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UTILIZATION OF SURFACE MINER IN SURFACE MINING INDUSTRY

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ABSTRACT
Ruggedly-built Surface Miners are used for the extraction of a wide range of primary resources by cutting in open cast mines. Thanks to selective extraction, they achieve high degrees of material quality and enable optimal exploitation of mineral deposits. Surface miners made their debut in Indian surface mining industry in 1996 on a limestone deposit. The application of surface miner was extended for coal mining in the year 1999. Presently, more than 120 surface miners are working in Indian surface mines owing to its higher productivity and environment-friendliness. Presently, surface miner is also experimented for excavation of different deposits, namely, bauxite, hematite, sandstone, shale etc. Initially, the surface miners were being deployed largely on trial-and-error basis or on the basis of in-field experimental runs. Surface miner completely eliminates drilling blasting and primary crushing unit and thus reduces their associated environmental hazards. Apart from this, the sized excavated material increases the transport/conveying efficiency and thus saves the energy requirement in transportation. Application of surface miner with proper planning yields better efficiency. The planning can be categorized into two parts, namely, short term and long-term planning. Short term planning is within the control of field engineer and is carried out to achieve the steady production rate and quality control. Short term planning is carried out to select the operating mode, place of operation etc. Surface miner can allow a steep slope angle. As the blasting (short term stress) is eliminated the factor of safety for the pit slope can be kept low. This reduces the stripping ratio and increases the overall productivity of the mine. These are the essential consideration for long term planning with surface miner.

Keywords: Surface Miner, Open Cast Mining, Mine Planning, Environmental Hazards.

1 INTRODUCTION
Mining is a very capital-intensive industry, and it is well known fact that the equipment availability and precise estimation of its utilization are very important because mine managers want to utilize their equipment as effectively as possible to get an early return on their investments as well reducing total production cost. While a lot of thrust is put on the selection of mining equipment's not much consideration is paid towards the measurement of effectiveness of those equipment's. The increase in automation, compounded by the increase in the size and capacity of equipment over the years has drastically changed the consequences of equipment ineffectiveness. In the present economic conditions, severe global competition, challenges of environmental and safety considerations, in order to achieve high production and productivity of HEMMs in opencast mines, it is pertinent to have high % availability and % utilization of equipment's besides ensure overall equipment effectiveness vis-Avis established CMPDI norms/global bench marks. This necessitates performance assessment of various equipment's in highly mechanized OCPs, critically analysis the idle/down time of equipment's and take ameliorative measures to improve machine productivity and performance.

OEE is a tool which evaluate and indicates how effectively a production operation is utilized. Utilization of equipment's can be only be improved and maintained successfully if an appropriate performance measurement system is used. One should also try to identify unproductive time losses within the system as these time losses affect availability, performance and quality. The consequence of proper data collecting system to estimate equipment effectiveness is also emphasized.

In Indian surface mining industry, surface miners made their debut in 1996. Presently, around 105 surface miners are working in Indian coal and limestone mines. The surface miners are being deployed largely on trial-and-error

basis and the investors are interested in field experimental runs. The applicability of surface miners is evaluated by the manufacturers based on compressive strength of rock. In this context, it is logical to found a method to evaluate the performance of surface miners. The overall equipment effectiveness (OEE) of the surface miners has been determined to evaluate their performance.

In this project, an attempt has been made to analysis the performance of Surface miners deployed at two highly mechanized OCPs of Mahanadi Coalfields Limited (MCL).

2 SURFACE MINER BENEFITS IN THE MINING INDUSTRY

Mining plays a crucial role in meeting the needs for industrial development and growth. One of the mining techniques commonly used to support mining productivity is surface mining, employing a surface miner.

The government itself has provided guidelines for good mining practices to realize environmentally friendly and community-conscious mining,

Surface mining is a mining method performed on or near the earth's surface. This method is usually utilized for extracting minerals or materials found in open layers or deposits.

A surface miner is a type of mining equipment or machinery used to excavate and extract minerals or materials from the earth's surface. This machine is specifically designed to remove the top layer of soil or rock to access deposits underneath, commonly employed in open-pit mining operations where the volume of material to be extracted efficiently is substantial.

The surface miner uses a cutting method to excavate material. It is equipped with a cutting drum or cutting head fitted with specialized cutting tools such as teeth or discs. As the machine moves forward, the cutting tool rotates and cuts the material, effectively excavating it.

3 VARIOUS ADVANTAGES OF USING A SURFACE MINER INCLUDE:

Selective Mining:
Surface miners can perform selective mining, with the capability to extract specific layers or types of material without the need for blasting across the entire area. This allows for more precise and efficient mining, reducing waste and maximizing resource utilization.

Lower Environmental Impact:
Surface miners generate significantly less dust, noise, and vibration compared to drilling and blasting methods. This contributes to a lower environmental impact and improves working conditions for operators.

Improved Safety:
By eliminating the need for explosives, surface miners provide a safer working environment for mine workers. This reduces risks associated with blasting operations, such as flying rock fragments, ground vibrations, and hazardous gases.

Cost Savings:
Surface miners can save costs by reducing drilling and blasting expenses, required labour, and production downtime associated with blasting activities. Additionally, the ability for selective mining helps optimize production and minimize waste.

High Production Rates:
Surface miners are designed for high production rates, allowing for efficient excavation of larger volumes of material. These machines can operate continuously, providing a steady flow of material for processing.

However, it's important to note that the suitability of using a surface miner depends on various factors, including deposit type, material characteristics, and specific mining conditions. Proper planning, site evaluation, and

adequate operator training are crucial for the successful implementation of mining operations using surface miners.

4 TYPES OF SURFACE MINER

There are basically 3 types of surface miners that are available in market today, they are categorized basedon their design. Different types of Surface miners are:

- **Machines with middle drum configuration.**

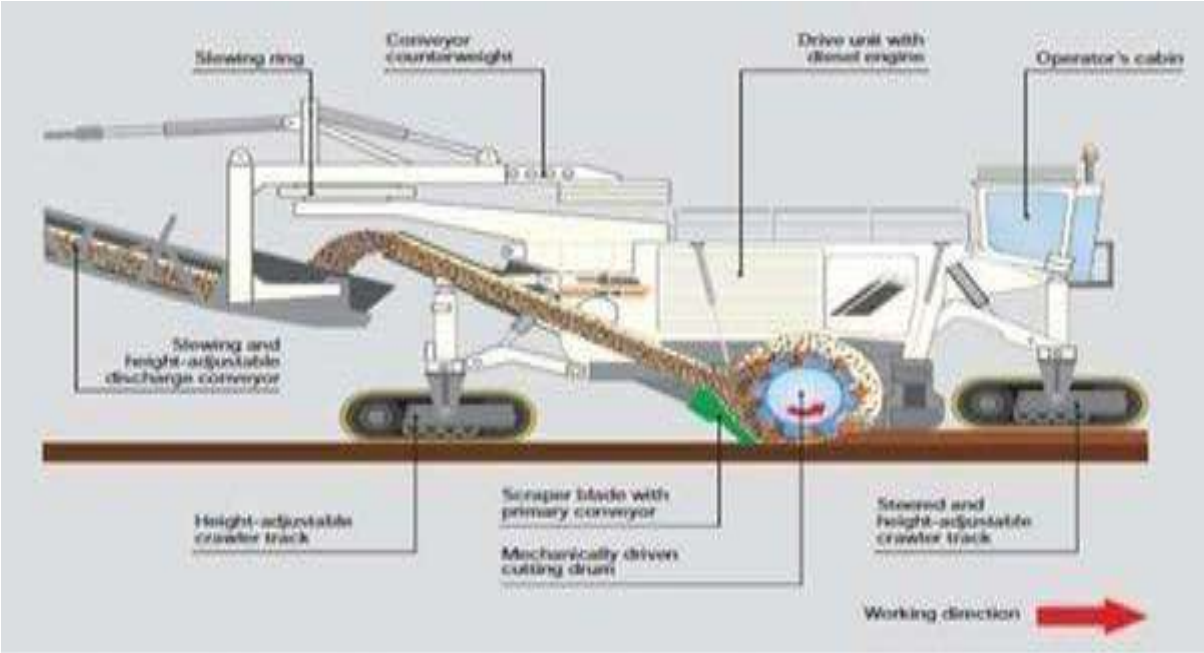

Figure 1 Machine with middle drum configuration (www.wirtgen.com)

These are the most commonly available surface miners in the market. Wirtgen, Bitelli, Huron and L&Tmachines belong to this group.

- **Machines with front boom cutting drum.**

Fig 2 Machines with front boom cutting drum.

- **Machines with front cutting whe**

5 SPECIFICATIONS OF SURFACE MINERS

Details specifications of Different types of surface miners are given in Table 1: Wirtgen (Model no. SM2100, SM 2200, SM 2500, SM 3700, SM 4200), L&T (Model no. KSM304 & KSM 223), Trencor 3000SM, Takraf [11] (Model no. MTS 180, MTS 300, MTS 500, MTS800, MTS1250, MTS2000), Bitelli (Model no. SF202 M), and Vermeer [13] (model no. T855, T955, T1055, T1225). Among these Wirtgen is the world's largest manufacturer of surface miners.

SURFACE MINER APPLICATIONS IN INDIA

In India, Surface miners were first introduced on trial bases at the lime stone mine of Gujarat Ambuja cements in 1994. Finally, in the year 1995 Wirtgen introduced surface mining technology in India in Gujarat Ambuja cements limited. In the same year Madras cements also deployed its first Wirtgen surface miner. Today, more than 16 surface miners are in operation in different limestone quarries of India. When it comes to coal mines, the first break through of surface miner (Wirtgen make – 2100SM) took place in 1999 at Lakhanpur opencast coal mines of Mahanadi Coalfields Limited (MCL), a subsidiary of Coal India Limited (CIL). A total of 47 surface miners (32 Wirtgen, 3 Bitelli, 12 L&T make) of different sizes and capacities have been deployed in different collieries of MCL, Central Coalfields Limited (CCL) and South Eastern Coalfields Limited (SECL) during 2010-2011.

Table 2 Surface miner details in Indian coal fields [8].

Coal Company	Project	Size(mm)	Make	Population	Coal productin(in Million Tonnes) Aunnum
CCL	Ashok	3800	Wirtgen	1	6.01
	Piparwar	2200	Wirtgen	5	6.01
SECL	Gevra & Dipka Expansion	3200	L&T	6	22.82 Gevra 11.72 Dipka
		3800	Wirtgen	5	
	Kusmunda	3200	L&T	2	4.71
MCL	Basundara(W)	3800	Wirtgen	10	51.47

	Samaleswari Belpahar				
		3000	L&T	4	
		2200	Wirtgen	3	
	Lakhanpur Hingula Ananta Bhubaneswari Bharatpur & Lingraj	2100	Wirtgen	8	
		2200	Bitelli	2	
			Bitelli	1	
Total				47	

Types of Loading

a) Conveyor loading

In this type of loading, the excavated material is directly loaded into the trucks or dumpers. This arrangement consists of a scrapper plate which helps in collecting the excavated material, primary and discharge conveyors which helps in transporting the excavated material and also a discharge boom thatcan slew in both directions and also the height of the boom can be adjusted according to the requirement.

Figure 3: Conveyor loading system (www.wirtgen.com)

This arrangement intrinsically involves loss of time which occurs due to the replacement of a filled-up dumper or truck with an empty one. So, the efficiency of this arrangement mainly depends on the numberof dumpers working, availability of space for the trucks or dumpers to have good manoeuvrability, andalso the positioning of the empty dumpers.

b) Windrowing

In this method, the material excavated is heaped behind the machine in a row. Later, this material is loadedinto dumpers by using different loading equipment like front end loader and scraper.

The overall efficiency is more for windrowing method because it is independent form truck loading. In addition, there is also no operating cost of the conveyor. Thus, it is the most productive mode of a surface miner.

Side casting

In this method, the discharge belt dumps the material on the side of the cut being made by the surface miner, shown in Figure 14. This dumped material is later loaded to dumpers/trucks with the help of loaders and taken away.

Figure 4 Side casting system (www.wirtgen.com)

OVERALL EQUIPMENT EFFECTIVENESS

Overall equipment effectiveness (OEE) is a simple tool developed by Seiichi Nakajima in the 1960's to measure the performance against the capability of the equipment. It takes into consideration the most common and important sources of productivity loss, which are called six big losses. These losses are quantified as availability, performance and quality. Most of the mining equipment involved mainly for production are either cutting/excavating or loading/transporting. So, for calculating the OEE of the mining equipment we have replaced here the quality rate with utilisation rate. So, for mining machinery,then OEE will be

$$OEE = Availability \times Performance\ rate \times Utilisation\ rate$$

Were

$$\text{Availability} = \frac{(\text{Total Available time}) - (\text{Total Downtime})}{\text{Total available or planned time}}$$

Total Available time refers to the total available shift/ planned time for production and downtime refers to any events that stop planned production for an appreciable length of time. It includes equipment failures, material shortages, Maintenance of equipment and changeover time.

$$\text{Performance rate} = \frac{\text{Actual output from a machine (when meet the required quality standard)}}{\text{Rated output (during the time machine is operating)}}$$

Performance rate is used for calculation of losses that arise due to the operation of the mining machine at reduced performance levels. The reason may be because of reduced machine speed or delay in cycle time and losses in operational efficiency resulting from the loss of optimum machine performance e.g. shovel bucket not taking full load, taking more loading time etc.

$$\text{Utilisation rate} = \frac{\text{Use or Worked time}}{\text{Total planned time}}$$

The above mentioned three efficiency measures along with six big losses and performance indicator are given in Table 2.5. The next step after the estimation of OEE is to compare it with the benchmark values. As a benchmark, if the OEE score is

- < 65% Unacceptable, require help now.
- 65-75% Passable only if quarterly trends are improving.
- >75% pretty good, but should not stand still. Drive to world class (80%).

Measurement of OEE is required for proper management the equipment. The advantage of using OEEas a measure is that it clearly identifies causes of losses in machine effectiveness, and allows the continuous monitoring of the most critical factors which influence machine performance. A little improvement on the OEE represents a significant contribution to mine productivity, profitability and capabilities.

6 METHODOLOGY

The methodology adopted in this project is as follows:

- ❖ In order to achieve the stated objectives, field survey and data collection was carried out in Lakhanpur opencast coal project and Samaleswari opencast coal project of Mahanadi CoalfieldsLimited.
- ❖ A record of working hours (WH), idle hour (IH), Maintenance hour (MH), Break down hour (BH) and Achieved production details on monthly and daily basis were collected from above mentioned mines.

a) Calculation of availability, utilization rate and performance rate by:

$$A = \frac{SSH - (BH + MH)}{SSH}$$

$$U = \frac{SSH - (BH + MH + ID)}{SSH}$$

$$Pr = \frac{Achieved\ production(Tons)}{Target\ production(Tons)}$$

Where, A is Availability, U is Utilisation rate, Pr is Performance rate, SSH is scheduled shift hour, MH is maintenance hour, BH is breakdown hour and ID is idle hour.

b) Calculation of OEE:

$$OEE = Availability(A) \times Performance\ rate(Pr) \times Utilisation\ rate(U)$$

For calculating OEE, A, U and Pr have been given the equal weights but when it comes to actual practice

in the field this may not be case. So, we assume weights as follows: availability: 0.2, utilisation: 0.7 and performance rate: 0.1 for calculating on daily basis and for calculating on monthly basis we assume weights as follows: availability: 0.3, utilisation: 0.5 and performance rate: 0.2. These weights have been taken after considering the relative importance of the above using Analytic Hierarchy process (AHP).

So, using the above we have

$$OEE(Daily\ basis) = (A^{0.2}) \times (Pr^{0.1}) \times (U^{0.7})$$

$$OEE(Monthly\ basis) = (A^{0.3}) \times (Pr^{0.2}) \times (U^{0.5})$$

c) Analysis of availability, utilization rate, performance rate, OEE, Idle hours, breakdown hours, achieved production is done with the help of graphs.

7 DISCUSSIONS

The following discussions are made on the performance of Surface miners deployed at Samalewari OCP and Lakhanpur OCP based on the field studies and analysis conducted.

7.1 Daily Basis

(a) Lakhanpur Opencast project

For surface miner SM-468(Rungta), the average %availability and %utilisation is observed to be 67.19% and 48.44% respectively. The average breakdown and idle hours are observed to be 3.85 and 4.5 respectively. The Theoretical and Estimated OEE are found to be 0.22 and 0.54 respectively.

For surface miner SM-625(Rungta), the average %availability and %utilisation is observed to be 48.78% and 37.15% respectively. The average breakdown and idle hours are observed to be 9.44 and 2.79 respectively. The Theoretical and Estimated OEE are found to be 0.089 and 0.40 respectively.

For surface miner SM-634(Rungta), the average %availability and %utilisation is observed to be 75.95% and 57.99% respectively. The average breakdown and idle hours are observed to be 1.125 and 4.31 respectively. The Theoretical and Estimated OEE are found to be 0.366 and 0.634 respectively.

For surface miner SM-336(Rungta), the average %availability and %utilisation is observed to be 57.99% and 42.45% respectively. The average breakdown and idle hours are observed to be 6.25 and 3.73 respectively. The Theoretical and Estimated OEE are found to be 0.15 and 0.47 respectively.

For surface miner SM-L&T-303(015), the average %availability and %utilisation is observed to be 69.33% and 38.99% respectively. The average breakdown and idle hours are observed to be 1.98 and 7.28 respectively. The Theoretical and Estimated OEE are found to be 0.15 and 0.45 respectively.

For surface miner SM-L&T-303(021), the average %availability and %utilisation is observed to be 77.88% and 48.32% respectively. The average breakdown and idle hours are observed to be 0.125 and 7.09 respectively. The Theoretical and Estimated OEE are found to be 0.3481 and 0.5672 respectively.

8 CONCLUSIONS

The performance of different operating models of surface miner deployed at Lakhanpur opencast project of Mahanadi Coalfields Limited (MCL) was analysed on daily and monthly basis.

The assessment is carried out by analysing the %availability, %utilisation and Overall Equipment Effectiveness (OEE) of the surface miner. Overall Equipment Effectiveness (OEE) is a simple tool developed to measure the performance against the capability of the equipment. It takes into consideration the most common and important sources of productivity loss, which are called six big losses. In this assessment, for calculating OEE, Availability (A), Utilisation rate (U) and Performance rate (Pr) are given different weights. These weights are taken after considering the relative importance of the above parameters using Analytic Hierarchy process (AHP).

The assumed weights are as follows: availability: 0.2, utilisation: 0.7 and performance rate: 0.1 for calculating on daily basis and for calculating on monthly basis we assume weights as follows: availability: 0.3, utilisation: 0.5 and performance rate: 0.2.

9 SCOPE FOR FUTURE STUDIES

In future, a software can be developed to calculate all these assessments in a nutshell. In addition to these we can also add financial assessment.

Artificial Neural Networks can be used to predict the future performance of the surface miner.

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