

PERFORMANCE ASSESSMENT OF SURFACE MINER IN INDIAN COAL MINES

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ABSTRACT

The increasing demand for coal in India has accelerated the adoption of advanced mining technologies. Surface miners are gaining importance as they eliminate drilling and blasting, reduce environmental impact, and enhance workplace safety. This study evaluates the performance of surface miners in Indian coal mines by analyzing key parameters such as machine availability, utilization, production efficiency, and overall equipment effectiveness (OEE). Field data from opencast mines was assessed to identify the impact of operating practices, geological conditions, and maintenance strategies on productivity. The results show that effective deployment of surface miners not only improves production but also lowers operational costs, reduces dust and vibration, and ensures better coal recovery. The findings provide useful insights for mine planners and policymakers to maximize the benefits of surface miner technology in Indian coal mining operations.

Keywords: Surface miner, Coal mining Production efficiency, Machine availability Environmental impact

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 equipments not much consideration is paid towards the measurement of effectiveness of those equipments. 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 equipments besides ensure overall equipment effectiveness vis-avis established CMPDI norms/global bench marks. This necessitates performance assessment of various equipments in highly mechanized OCPs, critically analyse the idle/down time of equipments 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 analyse the performance of Surface miners deployed at two highly mechanized OCPs of Mahanadi Coalfields Limited (MCL).

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With a critical mass of progress in regulatory reforms and soaring economic growth, the Indian Power Sector is now primed for take-off. How India deals with the remaining challenges of the restructuring process and emerging fuel shortages will dictate what happens in the years to come. India has set itself an ambitious target of more than doubling per-capita electricity consumption by 2011. India's coal demand is expected to grow 7% annually over the next decade. Much of this increased demand will come from power generation, which currently accounts for about 80% of total coal consumption. For a country that has relied heavily on domestic coal, the stresses of such a demand growth are already apparent. Over the last decade, coal imports have steadily risen at an annual rate of 12%. The expected coal demand by the terminal year of XIth Five Year Plan is only 650 MT. To meet this challenge, technology up-gradation, apart from opening new mines, is the need of the hour. Surface Miner technology has a huge potential of enhancing coal production from existing mines as well as new mines.

These factors have prompted the mining community to look for a non-conventional method and to increase "QUALITY PRODUCTION" and productivity while meeting the requirement of being environmentally safe operations. This was the back ground for the epoch-making introduction of 'Wirtgen Surface Miner' at Lakhanpur Opencast Project of Mahanadi Coalfields Limited, in Orissa for the first time in the history of coal mining Industry in India on 21st June, 1999.

2. OBJECTIVE

The objective of a surface miner is to extract primary resources like coal, gypsum, rock salt, phosphate, bauxite, or limestone from open-cast mines. Surface miners are designed to operate in tough conditions and are used for a variety of applications, including: to estimate % availability, % utilization and analyze idle hours of Surface Miners at and Samleswari OCP. To determine Overall Equipment Effectiveness (OEE) of Surface Miner at SOCP.

- **Mining:** Surface miners can extract primary resources with high purity and maximize the use of mineral deposits.
- **Safety:** Surface miners increase safety by eliminating the need to store and handle explosives, and by enhancing slope stability.
- **Efficiency:** Surface miners can reduce the time needed to close mines for blasting, which can delay production.
- **Environmental impact:** Surface miners can reduce environmental hazards by eliminating drilling, blasting, and primary crushing units.
- **Improved Material Quality:** Produce uniform material sizes, reducing the need for additional crushing and screening. two estimates % availability, % utilization and analyze idle hours of Surface Miners at Samleswari OCM. To determine Overall Equipment Effectiveness (OEE) of Surface Miner at sample.

3. PROJECT PROFILE OF THE MINES

The project profile of Samleswari Mines presents detailed information on mine capacity, coal reserves, extraction history, key operational parameters, etc., which are essential for effective mine planning and performance evaluation (Table 1).

Table 1 Project Profile of Samleswari Mines

S. No.	INFORMATION	DATA
1.	Mine Capacity	15 MT Coal
2.	Total balance Mineable Coal Reserve on 1.4.2025	54.33 MT
3.	Coal Extracted till 31.03.2025	103.48 MT
4.	Stripping ratio (Avg.)	2.65:1 cum /Te
5.	Gradient	1 in 17 to 1 in 19
6.	Avr Quarry Depth at north patch	120 M
7.	Avr Quarry Depth at south patch	80 M
8.	Project Area	1384.677 Ha.
9.	Excavated AREA	856.759 Ha.
10.	Lease Hold Area	1334.912 Ha.
11.	Average thickness of coal seam	22 M
12.	Average overburden thickness	70M-130M
13.	Quality of Coal grade	G14
14.	Main Customer	TNEB, KPCL, WBPDC, CESC
15.	Production 2024-25(Coal)	14.05 M T
16.	O.B. Removal 2024-25	24.07M.(Cu M.)

3. GENERAL DESCRIPTION OF SURFACE MINERS

A surface miner also called as continuous surface miner, is the technology in which extraction, crushing and loading of minerals is done in single pass. So, this technology, can be used as a substitute to conventional method of mining which involves drilling and blasting of minerals and rock deposits, if applicable. It also eliminates primary and secondary crushing.

3.1 Types of Surface miner

Surface miners are broadly classified based on their cutting drum configuration and positioning. The design of the cutting system determines the machine's suitability for different geological conditions, production capacity, and material handling efficiency. Three common types of surface miners are illustrated below: machines with a front cutting wheel, machines with a middle drum configuration, and machines with a front boom cutting drum (Figures 1–3).



Figure 1 Machines with front cutting wheel

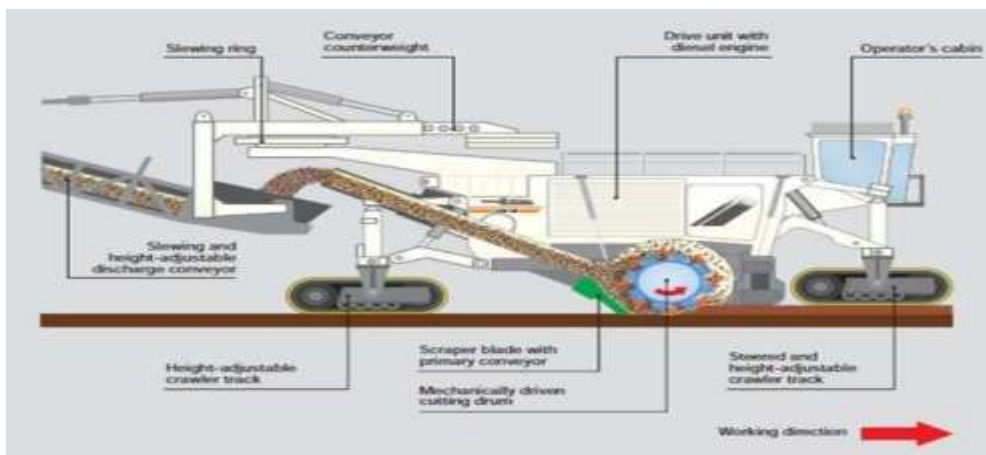


Figure 2 Machine with middle drum configuration



Figure 3 Machines with front boom cutting drum

3.2 Working Principle of Surface Miner (Wirtgen)

The surface miner is provided with a drum shaped cutting or milling head fitted with a number of tungsten carbide tipped replaceable picks extending across the full width of the machine in the form of a helix which facilitates propelling of the cut materials towards the centre of the machine. The cutting drum is located between the two sets of crawlers and is centrally positioned making the machine compact. The milling drum is mechanically driven by the direct drive system through V-belting directly via a mechanical clutch on the fly wheel side of the diesel engine. The milling drum holds cutting tool holders welded on the drum body and cutting tools are fixed on to these holders by clip.

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The milling drum operates in up-milling direction and cuts the material slice –by- slice on the floor of the bench. The cut materials are picked up by a tool and flight system centrally on the primary conveyor belt which during transportation further reduces the size of the material. The primary belt conveyor further transports the material to the secondary conveyor, which in turn loads the material finally onto the trucks or side casted in the mine. The cutting drum is followed by a scraper blade which gathers any material left on the floor. This ensures a clean and smooth floor without any undulations. Dust suppression is ensured by means of water spray 21 arranged on cutting drum, which also serves the dual purpose of cooling the picks, thus enhancing their usual life while leaving the working environment totally dust free.

The surface miner has two sets of crawlers; each individual crawler unit in front set has its own steering cylinder facilitating negotiation on the sharp turns. Each crawler unit and the cutting head can be raised or lowered by means of hydraulic cylinders provided for the purpose. The surface miner is equipped with an air –conditioned operator’s cabin, which has all machine controls within comfortable reach of the operator. The depth is adjusted by setting the number through electronically controlled depth regulator located at the side of the machine. The surface miner is also equipped with flood light for night operation.

3.2.1 Optimum working length:

The optimum working length differs very much depending on the travelling speed and hardness of the rock. In harder rock, where the travelling speed is low (e.g.5m/min), the optimum working length is approx. 250 m for 2100 SM. In soft material, where the travelling speed is high (e.g. 20m/min), the optimum working length is approx. 900 m and even more.

3.2.2 Machine Operation:

The machine is operated by an operator inside the cabin who is responsible for smooth operation and control of the machine. The operator in the cabin controls the speed, position of the belt conveyor for proper loading into the tippers. The machine normally loads on to tippers directly by slewing the belt conveyor. In case of failure of the mechanism of belt conveyor, the machine can produce coal by windrowing operation. In windrowing, the machine moves at a faster rate and cuts the slices and leaves behind conical section of cut coal which can be loaded by deploying pay-loaders on to the 22 tippers. The efficiency of machine improves in windrowing operation, so, in samleswari OCP coal is being loaded by pay loader into tippers/hywas after windrowing operation.

3.2.3 Continuous Process of Improvement: A continuous process of improvement for our customers’ benefit is one of the fundamental company philosophies cultivated by WIRTGEN – the market leader in surface mining. Increasing both the cutting performance and effective uptime is one of our main priorities in surface mining. Selectivity is additionally undergoing a continuous improvement process.



Figure 4 Surface Miner

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3.2.4 High Production Rates Using the Windrowing Process: Mining soft rock at maximum production rates and economic efficiency – the 2200 SM 3.8 surface miner has been developed to meet exactly these criteria for success. The centrepiece of the compact, yet powerful machine is the 3.8 m wide cutting drum which offers numerous innovative features. It cuts soft rock with unconfined compressive strengths of up to 35 MPa, such as coal or salt, in a highly productive process, depositing it in three windrows behind the machine.

3.2.5 Selective mining

One of the most important features of the Surface Miners is their ability to work selectively. Thin seams interspersed with intermediate rock layers can be cut precisely and economically, for example.

Mining companies throughout the world are exploiting the advantages of WIRTGEN Surface Miner technology with its extremely precise control of the cutting depth to extract high-quality mined material (ROM) in coal mines, limestone mines, bauxite mines, phosphate mines and gypsum mines.

Selective mining with Surface Miners ensures that thin seams of high-grade minerals and overburden can be mined separately.



Figure 5 Penganga OCM

3.2.6 Technical specification:

- **Cutting drum**
 1. Cutting width, max, 3,800 mm
 2. Cutting depth with conveyor system in windrowing mode *1 0 – 350 mm
 3. Number of cutting tools 100
 4. Drum diameter with tools 1,300 mm

- **Engine**
 1. Manufacturer Caterpillar
 2. Type C27 ATAAC
 3. Cooling water
 4. Number of cylinders 12
 5. Rated power at 2,100 r.p.m 708 kW / 950 HP / 963 PS
 6. Fuel consumption, full load 187 l / h
 7. Fuel consumption, 2/3 load 125 l / h
 8. Emission standards no EC regulation / US Tier 2

- **Electrical system**
 1. Electrical power supply 24 V
- **Tank capacities**
 1. Fuel tank 1,400 l
 2. Hydraulic fluid tank 550 l
 3. Water tank 5,000 l
- **Driving properties**
 1. Operating and travel speed 0 – 84 m / min (0 – 5 km / h)
 2. Theoretical gradeability 90%
 3. Max. longitudinal inclination of machine when operating at upward or downward slopes 25%
 4. Ground clearance 370 mm
- **Crawler units**
 1. Crawler units front and rear (L x W x H) 2,200 x 370 x 790 mm
- **Shipping dimensions**
 1. Machine without cutting drum assembly (L x W x H) 9,340 x 2,800 x 3,000 mm
 2. Upper part of operator's cabin (L x W x H) 2,550 x 3,300 x 1,500 mm
 3. Roll bar (L x W x H) 6,400 x 2,240 x 1,637 mm
 4. Cutting drum assembly 3,800 mm (L x W x H) 4,570 x 2,800 x 2,150 mm
 5. Technical specification
 6. *2 = Weight of machine with half-full water tank, half-full fuel tank, driver (75 kg) and on-board tools, excluding optional equipment
- **Weight of base machine**
 1. Empty weight of machine without filling media 50,350 kg
 2. Operating weight, CE *2 53,500 – 61,500 kg
- **Transport weights of individual components**
 1. Weight of upper part of operator's cabin 1,300 kg
 2. Weight of cutting drum assembly 3,800 mm 18,000 kg
 3. Weight of roll bar 1,450 kg
 4. Additional weight, front 4,700 kg
- **Weights of operating agents**
 1. Water tank filling in kg 5,000 kg
 2. Diesel tank filling in kg (0.83 kg / l) 1,160 kg
- **Driver and tools**
 1. Driver 75 kg
 2. On-board tools 30 kg
- **Optional additional equipment**
 1. Canopy 280 kg
 2. Fully enclosed operator's cabin 2,320 kg
 3. Low-temperature kit 1,130 kg
 4. Additional weight, rear 2,500 k

3.2.7 Specifications of Surface miners

Details specifications of Different types of surface miners are given in Table 2: 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.

Table 2 Specification of different surface miner models

	Parameters	Drum width (m)	Machine power (kW)	Operating weight (ton)	Rated capacity (m ³ /h)	Cutting depth (mm)	Maximum cutting speed (m/min)	Operating gradient (1 in x)
Wirtgen GmbH	SM 2100	2.0	448	41	550	250	25	6
	SM2200	2.2	671	49	668	350	84	6
	SM2500	2.5	783	100	845	600	25	7
	SM3500	3.5	895	137	1900	47	25	12
	SM4200	4.2	1194	184	2400	600	20	5
Vermeer	T855	2.5	281	40.8	NA	812	28	NA
	T955	3.4	309	56.7	NA	812	20	NA
	T1055	3.4	317	61.2	NA	812	16	NA
	T1255	3.7	447	99.8	NA	610	12	NA
L & T	KSM223	2.2	597	NA	NA	350	83	8
	KSM304	3.0	895	100	NA	400	20	5
TAKRAF GmbH	MTS180	3.3	500	NA	180	700	NA	NA
	MTS300	4.0	750	NA	300	875	NA	NA
	MTS500	4.9	1650	NA	500	1050	NA	NA
	MTS800	5.6	2000	NA	800	1225	NA	NA
	MTS1250	6.5	2500	NA	1250	1400	NA	NA
	MTS2000	7.4	2500	NA	2000	1575	NA	NA

4. OPERATING MODES

The surface miner can be operated in different ways based on the onsite requirements. The operating methods of surface miner are mainly categorised into three categories depending on the machine travel mode. They are:

a) Empty travel back method:

In this method, the surface miner cuts the material from one end of the pit then it moves back to the starting end. During the backward movement there will be no cutting of material, i.e., it travels back empty. After coming back to the starting point, the machine is adjusted for a new cut in adjacent strip as shown in the Figure 6.

This method is generally adopted in the mines having a less pit length, where the turning time is more than the empty travel back time. It is also applicable in case of bad pit-end condition where the machine is not able to turn there or when the pit width is not sufficient to allow the turning of machine at the end of a cut.

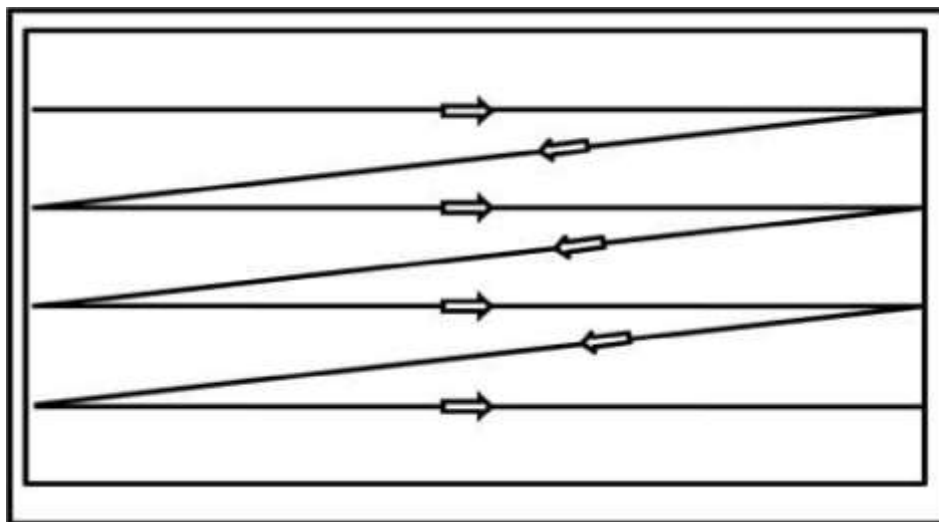


Figure 6 Empty travel back method

b) Turn back method:

In this method, the surface miner cuts from one end of the area and after completing the cut, the cutting drum is raised and the machine turns back, and set itself at the adjacent strip as shown in Figure 7.

This method is generally adopted in the mines having a field length of more than 200 m, so that the time consumption in turning is lesser than empty travel back time. This method is widely used in limestone mines as it gives more production.

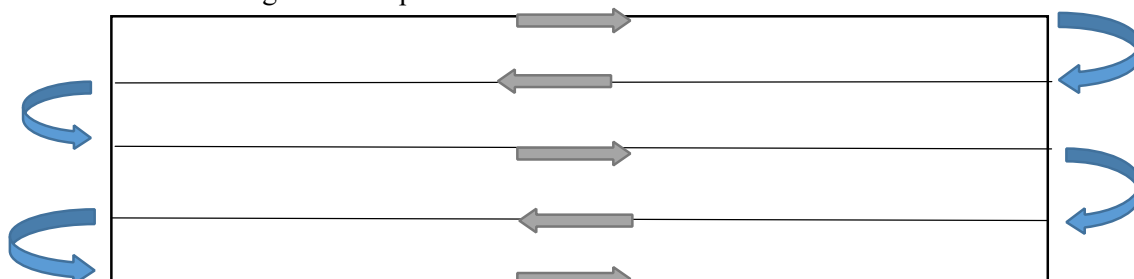


Figure 7 Turn back method

c) Continuous mining method

In this method, the Surface miner operates on an even field and continuously cuts the material. The machine moves with cutting the material and near the pit end, it turns with a gentle angle without raising the cutting drum, so that there is no discontinuity in cutting operation. The cut area gets an oval shape, as shown in the Figure 8.

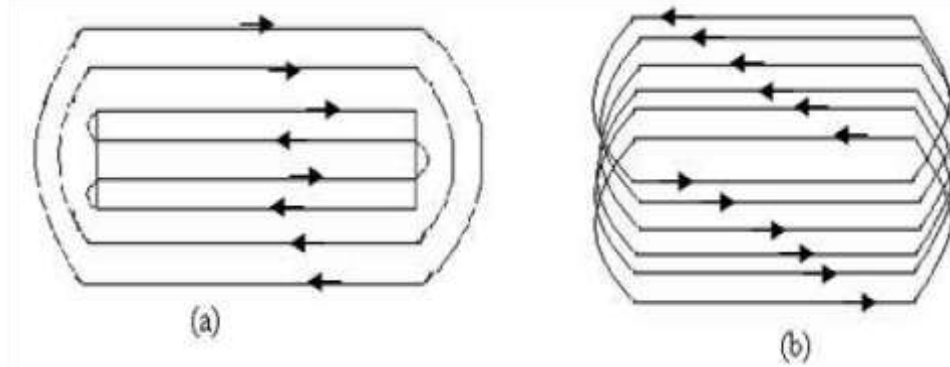


Figure 8 Continuous mining method

After it completes an elliptical movement, next adjacent cut is taken. This process continues till the elliptical turning gets a limiting angle. Then machine goes for turn back method.

4.1 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 that can slew in both directions and also the height of the boom can be adjusted according to the requirement (Figure 9).



Figure 9 Conveyor loading system

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 number of dumpers working, availability of space for the trucks or dumpers to have good manoeuvrability, and also 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 loaded into dumpers by using different loading equipment like front end loader and scraper (Figure 10).



Figure 10 Windrowing system

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.

c) 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 11. This dumped material is later loaded to dumpers/trucks with the help of loaders and taken away. In this method, the machine is free from disturbances caused due to loading.



Figure 11 Side casting sys

Table 3 Comparison of Surface Miner and Conventional System of Mining

Mining by surface miner	Conventional system of mining
No requirement of drilling, blasting and crushing	Requirement of drilling, blasting and crushing.
Mining is possible in close proximity of village, road and other permanent structure.	Mining is not possible due to restriction in blasting

No chance of spontaneous heating and fire.	Blasting produces crack in the coal bench which leads to spontaneous heating and fire.
Stability of bench and high wall is comparatively much better.	Stability of benches and high wall is comparatively poor due to induced stress caused by blasting.
It is an environmentally friendly method of mining	Drilling, blasting and crushing produces adverse effect on environment.
Selective mining is possible as a result quality of mined out coal is better.	Selective mining is not possible.
Thin seam mining is possible as a result nonworkable seam becomes workable.	Thin seam mining is not possible.
Less capital investment and infrastructure are required.	High capital investment and infrastructure is required.

4.3 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

$$OEE = Availability \times Performance\ rate \times Utilisation\ rate \dots\dots\dots(1)$$

$$Availability = \frac{(Total\ Available\ time) - (Total\ Downtime)}{Total\ available\ or\ planned\ time} \dots\dots\dots(2)$$

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.

$$Performance\ rate = \frac{Actual\ output\ from\ a\ machine\ (when\ meet\ the\ required\ quality\ standard)}{Rated\ output\ (during\ the\ time\ machine\ is\ operating)} \dots\dots\dots(3)$$

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.

$$Utilisation\ rate = \frac{Use\ or\ Worked\ time}{Total\ planned\ time} \dots\dots\dots(4)$$

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%).

4.4 Six big losses

In mining operations, the concept of Overall Equipment Effectiveness (OEE) is widely employed to evaluate productivity, wherein the six big losses are identified as the major factors contributing to equipment inefficiency. These losses are broadly classified into downtime, speed, and utilization categories, as summarized in Table 4.

Table 4: Six Big Losses and Their Corresponding OEE Categories

Six Big Loss Category	OEE Loss Category	OEE Factor
Unplanned shutdown losses	Downtime Losses	Availability (A)
Breakdown losses		
Setup and Adjustment		
Idling and Minor Stoppages	Speed Losses	Performance rate (P)
Reduced Speed		
Reduced Yield at start or process transition	Use Losses	Utilisation rate(U)
Idle Time		

4.5 DATA COLLECTION AND ANALYSIS

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 Penganga opencast project and Mungoli opencast project of Western Coalfields Limited.

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.

Calculation of availability, utilization rate and performance rate by:

$$A = \frac{SSH - (BH + MH)}{SSH} \dots\dots\dots(5)$$

$$U = \frac{SSH - (BH + MH + ID)}{SSH} \dots\dots\dots(6)$$

$$Pr = \frac{\text{Achieved production(Tons)}}{\text{Target production(Tons)}} \dots\dots\dots(7)$$

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.

Calculation of OEE:

$$OEE = \text{Availability}(A) \times \text{Performance rate}(Pr) \times \text{Utilisation rate}(U) \dots\dots\dots(8)$$

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 other above using Analytic Hierarchy process (AHP).

So, using the above we have

$$OEE(\text{Daily basis}) = (A^{0.2}) \times (Pr^{0.1}) \times (U^{0.7}) \dots\dots\dots(9)$$

$$OEE(\text{Monthly basis}) = (A^{0.3}) \times (Pr^{0.2}) \times (U^{0.5}) \dots\dots\dots(10)$$

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

Table 5 Daily performance of surface miners in Samleswari OCP

Date	S/T	W/H	M/H	I/H	B/D	Availability	Utilisation	Target Production(T)	Achieved Production(T)	Performance rate	Theoretical OEE	Estimated OEE
21/12/2024	24	7	5	12	0	79.17	29.17	15000	4906	32.71	0.0755	0.36
22/12/2024	24	15	5	4	0	79.17	62.5	15000	12264	81.76	0.4045	0.67
23/12/2024	24	15	4	5	0	83.33	62.5	15000	14260	95.07	0.4951	0.69
24/12/2024	24	17	4	3	0	83.33	70.83	15000	14282	95.21	0.5620	0.75
25/12/2024	24	8	4	4	8	50	33.33	15000	8065	53.77	0.0896	0.38
26/12/2024	24	12	3.5	6	2.5	75	50	15000	10601	7.67	0.2650	0.56
27/12/2024	24	3	0	0	21	12.50	12.5	15000	3001	20.01	0.0031	0.13
28/12/2024	24	6.5	2.5	3	12	39.58	27.08	15000	5070	33.80	0.0362	0.30
29/12/2024	24	13	5	6	0	79.17	54.17	15000	11588	77.25	0.3313	0.61
30/12/2024	24	7	4	5	8	50	29.17	15000	4901	32.67	0.0476	0.33
31/12/2024	24	12.5	4.5	7	0	81.25	52.08	15000	9705	64.7	0.2738	0.58
01/01/2025	24	12	2	1.5	8.5	56.25	50	15000	8796	58.64	0.1649	0.52
202/01/2025	24	14.5	5	4.5	0	79.17	60.42	15000	12270	811.8	0.3912	0.66
03/01/2025	24	14	5	5	0	79.17	58.33	15000	11018	73.45	0.3392	0.63
04/01/2025	24	11.5	6.5	6	0	72.92	47.92	15000	8799	58.66	0.2050	0.53
05/01/2025	24	14	4	6	0	83.33	58.33	15000	11330	75.53	0.3672	0.64
06/01/2025	24	13	6	5	0	75	54.17	15000	11779	78.53	0.3190	0.60
07/01/2025	24	14	6	4	0	75	58.33	15000	14508	96.72	0.4232	0.65
08/01/2025	24	12.5	5.5	6	0	77.08	52.08	15000	13485	89.90	0.3609	0.59

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09/01/2025	24	11	4	3	6	58.33	45.83	15000	10437	69.58	0.1860	0.50
10/01.2025	24	10.5	3.5	4	6	60.42	43.75	15000	9917	66.11	0.1748	0.49
11/01/2025	24	13.5	3.5	4	3	72.92	56.25	15000	13930	92.87	0.3809	0.62

12/01/2025	24	13.5	4	3	3.5	68.75	56.25	15000	13423	89.49	0.3461	0.61
13/01/2025	24	9	0	1	14	41.67	37.5	15000	9016	60.11	0.0939	0.40
Total	576	279	96.5	108	92.5	67.19	48.44	360000	247351	68.71	0.2236	0.54

S/T= Scheduled Time, M/H= Maintenance Hour, I/H= Idle Hour, B/H= Breakdown Hour, W/H= Working Hour,

4.6 Safety features

Surface miners are equipped with a range of advanced safety features that enhance operational reliability, protect equipment, and ensure operator well-being. Key safety provisions include:

- **Automatic Fire Detection and Suppression System (AFDSS):** Automatically detects and extinguishes fires, thereby minimizing equipment damage and safeguarding operator safety.
- **Rear-View Camera:** Enhances visibility in blind spots, reducing the likelihood of accidents involving other machinery or personnel.
- **Side Mirrors:** Provide additional visibility, allowing operators to effectively monitor their surroundings and prevent collisions during operations.
- **Hydraulic Brakes:** Ensure responsive and reliable braking, which is critical for both routine operations and emergency situations.
- **Real-Time Diagnostics:** Continuously monitors vital systems such as hydraulic pressure, engine performance, and fuel levels, enabling early detection of faults.
- **Automatic Shutoff:** Initiates machine shutdown under unsafe conditions, preventing accidents and equipment damage.
- **Eco-Friendly Mining:** Minimizes operator fatigue, contributes to sustainable practices, and reduces environmental impact.
- **Reduced Manpower Requirement:** Streamlines operations by lowering dependence on manual labor, thereby improving safety and efficiency.
- **Elimination of Blasting:** Removes the hazards associated with drilling and blasting, significantly improving workplace safety and environmental conditions.

5. Conclusions

Surface miners have emerged as one of the most widely adopted mining technologies in Indian surface mines. Their applicability largely depends on rockmass characteristics and machine parameters. The rockmass cuttability classification serves as a practical tool for determining the suitability of surface miners and also helps predict the expected production rate, which is crucial for assessing deployment feasibility. With proper planning, surface miner productivity can be enhanced by up to 30%. Therefore, it is strongly recommended that long-term planning be undertaken before deployment, and where necessary, different types of surface miners should be selected for varying rock conditions. In addition to productivity, the proven environmental benefits of surface miners must also be acknowledged, as they contribute significantly to indirect cost savings.

Recommendations:

It is recommended to expand the application of surface miners to other mining sites, focusing on adapting the technology to various geological conditions. Further research into enhancing wear resistance and cutting technology can improve durability and cost-efficiency.

In conclusion, the surface miner project has successfully demonstrated the potential of this technology to revolutionize mining operations, setting a benchmark for future projects and fostering sustainable mining practices.

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