of Automatically/Remote Controlled Machines/Robotic Mining System has a potential to turn mining operations into a completely manless activity or to minimize manpower requirement with more efficiency in hostile mine environments. **Automation would reduce risk, enhance safety, production and productivity even under arduous, hazardous, difficult and complex mining conditions. Energy of surplus work force could be engaged in other jobs for better labour productivity.**

Geological mapping for exploration, production, productivity and safety in coal mining industry compared to America & China has remained at lower level over considerable period of time even after good amount of investment. In order to meet the increased and consistent demand of coal in future, maintaining the environmental requirements, it has become necessary to explore and have a closer look at various aspects of mine planning and designing, mine layout, mine mechanization and transportation, automation of operations, provision of comfortable and safe working condition, better system of communication, risk and resources management, proper equipment deployment and its optimization, work culture skill/competency development and motivation of human resources & proper **work-life balance** to achieve objectives of the organization efficiently and economically.

**Mass Production Technology though successful worldwide could not be practical successfully in our country. We need to do introspection in recognizing the lacunae in existing mining practices.** A holistic approach, analysing the total system is required from geology of coal deposit to exploration, planning, selection of mining methods, selection & deployment of mining machineries, support system, training and skill development, strategy for change management and addition of new technology, ultra safe blasting techniques, ventilation, transportation of coal from mine coal face to market i.e., to esteemed customer, internal & external risk/resource management and improving upon the system & organizational culture along with time, automation and computerization. Further equipment optimization & implementation of **(RCM) Reliability Centred Maintenance** which is effective in optimizing the preventive maintenance and also in reducing the maintenance requirement, application of ERP software for cost reduction & waste management etc.

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