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Modernization of underground coal mine with mass production technology

1. Introduction:

The current trend in coal production in India shows that underground mining contributed less than 5% of the total coal produced whereas around 60% of this world coal production comes from underground mines and the remaining 40% from opencast mines. Where in China 99%, in South Africa 50%, in USA 36.5% and in Australia 20% of total coal production comes from underground mines respectively. However as per the CMPDIL Report, 70% of the country's coal reserves are amenable to be worked by underground methods and around 42% (138.32BT reserves) are proved Reserves below 300m depth which can only be mined through Underground Methods, still India's position is far behind comparative to other countries. On the other side, in India, the contribution of opencast mining to coal production is at its peak. According to the Indian Bureau of Mines, there were 455 operating coal mines in India, out of which 219 were opencast, and 213 were underground. The remaining 23 were mixed collieries. Even though the number of underground coal mines is proportionately equal to opencast coal mines, their production rates are nowhere on a comparable scale. This trend is not sustainable in the Indian scenario due to environmental issues, coal quality problems, and socio-economic stresses due to opencast mining. The solution lies in the modernization of underground coal mines by adoption of Mass Production Technology which can compete with opencast mining in terms of OMS and production rate. Furthermore, Coal India Limited (CIL) has also launched a mission to upscale the coal production from underground mines to 100 million tonnes by 2027–28.

2. Need to Modernize Underground Mines in India

2.1. Most of the underground mines in India are conventional and the resulting shortfall in production due to exhaustion/closure of opencast mine cannot be made up by conventional underground mining. Hence to maintain the productivity and fulfill the demand, modernization with introduction of Mass Production Technologies in underground mines on urgent basis as planning, execution and adaptation is the need of the hour.

2.2. Damaging environment, land, flora and fauna is another burning issue due to opencast mining and calls for an alternate option. Opencast mine disrupts the natural equilibrium of the surroundings. The surrounding habitat is disturbed on account of air pollution, dust and noises by the activities of opencast mine.

2.3. As the gestation period is generally more in the case of underground projects, hence we have to start our planning for Mass Production Technologies in underground mines well in advance.

2.4. The safety statistics of underground coal mines in India is not upto the mark and by modernizing the underground mines, the safety standards of the mine can be improved.

3. Conventional Mining

3.1. **Present Practice:**
The majority of Indian underground coal mines are still working with conventional mining. This process involves drilling and blasting technology for the extraction of coal and LHD/SDL for conveyance/transport of blasted coal, followed by the installation of supports. A rib-and-slice method is commonly practiced in conventional depillaring. A rib/snook is left against the goaf along with breaker-line support in openings at the goaf edge. Left-out rib/snook is judiciously reduced at the time of retreat to facilitate the caving of the roof strata.

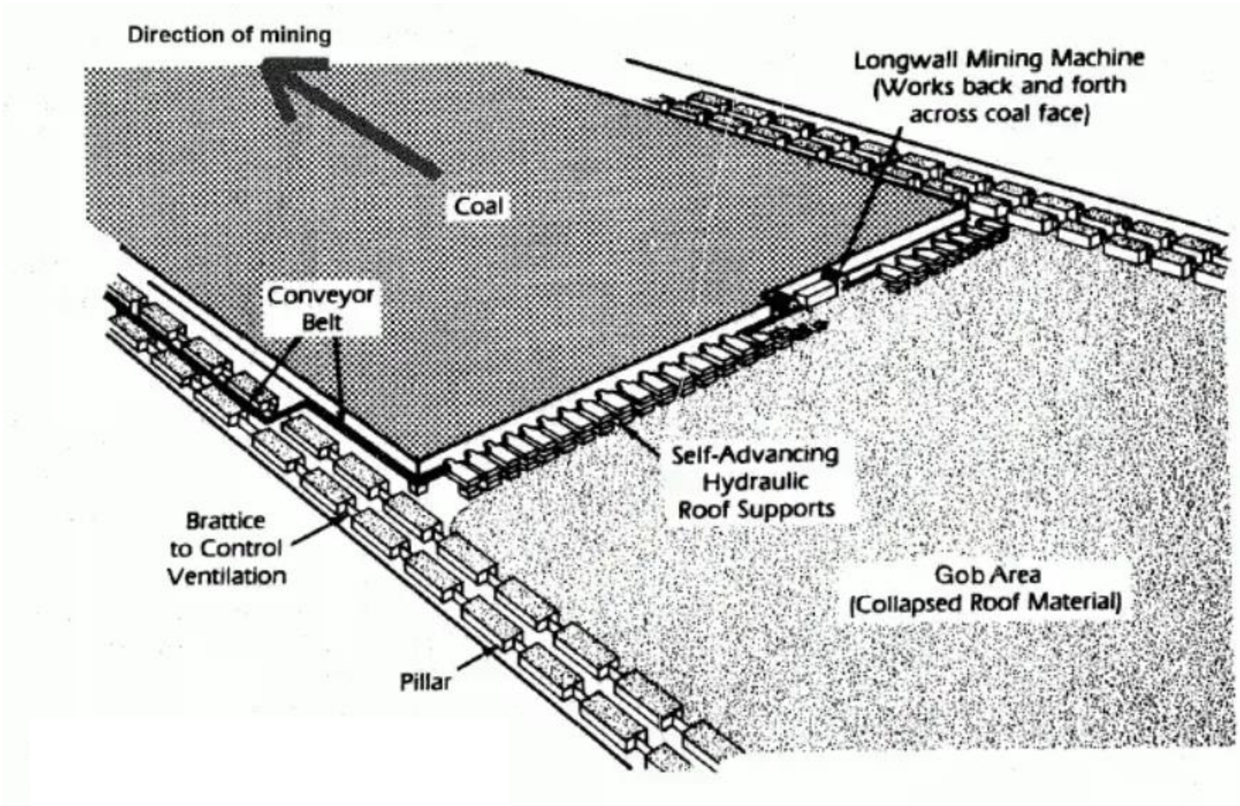
3.2. **Drawbacks of current approach**
The conventional underground mining gives very less productivity and most of the conventional mines are not economical. The OMS of such mines are very less and the operating cost are much higher. The rate of recovery in conventional mine is only upto 65% and the rest mineral is left which cannot be extracted in future resulting loss of national property. In terms of safety also the conventional mining approach is adverse. More than 90% of the UG incidences occur in conventional mines.

It is high time to modernize existing conventional mines by adopting mass production technology, such as Longwall Technology and Continuous Miner.

4. Longwall Technology

4.1. **History:**
First endeavor for mechanization with the introduction of longwall technology was in 1978, which was the deployment of Power Support Longwall (PSLW) technology in Moonidih, BCCL. After that, further attempts to deploy Longwall were made in several mines in BCCL, ECL, WCL, & SECL. The technology could not achieve its desired level of success. The collapse/damage of powered supports in SECL (Churcha West) & ECL (Kottadih), in the year 1990 and 1997, respectively, has set in sense of apprehension about its applicability and success in Indian coal mines.

4.2. **Overview:**
Longwall mining is a highly efficient underground coal extraction technique characterized by its use of a specialized shearer that traverses a designated area, known as the "longwall face." This face can extend for hundreds of meters, allowing for continuous coal removal. The process involves systematically removing coal along the face, creating a void behind the shearer. A crucial component of longwall mining is the longwall shield, a hydraulic support system that safeguards miners and equipment from the collapsing roof. As the shearer advances, these shields move forward, providing structural support to the excavated area.



4.3. **Major reasons for not achieving adequate success of longwall mining in India:**

a. No policy for introduction of mass production technology: Even after Nationalization there was not any firm policy of Government for Mass Production Technology. Hence no private/Govt. Company came forward to manufacture equipments for mass production.
b. Standardisation of longwall equipment: There was no standardisation of longwall equipment in India. Longwall equipments procured in India were having different specifications. As a result no indigenous manufacturers were motivated to manufacture small demand of Longwall spare parts. As the numbers of operating faces were less, suppliers were not able to provide either manufacturing facility or spare depot in India. Further Longwall equipments imported from abroad was not suitable for Indian hard coal.
c. Mismatching place of application: Longwall faces were introduced in extremely critical condition (viz. difficult geo-mining condition, steep & thin seams, Degree III gassiness, very high ambient temperature) and failed. These has caused misapprehension that the Technology is not suitable for Indian mining condition, in general.
d. Lack of infrastructure facility: Longwall equipment deployed in already running mines having insufficient infrastructure facilities to match the desired level of production.
e. Lack of advanced geo-technical studies and R&D facilities: In most of the cases insufficient geological information and geotechnical knowledge due to inadequate bore hole density (exploration) led to wrong planning including wrong selection of powered roof support, orientation of panels with respect to lateral stress direction.

Weak geological information, wrong interpretation of faults, thinning of seams, intrusion and variation of strength of immediate roof, poor knowledge of hydro-geology caused continuous water percolation in the strata which led to strata control problems in many incidents. The glaring example in this regard is failure of powered support at Churcha(SECL) and Khottadih(ECL). In both the cases the supports collapsed and failed to withstand the load exerted by super incumbent strata during periodic weighing due to underrated supports. These two incidents gave severe negative impacts to the programme of large scale introduction of longwall technology in other Indian mines.

4.4. Future prospect of success of Longwall Technology:

4.4.1. Pre-planning of site feasible for deployment of Longwall to be done and scientific study for various constraints should be done so that the earlier incidence of failure of Longwall is not repeated.

4.4.2. We should utilize the learnings from leading countries. Both China and India introduced Longwall almost at same time. But today China has not only gone far ahead from India in terms of the technology but also it has become world leader in Coal production. China has made tailor made equipment suitable to their geo-mining conditions. For this they first developed required skills for their manpower. They have given adequate importance to applied R&D for product design and quality improvement.

4.4.3. Indigenous manufactures to be encouraged to develop their technical expertise to produce equipments which are suitable to Indian geo-mining conditions at lesser cost. Further spare and maintenance issues will be resolved by this. Proper economic instrument like tax holding etc. may be thought of.

4.5. New Initiatives:

4.5.1. Indigenous Development of IoT Enabled Technology for Monitoring, Analysis and Interpretation of Longwall Shield Pressures for improving Safety and Productivity IIT, Kharagpur**,** CMPDI Ranchi at Jhanjra Area ECL. In this system the shield pressure of longwall support can be remotely monitored for enhancing the safety of deployed men and machinery.

4.5.2. One of the key activity of longwall operation is the shifting of power support. In this regard, mechanization can be introduced to ease out the process of shifting with more safer way.

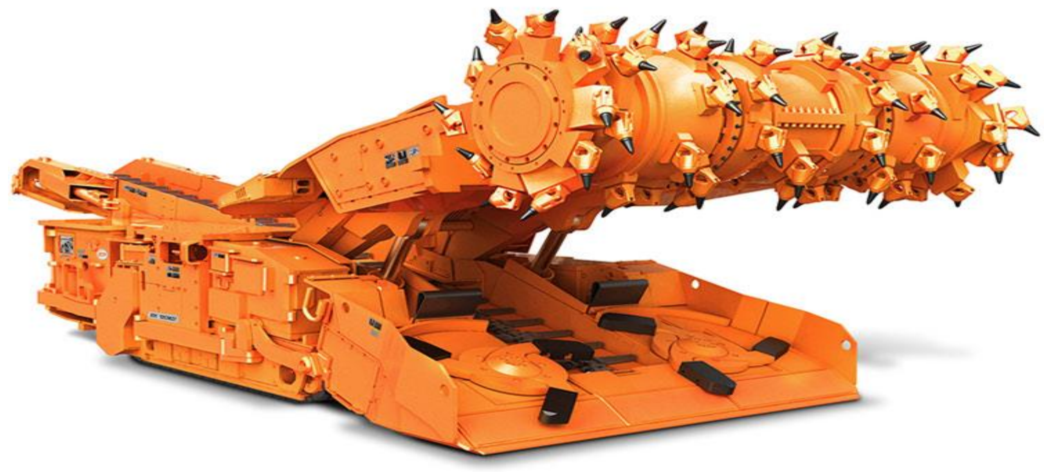
5. Continuous Miner:

5.1. History:

The first fully mechanised Bord and pillar system using continuous miner technology started its operation in 2002 at Chirimiri, Anjun hill mine at SECL. Since beginning the system has achieved over 40000 tons/ month during development and 50000 Tons/month during depillaring. After that continuous miner were deployed with success in many other mines of India. Today mechanised depillaring operations using continuous miner technology have been considered to be a success in India. Its success has paved way for its wide application in underground mines.

5.2. Overview

Continuous miner technology represents a significant advancement in underground mining, revolutionizing the extraction of coal and other valuable minerals. This method offers efficiency, safety, and increased production rates compared to traditional mining techniques. A continuous miner is a large machine with a rotating drum equipped with cutting bits. It can continuously extract material from the mining face, eliminating the need for intermittent drilling and blasting.



This not only enhances productivity but also reduces downtime associated with manual tasks. One of the key advantages of continuous miners is their ability to operate in confined spaces, making them suitable for narrow coal seams.

5.3. **Reasons of the success of CM technology in India:**

5.3.1. One of the major advantages of introduction of Continuous Miner is that it can be deployed in already developed galleries or any ongoing project. In recent practice many of the CM projects have been awarded in ongoing mines and are being operated successfully. In Sarpi Mines of Bankola Area and Khottadih Mine of Pandaveswar Area, ECL, CM has been deployed in already developed panels and such practice gives flexibility for modernizing or introducing mass production technology in ongoing mine.

5.3.2. CM can be deployed in challenging geological conditions which gives it flexibility to be deployed in indian mining condition.

5.3.3. Continuous miner can be operated in a wide range of coal seam thickness.

5.3.4. Continuous miner requires less capital as compared to Longwall technology.

5.3.5. Continuous Miner and its allied machineries are integrated with environmental monitoring system which favors it to be operated in gassy mines.

5.4. **New initiatives for Continuous Miner Technology:**

5.4.1. Continuous Miner may be integrated with backfilling technology (Continuous Miner with Active Fill Technology) which will ease out the problem of subsidence and consequences thereof.

5.4.2. The allied fast moving machineries like Shuttle Car may be integrated with ultrasonic systems which can alert the operator to avoid collision.

5.4.3. ADAS (Advanced Driver Assistance Systems) may be integrated with fast moving allied machineries to increase efficiency and safety.

6. Parallel aspects of Underground Mine modernization:

6.1. Underground mining and allied operations can be monitored remotely with the help of modern communication system. A breakthrough is required in the field of underground communication system. Two way video calling system from surface to underground is required to be established for ensure better productivity and safety.

6.2. SMART services and Maintenance management is required to be developed and adopted for early detection of maintenance requirements. This will not only ensure proper maintenance of the machineries but any untoward incidences in this regard can completely be avoided.

6.3. Environmental Tele Monitoring System can be adopted for avoiding incidences related to mine gases.

6.4. Underground transportation system for manpower can be adopted for utilizing the manpower efficiency. There are several transportation systems present viz. FSV, Chair Lift etc but very few mines are having it operational.

6.5. Underground coal transportation system requires a breakthrough. Installation, shifting and maintenance of belt conveyors are required to be modernized. Belt load detection technology is already available which provides data for abnormal load on belt motor and it also gives detail about probable point of concern. It is interlocked with the power connection of belt motor and disconnects the power supply when any abnormality is observed.

6.6. Underground workshop can be established for rectifying the major breakdown belowground. The major overhaul of CM, allied machineries along with longwall equipment may be performed belowground saving time and hence increasing productivity of the mine.

6.7. A system can be established for remotely accessing the strata condition by remotely displaying the strata instruments reading.

6.8. Nitrogen and CO2 plant can be established near the pit top of fiery coal mines for immediate fire fighting. One of such Nitrogen plant is established in Moonidih Colliery, BCCL.

7. Conclusion

The open cast mines are besieged with a number of environmental implications like land degradation, impact on flora & fauna, pollution of air and noise etc. Shallower deposits coal will last for only another 20-25 years. This calls for urgent development of underground mechanised coal mine for mass production in India. Adequate efforts in this line are required. Adequate thrust on R&D and skill development is prerequisite for this number of mechanised faces are to be planned so that indigenous manufactures are encouraged to produce equipment which are economic and services & spares issues which were bottleneck earlier will be resolved. In order to meet the objective of CIL for achieving 100 MT from underground coal mine by 2027-28, the existing mines need to be introduced with mass production technology. In future the ratio of coal production from UG mines and open cast mines of India should be matched with international standard which will ensure coal import independency of the country. The mechanized mines are not only highly producing but safer also and it requires minimal human resource engagement at the hazardous site.

As India continues to embrace technological advancements in its coal mining sector, the introduction of mass production technology reflects the commitment to enhancing both efficiency and safety. Balancing these improvements with environmental stewardship will be the key to establishing the robust and sustainable foundation for the future of underground coal mining in the country.