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Reliability Assessment of Continuous Surface Miners - A Technology for Sustainable Growth of Indian Coal Industry

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Abstract:

The steep increase in demand of coal as a prime fuel has compelled Indian Government to keep challenging targets of 795MT in 12th plan and 1000MT by the end of this decade. The ambitious growth needs to be seen in its proper perspective. All the available options such as existing Coal PSU's and import avenues are needed to be evaluated in line with country's economy. The expensive and evasive approach will lead to a disaster which can put the country's prime mineral to jeopardy. The exploitation of opencast coal mines with due regards to conservation and quality is a need of the hour. The basic aim of mining fraternity should be of constant vigil and focus on the heat value generation for the country by using this crucial fuel resource. The focus on quantity production needs a paradigm shift towards quality production. The methods of opencast mining had a tendency to produce at a very quick pace which conventional shovel-dumper equipment system does not tending to sustain and the presence of inherent technologies put quality aspect in turmoil. The advent of Surface Miners in Indian coal mines led to proper handling of this precious resource as the multi dimensional activities are reduced to larger extent. This machine is a combination of various mining activities and has proved over a period that the technology is sustainable in Indian mining conditions and can lead to a definite growth in terms of tonnage as well as heat value of coal. At present around 110 Surface Miners are operating in India which is about 1/3rd of global population. The appropriate use of this technology will lead to sustainable growth if its reliability and productivity parameters are handled with due diligence.

Keywords: coal mines, continuous surface miners', production, optimization, reliability.

1.0 INTRODUCTION:

Coal is the mainstay of India's energy sector accounting for over 55% of primary commercial energy. This share will further increase to around 60% in coming years as per the planning commission. The gap between the demand and the domestic supply of coal has made it imperative to augment domestic production both from the public sector and the private sector. This has expedited the reform process for realizing efficiency gains through increased competition in the sector during the Twelfth plan. The initial years of 12th plan are likely to see continuing constraints on coal availability reflecting the difficulties experienced in increasing production in the last two years of production of the eleventh plan. Delays in obtaining Environment & Forest clearances, land acquisition and R & R issues continue to plague coal production and remedial action is urgently needed. There is urgent need to take effective measures to step up coal production. The Working Group on Coal in the most optimistic scenario has suggested domestic production for the Twelfth Plan period from various sources as shown in **Table 1.0** as given below:

Table No 1.0: Scenario of Domestic Coal Production

Sector	Eleventh Plan (2011-12)	Twelfth Plan (2016-17) Projection
CIL	435.84	615.00
SCCL	52.21	57.00
Captive Blocks	36.04	100.00
Others	15.91	23.00
Grand Total	**540.00**	**795.00**

*Source: Ministry of Coal, GOI.

The incremental production envisaged in the optimistic scenario of the Twelfth Plan works out to 255 MT over the production level of 540.00 MT during the Eleventh Plan. Major contribution has to come from the CIL, which is expected to add incremental production of 185.50 MT yielding a cumulative annual growth rate in coal production of 8 percent. This is much higher than the actual growth rate of 4.6 percent achieved in the Eleventh Plan. In Indian scenario the major contribution of coal production is from opencast mines amounting to almost 85% including all producing mines. The increase in efficiency of opencast mines is a major task for the entire coal sector in India. The Twelfth Plan gives thrust on improvement of operational efficiency of the coal mining companies by establishing benchmarks for different mining operations and work force productivity comparable with international standards. The productivity norms of different heavy earth moving machinery (HEMM) benchmarked earlier for both availability and utilization in different coal companies would be examined so that these become comparable with international standards. The current scenario in the country has exerted incredible pressure on Coal India Limited (CIL) and to fulfill this energy need, the

importance of Mega sized Opencast Coal Projects from where CIL could jack up the production have become areas of concern.

2.0 REVIEW OF SURFACE MINERS' ACROSS CIL:

The use of Surface Miners in subsidiaries of CIL can be traced back to 1999 when the first Surface Miner was deployed in IB Valley coalfields in Lakhanpur mines. Since then the production level has increased drastically with the deployment of the Surface Miner in various mines of subsidiary companies of CIL. The technology could easily adapt to the Indian coal mining conditions and had largely succeeded in giving a tremendous boost to coal production in CIL. At present in various subsidiaries of CIL, 63 no's of Surface Miners are deployed almost in all Mega Projects and the distribution as on 1st April 2014 is depicted in **Table 2.0:**

Table No 2.0: Subsidiary wise population and production statistics of Surface Miner

Mine/ Company	Dept. / Hired	Population as on 1st April 2014	Production						
			2013-14	2012-13	2011-12	2010-11	2009-10	2008-09	2007-08
Sonepur Bazari (ECL)	Hired	2	2.646	2.239	1.501	1.345	0.917	0.299	0.000
Ashoka (CCL)	Hired	3	5.807	5.813	5.408	6.013	5.480	5.582	5.108
Piparwar	Hired	1	2.701	2.801	2.609	2.764	1.434	2.183	2.329
Amlo	-	-	0.000	0.000	0.000	1.010	0.000	1.100	0.000
K.D.	-	-	0.000	0.000	0.000	0.000	0.000	0.000	0.682
Rajrappa	-	-	0.000	0.000	0.000	0.198	0.000	0.000	0.000
Pindra			0.000	0.000	0.000	0.385	0.000	0.000	0.000
Tarmi			0.000	0.000	0.000	0.167	0.000	0.000	0.000
Gevra(SECL)	Hired	8	33.880	31.425	25.216	22.877	21.977	21.333	8.979
Dipka	Hired	6	24.883	25.727	15.087	11.724	0.633	0.000	0.000
Kusmunda	Hired	4	12.966	12.446	12.153	4.712	0.000	0.000	0.000
Chhal	Hired	1	1.473	1.518	0.791	0.000	0.124	0.571	0.000
Baroud			0.000	0.000	0.000	0.000	0.000	0.005	0.000
Ananta(MCL)	D & H	4	5.684	6.716	6.148	7.060	5.496	4.832	4.793
Lingaraj	D & H	3	5.370	8.079	6.324	5.747	4.974	5.068	5.546
Hingula	D & H	1	3.547	3.103	3.931	4.646	7.690	6.100	7.661
Bel-pahar	D & H	4	5.620	4.772	2.663	4.999	4.747	3.870	3.036
Lakhanpur	D & H	7	14.974	14.809	14.152	13.280	12.300	10.123	8.761
Bhubneshwari	D & H	7	24.447	17.909	6.662	2.091	2.094	1.356	0.197
Bharatpur	Hired	1	3.330	4.155	5.352	5.507	6.204	5.140	4.059
Balaram	D & H	1	0.951	1.157	0.000	0.000	0.000	0.000	1.455
Sameleswari	D & H	4	7.813	8.218	8.357	9.914	5.800	6.580	5.070
Basundhara(W)	D & H	2	4.066	1.674	2.086	2.377	1.218	0.629	1.035
Kulda	D & H	1	4.982	2.558	0.939	0.000	0.000	0.503	0.000
Kaniha	Hired	2	4.526	0.682	0.337	0.015	0.000	0.000	0.000
Chendipada	Hired	1	0.269	0.000	0.000	0.000	0.000	0.000	0.000
Lajkura	Dept.	1	0.884	0.000	0.000	0.000	0.000	0.000	0.000
Total CIL (SM)	**D & H**	**63**	**170.819**	**155.801**	**119.716**	**106.111**	**81.088**	**75.274**	**58.711**
Prod. CIL			**462.422**	**452.211**	**435.838**	**431.320**	**431.260**	**379.459**	**360.913**
% Share			**36.94**	**34.45**	**27.47**	**24.60**	**18.80**	**19.84**	**16.27**

*Source: Ministry of Coal, GOI.

The above table shows the total share of all the Mega Opencast Mines of Coal India Limited. The percentage share of Surface Miner has increased to 36.94% of CIL target in the year2013-14. The importance of Surface Miner can well be

understood by the tonnage which these machines are handling in these years. The focus of this paper will be on Gevra Project of South Eastern Coalfields Limited which is now being planned for enhanced production which will have a huge impact on the growth of coal industry in days to come.

3.0 PERFORMANCE IN SECL:

The phenomenal rise in production can be largely attributed to the deployment of Surface Miners' in the Korba coalfields and further enhancement in present scenario of the country in respect of coal extraction can be achieved by using this surface miner technology. Over the years it can be seen that percentage of share of coal production in South Eastern Coalfields Limited (S.E.C.L), has increased up to almost 60 percent and is likely to increase in coming years. This trend of production from the technology under discussion is evident from The **Table 3.0** given below, showing details of production share held by Surface Miner operations in various mines of SECL.

Table No.3.0: YEARWISE SURFACE MINER COAL PRODUCTION OF S.E.C.L.

YEAR	TOTAL PRODUCTION	SURFACE MINER PRODUCTION						% OF TOTAL PRODUCTION (Fig. in Lakh Te.)
		GEVRA	DIPKA	KUSMUNDA	CHHAL	BAROUD	TOTAL	
2005-06	830.24	128.41	--	--	--	--	128.41	15.47
2006-07	885.02	149.79	--	--	--	--	149.79	16.93
2007-08	937.91	89.79	--	--	--	--	89.79	9.57
2008-09	1011.5	213.33	--	--	5.71	0.05	219.09	21.66
2009-10	1080.09	219.77	6.33	--	1.24	0	227.34	21.05
2010-11	1127.05	228.77	117.24	47.12	0	0	393.13	34.88
2011-12	1138.37	252.16	150.87	121.53	7.91	0	532.47	46.77
2012-13	1182.19	314.25	257.27	124.46	15.18	0	711.16	60.16
2013-14	1242.61	338.80	248.83	129.66	14.73	0	732.02	58.91
2014-15 (Upto SEP)	543.67	157.18	116.16	62.28	6.31	0	341.93	62.89
Total	**9978.65**	**2092.25**	**896.7**	**485.05**	**51.08**	**0.05**	**3525.13**	**35.33**

*****Source: South Eastern Coalfields Limited, Bilaspur.

3.1 Production Analysis of Surface Miners':

The detailed analysis of production statistics as shown in the **Tables 2.0 and 3.0** depicts presence of 63 surface miners' spanning across 27 opencast mines of CIL contributing to the extent of approx. 37% of CIL's production for the year ended 2013-14. Further for the SECL, the technology is found to contribute as high as approx. 60% during the same year. The surface miner technology is thus found to be proving its success year after year next to the shovel-dumper equipment system and is likely to continue to be a major source of contributor to the coal production in the coming decades.

4.0 RELIABILITY OF SURFACE MINERS':

The performance of Surface Miner in terms of reliability and productivity is of prime concern as is done with other technologies deployed in production of Indian coal mines. Due to hired deployment of Surface Miner, the issue of optimization of productivity and improving the reliability of these machines was not much looked after. Now with the advent of deploying departmental Surface Miners and surmounting pressure of coal production, this subject may become a cynosure for the practicing mining engineers. With this aspect as a focus some field observations are being made in respect of Surface Miner operations as they pertain to production and productivity. The objective is to make the machine most reliable and then extract the coal up to its optimum capacity. This shall be of immense importance as the prevailing stiff targets of coal extraction can only be overcome by deploying surface miners all around the mines of CIL wherever possible.

High equipment reliability is a choice and not an accident of fortune. To a great extent you can choose how long you want between equipment failures. You can deliver high equipment reliability by ensuring the chance of incidents that cause failures of equipment parts are low. The secret to remarkably

long and trouble free equipment lives is to keep parts and components at low stress, within good local environmental conditions, so there is little risk they are unable to handle their design duty. If there is nothing to cause a failure, the failure will not happen and your equipment continues in service at full capacity and full availability.

Reliability Calculations are methodology for analyzing the expected or actual reliability of a product, process or service, and identifying actions to reduce failures or mitigate their effect. Literature and review of studies conducted so far depicts that generally below listed methodologies are employed for reliability estimations:

- Stress Analysis
- Reliability Predictions (MTBF: Mean Time Between Failures)
- FMCA (Failures Mode and Effect Analysis)
- FMECA (Failures Mode Effects and Criticality Analysis)

The succeeding sections briefly outline the reliability analysis carried out for a particular Surface Miner Model 2200/3800 for one year period considering the various constraints imposed by the practicing industry.

4.1 Breakdown Analysis:

The detailed study of Breakdowns under various heads of a Surface Miner Model SM 2200/3800 for the period from July 2013 to June 2014 is given below. They are classified as Mechanical and Electrical Breakdowns.

Table 4.0: Breakdown Details of Surface Miner Model SM 2200/3800

Sl. No.	Description of Mechanical Breakdowns	Percentage of Total hrs (%)
1	Steering Cylinder Leakage	4.10
2	Lifting Cylinder Leakage	5.01
3	Grease Banjo Bolt Damage	1.59
4	Chain drawn out due to steps and other reasons	2.24
5	Cracking of Idler at the corner	5.56
6	Milling drum shaft damage	2.38
7	Coupling crack due to high temperature and torque	3.85
8	Track gear box leakage or bolt damage	1.67
9	Advance drive pump failure	5.16
10	P.T.O Coupling failure	4.83
11	Fan pump failure	1.73
12	Shoe plate damage	2.65
13	Splitting of Shear coupling	1.37
Description of Electrical Breakdowns		
14	Emergency System is not functioning	2.16
15	Alternator not charging	2.85
16	Milling drum rotation blockage	1.32
17	V- Belt tension is not working	1.82
18	Main control panel not functioning	4.32
19	Engine temperature is too high	10.93
20	Height adjustment cylinder not working	3.30
21	Rear side both steering not working	3.74
22	Water sprinkler unit not functioning	4.83
23	Hydraulic temperature too high	2.62
24	Clutch is not rotating	2.21
25	Lighting system not working	3.88
26	Engine starting problem	7.62
27	Air Conditioning unit not functioning	4.77

As can be observed from the data given above, the major breakdowns in Surface Miner are attributed to high engine temperatures, hydraulic Cylinder leakages, idler cracking, drive pump failures, coupling failures, main control panel, water sprinklers, lighting, engine firing and air-conditioning unit.

The Table 5.0 given below shows the breakdown hours, maintenance hours, idle hours and working hours in percentage for the Surface Miner Model SM 2200/3800

Table No 5.0: Classification Total Available Hours in Percentage

Sr No	Hourly Classification	Percentage (%)
1	Breakdown Hours	23.28
2	Maintenance Hours	8.35
3	Idle Hours	5.42
4	Working Hours	62.95

The breakdown hours, maintenance hours, idle hours and working hours in percent for the Surface Miner Model SM 2200/3800 indicates that the breakdown hours are a significant but then the idle hours is less as compared to the breakdown hours.

4.2 Reliability Analysis:

The Tables 4.0 and 5.0 given above briefly shows details of breakdown under various heads in respect of Surface Miner followed by analysis of total available hours. The reliability analysis is being done based on probability. Here the probability of failure P(F) is being calculated, the overall probability of failure for Surface Miner under consideration comes out to 0.22945. The Reliability of Surface Miner after probability estimates is coming out to be 0.77055.

Table 6.0: Reliability Analysis of Surface Miner Model SM 2200/3800

Sl. No.	Description of Mechanical Breakdowns	P(Failure)	%P(F)
1	Steering Cylinder Leakage	0.009535	0.9535
2	Lifting Cylinder Leakage	0.011676	1.1676
3	Grease Banjo Bolt Damaged	0.003697	0.3697
4	Chain drawn out due to steps and other reasons	0.005208	0.5208
5	Idler crack at the corner	0.012935	1.2935
6	Milling drum shaft damaged	0.005529	0.5529
7	Coupling crack due to high temp & torque	0.008963	0.8963
8	Track gear box leakage or bolt damaged	0.003892	0.3892
9	Advance drive pump failure	0.012019	1.2019
10	P.T.O Coupling failure	0.011252	1.1252
11	Fan pump failure	0.004041	0.4041
12	Shoe plate damage	0.006181	0.6181
13	Shear coupling split	0.003205	0.3205
Description of Electrical Breakdowns			
14	Emergency System is not working	0.005037	0.5037
15	Alternator not charging	0.006639	0.6639
16	Milling drum does not rotate	0.003091	0.3091
17	V- Belt tension is not working	0.004235	0.4235
18	Main control panel not working	0.010073	1.0073
19	Engine temperature is too high	0.025446	2.5446
20	Height adjustment cylinder not working	0.007704	0.7704
21	Rear side both steering not working	0.0087	0.87
22	Water sprinkler unit not working	0.011252	1.1252
23	Hydraulic temperature too high	0.006101	0.6101
24	Clutch is not rotating	0.005151	0.5151
25	Lighting system not working	0.009043	0.9043
26	Engine starting problem	0.017743	1.7743
27	Air Conditioning unit not working	0.011103	1.1103
Total/Overall Probability(Failure)		0.22945	
Reliability of Surface Miner SM2200/3800		0.77055	

5.0 CONCLUSIONS AND RECOMMENDATIONS:

Surface miner, a continuous mining machine, is getting popular in India owing to enhanced demand of production from coal mining industry. Selective mining without drilling and blasting, high production and small size products are some of the prominent attractive features obtained with these moving marvels. Using surface miner technology, high production targets can be achieved coupled with higher rate of recovery.

The surface miner is observed to have provided level-headed working capability at approx. 63% with breakdowns standing not much significant at 23%. The machine is expected to give good production rates if we can increase working hours by reducing breakdown and idle hours. This technology promises greater safety and its proper utilization can yield greater production. The reliability analysis depicted that the machine is reliable about 77% where as chances of failure is 23%. This indicates that there is a strong need to ensure operational reliability.

The following are the recommendations for the effective utilization of the surface miner:

1. Operational reliability can be improvised by planning activities like "campaign" strategy, whereby a "mini-shutdowns" are programmed at regular intervals to perform all necessary maintenance and inspections.
2. On line machine diagnostics and down time minimizing techniques can enhance reliability of the machine.
3. Immediate action to be taken for frequently impacting breakdowns.
4. Proper scientific layout, face availability can help reduce idle/waiting time to a great extent.
5. Proper management of time for all the cycle operations.

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