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GEO- Mining Based Reliability Assessment of Continuous Surface Miners–A Critical Review

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Abstract -At present the demand of coal is more than 1000MT in spite of more focus by Govt. on solar and other non conventional source of energy. The new perspective requires systematic operational planning and strict operational control of capital intensive machine. The proactive approach of equipment reliability assessment will be beneficial for surface coal mines. The quantitivly production paradigm is now shifting towards qualitatively. The conventional methods of coal extraction in surface mining does not sustained with qualitative aspect. The application of Surface Miners minimizes the mining activities up to a limited extent. Due to wide application and adoptability in surface coal mining, it shows that Surface miner is a proved technology can beneficial in different aspects. if its reliability and productivity parameters are handled with due diligence. The surface miner equipment handled the required gigantic and qualitative coal target. This technology is used as hallmark for selective mining. At present, Out of 422 Approximately 150 Surface Miners of different make and capacity are operated in India at different sectors. Appropriate use of technology fulfills techno-safe, economical and quality requirements along with avoidance strategy of blasting and crushing. Ability of surface miner to operate and cut coal effectively is limited to strength of coal. Update knowledge of coal characteristics and machine interactions utmost necessary for gigantic production and smooth operation. For best utilization of this technology, it is required to predict surface miner reliabilities on basis of geo mining parameter. *GEVRA OCP is world's third highest coal* producing mine, the yearly production target is 45 MT and subsequently increases up to 70 MT in next three years. Eleven numbers of surface miners are used as a part of systematic method of coal production along with Pay-loader & surface trucks. The Overburden handling uses Shovel-Dumper combination. Reliability assessment and evaluation of surface miner by Weibull analysis is detailed in this paper. Break down details of sub parts & whole of surface miner in three years is used in this study. Output element of this study is line fit plot & probability of failure of different subparts. Performance of the Surface miner are assessed through comparative evaluation of line fit plot & geo mining parameters. Probability of failure is helpful to design proactive maintenance strategy in advance. Due to compatibility & adoptability in production growth, there may be future scope of application in different mines so the reliability analyses of these equipments are to be studied.

Key Words: Reliability, Weibull Analysis, Reliability Evaluation, Reliability Assessment, Surface miner.

1. INTRODUCTION

India's two-third commercial energy mainly comes from coal and will be increased in subsequent years. The difference between demand and supply needs to cope up through reforming the process of coal production and technology adopted. There are various reasons related to government strategies, which hinder the coal production and appropriate measures required to boost up coal production. Opencast mines share almost four-fifth of total coal production in India so boost up the opencast mines production is a prime target for coal Industry. Govt. strategies also enforce to improve efficiency of the coal sectors in level of international standards. The output norms of capital intensive machines reviewed and become comparable with international levels. Incredible pressure on Coal Company wants boost up the opencast production have become thrust areas. Reliability related with better utilizations of human resource and capital investment. Better equipment reliability is a choice and reliability analysis at initial operational stage is essential to verify the reliability of the same equipment for further deployment Reliability analysis of mining equipment is helpful to estimate the failure patterns. In this study the sub-parts of Surface miner is integrated to evaluate the actual equipment reliability. A case study of surface miners presented in this paper to evaluate reliability as an early operating reliability.

1.1 Glimpses of Gevra Opencast Mine

The coal block of the project consist thick coal bench and strike direction is NW-SE to E-W in major part of the block. The average stripping ratio in this OCP is 1.3 along with thickness range 117 -174 m and seam gradient is 40 to 90 Surface miners are used for coal production, the slope angle of coal bench is of 600 to 750. Mainly 42 cum shovel- 240 Te dumper combinations with large diametric deep hole drills of 20 meters depth and 381 mm diameter are used for OB handling. The slope angle

of coal bench is of 600 to 750. In the year 2019 the coal and OB production targets 45 million tons and 58 million cubic meters respectively. It is expected to be the slated at a production target of 70 million tons in forthcoming years. To meet the gigantic target, A number of high capacity capital intensive mining machineries used that needs to reliable. Reliability is a performance indicator of overall equipment condition.

1.2 Technical description of Surface Miner under study

The quality production management in opencast mine due to layers of shale, & stone bands has become a difficult task. The application of Surface Miners was extended for coal mining in the year 1999. The design concept for the surface miner is based on the milling principal. Deployment of the Surface Miner technology largely succeeded and to increase the quality coal production along with minimizing terminal effect of mining. At present in every mega project of Coal India, maximum coal production is obtained by this technology. The technology is not only contributed as mass production technology but also produce appropriate size of fragmentation that is the emergent need of today. In Gevra OCP there are 12 numbers of surface miners for coal production which are of different make but Wirtgen Surface Miner 2200 SM was considered in this study. The technical specifications are been mentioned below:

Table 1- Technical & Operating Parameters of SM

Working width`	2.20 m
Max. cutting depth	0.35 m
Engine power	811 PS
Weight	51 t
Cutting drum drive	Mechanical
Number of crawlers	4
Travel drive	Hydraulic
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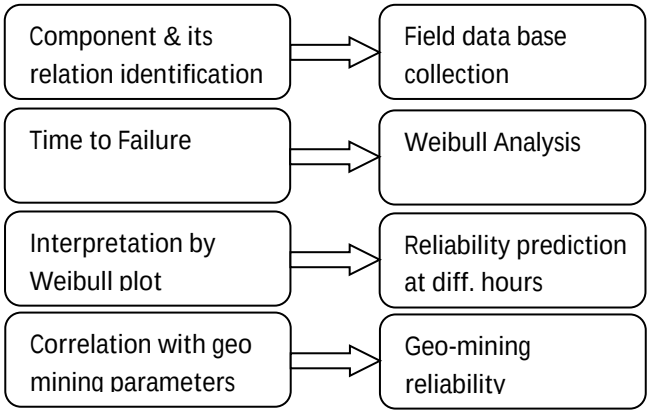
Max. cutting depth	0.35 m
Engine power	811 PS
Weight	51 t
Cutting drum drive	Mechanical
Number of crawlers	4
Travel drive	Hydraulic

Figure- 1: Overview of Surface Miner

2. RELIABILITY OF SURFACE MINERS'

Productivity is major concern even in hired Surface Miner or departmental surface miner. The evaluation & prediction of reliability of surface miner was considered the geo-mining parameter of coal. With this emergent issue some field observations and data study are being carried out with respect to operation of Surface Miner taken under study. The study of failure pattern is immense importance as the prevailing stiff targets of coal overcome by maintaining High equipment reliability, which may come from providing good operational environmental conditions. The classification of miners as milling type, bucket wheel type and ranging-shearer-drum type on basis of cutting drum, choice is decided on the required capacity and geo mining parameter of cutting strata. The evaluation of reliability of Surface miner is been studied in this paper and the methodology of the same is been developed. Mainly the methodologies applied for reliability estimations are Stress Analysis, Reliability Predictions (MTBF: Mean Time Between Failures), FMCA (Failures Mode and Effect Analysis) & FMECA (Failures Mode Effects and Criticality Analysis).The flow chart reliability evaluation of 2200 SM through Weibull analysis. The breakdown data of the machine has been acquired from the daily record data base of the component. From the OEM specifications and manuals, the specific life of the major assemblies and its sub-assemblies can be acquired. From the obtained results the probability of occurrence of error in data selecting for components failure, uncertainty is evaluated. Even a minor failure of the selected components leads to system failure and system operation breakdown and this is the case study of this research.

Figure -2: Flow chart of study work



Operating failure data collected from routine day wise data base. Intercalation pebbles & shale-sandstone bands other adversely impact on machine health. Reliability aspects of the equipment play important role for forecast of sub parts failure .On the basis of reliability forecast appropriate pro active maintenance scheduled and minimize the cost. The 2200 SM surface miner is selected for this study. Weibull analysis is used for a method for reliability evaluation. The Weibull formula for two parameter distribution is

$$R(x) = e^{(-(x/\alpha)^{\beta})} \quad ; \text{for } x>0$$

Where "β" is the shape parameter,
"α" is the characteristics life
"x" is the time to failure.

The Bernard's approximation formula for calculating Median rank is

$$F(t) = (i-0.3)/(n+0.4)$$

Where "i" is the corresponding rank of the data
"n" is the total number of samples

Weibull Analysis is beneficial in ascertain the failure probability; the output of this analysis is easier line fit plots. The two defining parameters of the Weibull line are the shape parameter β, and the characteristic life α. The Weibull distribution's easily approximate an exponential, a normal or a skewed distribution in Excel and not required more upgraded software.

3. DATA ANALYSIS

In this case study, the Average compressive strength, Tensile strength, Shear strength & Average density of three consecutive years has been collected from borehole logs and correlated with machine reliability. The geo mining parameter of the coal for the selected years is computed separately and is depicted in the Table given below. 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 given below shows the coal production from surface miner, breakdown hours, maintenance hours, idle hours and working hours in percentage for the Surface Miner Model SM 2200/3800

Table 3- Geo mining matrix

Year	Avg Compressive strength	Avg Tensile strength	Avg shear strength	Avg density
2013-14	8.50642857	0.626428571	1.519285714	1.527142857
2014-15	17.3117949	0.506410256	1.203846154	1.444102564
2015-16	15.8763895	0.739216152	0.948764846	1.527102138

Table 4- Year wise production and breakdown details

Year	Production	Breakdown hour
2013-14	3842800	2200.5
2014-15	3867600	2168.5
2015-16	3873200	2173

4. OUTPUT OF WEIBULL ANALYSIS

Figure -3: Year – 1 Overall Breakdown

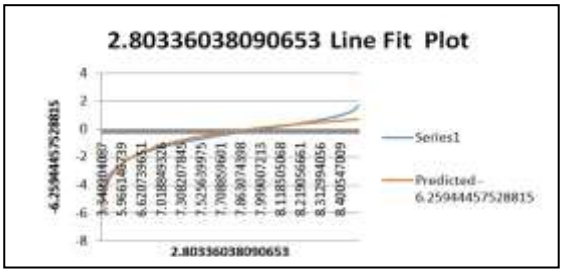


Figure- 4: Year –2 Overall Breakdown

Figure -5: Year –3 Overall Breakdown

4.1 Analysis of Weibull plots

In the line plots blue colored line represents the available reliability and red color line represents predicted reliability. From the line plot of 1st year over all breakdowns, it can be observed that the predicted reliability of 1st year follows almost same path all along the year except mild increasing trend of actual reliability in the middle. At final quarter of the year actual reliability follows same pattern while predicted reliability is in increasing trend .From the line plot of 2nd year overall breakdown, it can be observed that the predicted reliability of 2nd year follows straight line path throughout the year while actual reliability is lower at the initial phase of the year & after that follows increasing trend up to some extent till higher than predicted reliability. At the final quarter of year actual reliability is slightly lower than predicted reliability and again increasing trend.

From the line fit plot of Year 3 overall breakdown it can be observed that at some particular operating hours the predicted reliability line is lower compared to available reliability line which clearly show that the reliability of the machine is much better than the predicted reliability. The main cause for this condition to occur is the scheduled maintenance and mini shutdown system which means the maintenance carried out at some particular interval of time.

4.2 Reliability study of surface miner by using Weibull analysis:

Table -5:Reliability study of surface miner by using weibull analysis

Year	Year 1	Year 2	Year 3
CYCLE	Reliability	Reliability	Reliability
100	0.986068992	1	1
200	0.966491752	1	1
500	0.895663704	0.999999933	1
1000	0.765136741	0.999995674	1
2000	0.521856309	0.99972067	0.999999992
5000	0.122132088	0.933311539	0.999918873
10000	0.006046543	0.011600464	0.913017417
20000	4.07665E-06	0	0
30000	8.73357E-10	0	0
40000	8.06022E-14	0	0
50000	0	0	0
60000	0	0	0

4.3 Reliability analysis of surface miner under the given geo-mining conditions

This section depicted to establish a relation between selected year wise associated reliability estimates of surface miner and geo-mining parameters of coal. The following observation established after comparative analysis of the reliability graphical plots of the surface miners with the selected three years and selected geo-mining parameters. In this paper only two intervals of 1000 hours and 2000 hours are taken under study in selected three years.

1-It can be primarily established that the reliability of the surface miners decreases after a certain initial hours of deployment with the increasing compressive strength of the coal material to be handled.

2 -It can be primarily established that the reliability of the surface miners decreases after a certain initial hours of deployment with the increasing tensile strength of the coal material to be handled

3-It can be primarily established that the reliability of the surface miners decreases after a certain initial hours of deployment with the increasing shear strength of the coal material to be handled

4.4 Reliability impact of compressive strength

Figure -6: Compressive strength Vs Reliability at 1000 Hrs

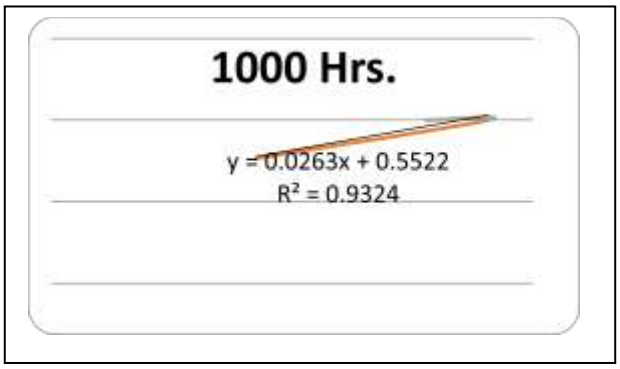
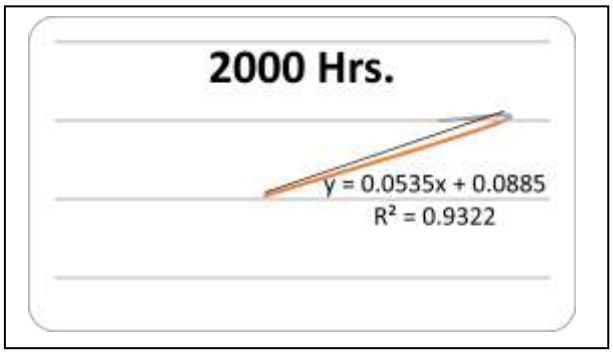


Figure-7: Compressive strength Vs Reliability at 2000 Hrs



4.5 Reliability impact of shear strength

Figure-8: Shear strength Vs Reliability at 1000 Hrs

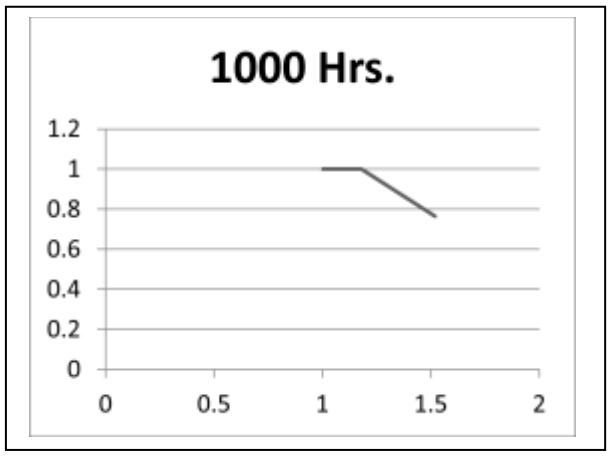
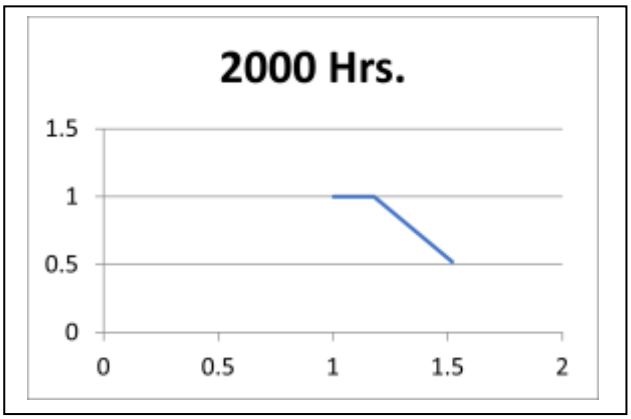


Figure-9: Shear strength Vs Reliability at 2000 Hrs



4.6 Reliability impact of Tensile strength

Figure-10: Tensile strength Vs Reliability at 1000 Hrs

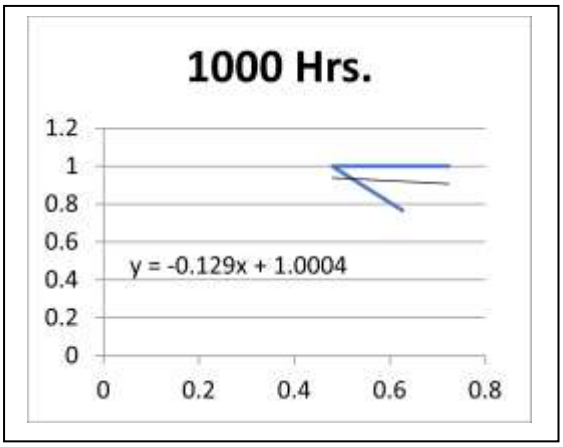
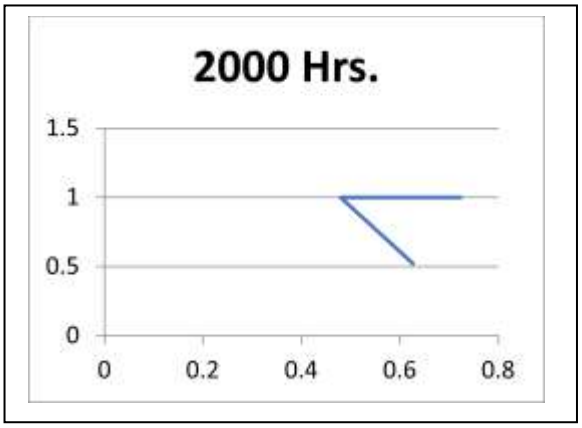
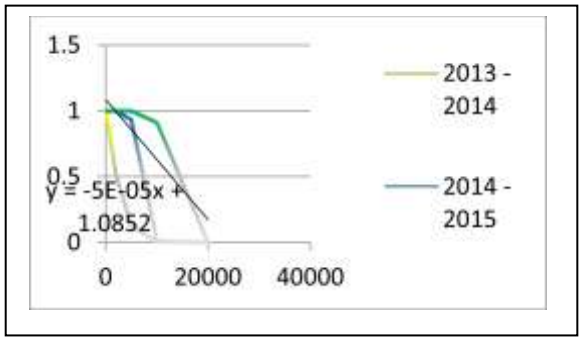


Figure-11: Tensile strength Vs Reliability at 2000 Hrs



4.7 Graph between yearly reliability and working hours for all the 3 years:

Figure-12: Reliability verses working hours



4.8 Observations

Reliability graph in the year 2013-14 follows drastically down trend at initial hours of deployment up to 2000 hrs. Reliability graph in the year 2014-15 follows straight line path during initial hours of deployment up to 2000 hrs. of working. Reliability graph in the year 2015-16 follows straight line path at initial hours of deployment up to 5000 hrs. Finally it shows that Reliability has a correlation with working hours & the geo mining characteristics of coal. Both are the prime factors that are responsible for variation in Reliability of surface miner.

4.9 Final Inference

Geo-mining parameters during the period of the study under different coal characteristics were analyzed individually and it was found that the reason of breakdowns were common except it was noted that the frequency of electrical problem is higher which required the review of the system from the point of view of original equipment manufacturer (OEM). The preparedness for pro-active maintenance strategy to improve the Reliability of machine is an essential function to be looked into. Operational failure will be minimized by way of provision for maintenance strategy formulation with regard to deployment of the surface miner.

5. CONCLUSIONS AND SUGGESTED FUTURE WORK

Different geo mining parameters during deployment of surface miner machine were considered primarily in this study. All the major heads of breakdowns were identified & they were analyzed by regression method of Weibull including the maintenance strategy of surface miner. In this study the importance of operational parameters were highlighted. The relations between all the operational parameters of surface miner machine and the mechanical reliability, which was calculated by Weibull analysis were developed and that are found useful to find out the predicted reliability at different phases of machine with respect to geo mining parameters .The study was aimed at improving the reliability of surface miner technology by identifying major thrust hold categories of breakdowns at different known geo mining parameters. The studies of various parameters including the breakdowns of the machine were found useful to identify the areas of concern from the operational point of view as well as from machine design point of view. The study also focused on possibility of few design changes from the OEM point of view. The major inferences which were derived from this research work are discussed in the following section.

5.1 Suggested maintenance strategy

The study suggested some of the areas as critical areas including the breakdown areas in the machine. The impact of all the breakdown reasons of all the electrical and mechanical nature during the study period was identified and Reliability of the machine was studied. Definitely the breakdown reasons are responsible for reduction of the reliability of the machine but the study was done to find out the greatest impact factor to suggest improvement in maintenance strategy of the machine. The following point should be considered during formulation of maintenance strategy:

1. A reliability review team will be trained in each mine.
2. Reliability review interval should be decided on basis of planned machine deployment strategy.
3. A three tier maintenance strategy should be developed.
4. Safety parameters of machine are also considered as input parameter during reliability analysis.

5.2 Suggested Deployment strategy

In future, a number of surface miners are planned to be deployed in this mega project as the target of the project is going to be doubled in the coming years. This study undertaken thus provides a guideline for predicted deployment with respect to the reliability as well as the productivity of the given surface miner.

5.3 Suggested future work

The studies of some of the important geo-mining parameters of surface miner were considered in this research study. In future the other parameters such as wear & tear of cutting picks, impact of deeper cut on machine reliability can suggest new relationship to find out the better way for improving reliability. The study of different make of surface miners deployed in other minerals can also be useful in strengthening the established relationship between different parameters which are suggested in this study.

5.4 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. Proper scientific layout, face availability can help reduce idle/waiting time to a greater extent.

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REFERENCES

[1] WIRTGEN(1984).WRITGEN INFORMATION/IW-2/84-22/5/84
[2] Wiilliam W. Dorner (1999), Using Microsoft Excel for Weibull Analysis, http://www.qualitydigest.com/pdfs/weibull.xls
[3] Coal India Limited, www.cil.nic.in