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Research Article

Reliability Modeling and Performance Analysis of Dumper Systems in Mining by KME Method

Chandra Mouli[Ȧ*], Subbarao Chamarthi[Ȧ], Ravi Chandra G[Ȧ] and Anil Kumar V[Ȧ]

[Ȧ]Mechanical Engineering Department, Vardhaman college of engineering, Andhrapradesh, India

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Abstract

Dumper is now used as a loading machine for intermediate mechanization in underground coal mining. For survival in the intense competition in the global business environment in recent years it is essential that LHD machine should be reliable and maintained effectively and efficiently. This paper seeks to study the reliability, availability and maintainability (RAM) of an 36T dumper machine with failure and repair data by KME method. The constraints and reasons for machine unavailability are outlined. The reliability and maintainability of an LHD and its subsystems are evaluated. Reliability and maintainability of an LHD system are disappointing. There is room to take decisions on optimal maintenance planning and machine improvement from this analysis.

Keywords: *reliability, availability, maintainability, LHD, KME.*

1. Introduction

Man has been constantly on the outlook of better working of Machines right from the invention of wheel till the sophisticated machinery of today. The machine life is most important in any production unit, as the machines are backbone of an industry. The need for not only efficient, but also reliable maintenance of the machinery is realized. The reliability of machinery is essential particularly, in production process, such as mines and heavy machinery, since the breakdown of any machine would cause an unpredictable loss or damage. Therefore, it is obvious that the reliability of such machine would have considerable impact not only on production but also machine life and human life.

Prevention is better than cure. Instead of allowing the occurrence of failure and suffering from huge loss or damage of assets, lives and environment, it is always worthwhile forestalling the occurrence. For such a fearless environment of successful operations without any failures, the machines must be maintained to exhibit high reliability. Thus it is an urgent need to apply the reliability centered maintenance techniques rather than time based and failure based maintenance techniques. The maintenance planning of equipment hence requires the orientation of reliability at every stage of its life. The present study is on effort in this direction that can provide some guidelines while planning the maintenance activities with an orientation of reliability.

There is a wide scope for conducting the analysis on the dumpers at OCP-III of Ramagundam. These machines are about 12 to 15 years old and have approximately run for about 95,000 machine hours on an average. This enables to take up these machines for study as they are suspected to have reached the third stage of bathtub curve (Machine Life Cycle).

There are several testing methods available for testing the behavior of these machines. The Trend analysis, Total Time Test (TTT) plotting are some effective tools to mention. The TTT plotting can be done using various statistical tools such as Most Likely Estimates (MLE), Kaplan-Meir Estimation (KME) and Piecewise Exponential Estimation (PEXE) etc. The present project is carried out with KME. The results are confirmed by the other methods namely MLE and PEXE. Further the Kaplan-Meir estimator is made used to find the design life, optimal maintenance period etc, which are useful information in maintenance planning. And there is further scope to extend this project by preparing suitable software so as to achieve the better and effective Reliability Centered Maintenance Planning.

2. Procedure for RCM Modelling

The field data is collected for the equipment categorized under repaired items in the form of Time between Failures (TBFs) and Time To Repair (TTRs). The data inconsistencies and errors are removed and the refined data is analyzed by both types of models viz. graphical and analytical models. However, more importance is given to graphical method since it provides better simple understanding and can be easily reproduced. The graphical tests such as eye-ball analysis, cumulative plot test and serial correlation determine the presence of trend. The machines, which exhibit presence of strong trend, are

*Corresponding author: **Chandra Mouli**

Table 1 Cumulative plot test table-C-374

Failure Number	TTR	CTTR	Cause	TBF	CTBF
1	8	8	Steering Problem	1776	1776
2	192	200	Accident	144	1920
3	12	212	Suspension Problem	1920	3840
4	72	284	Bucket Welding	504	4344
5	18	302	Operator Seat Damaged	120	4464
6	16	318	Hydraulic Hose Problem	1176	5640
7	24	342	Trans Problem	768	6408
8	8	350	Radiator Problem	24	6432
9	8	358	CLS	264	6696
10	8	366	Bucket Welding	336	7032
11	32	398	Bucket Damaged	48	7080
12	48	446	Exhaust Problem	2160	9240
13	16	462	Oil Leakage	1896	11136
14	96	558	NTL	3480	14616
15	48	606	Engine oil Leak		14616

Table 2 KME Method Table for C-374

F.NO	OTBF	LN(OTBF)	TI(BEETA)	PRODUCT	CDF	PHI	SLOPE
1	24	3.178054	210.7541	669.788	0.001222	0.000252	0.001725
2	48	3.871201	677.0202	2620.881	0.00392	0.000765	0.005449
3	120	4.787492	3166.566	15159.91	0.018203	0.008231	0.034665
4	144	4.969813	4304.286	21391.5	0.024662	0.009254	0.04317
5	264	5.575949	11942.75	66592.17	0.066941	0.039391	0.145722
6	336	5.817111	17924.24	104267.3	0.098764	0.051489	0.201742
7	504	6.222576	35474.37	220742	0.186009	0.119207	0.424423
8	768	6.64379	72094.78	478982.5	0.341809	0.282092	0.905993
9	1176	7.069874	147725.2	1044398	0.575581	0.596851	1.769282
10	1776	7.482119	295723.4	2212637	0.820153	0.984265	2.788684
11	1896	7.547502	330136.2	2491704	0.852702	0.991999	2.8367
12	1920	7.56008	337202.4	2549278	0.858618	0.992186	2.842991
13	2160	7.677864	411162.1	3156846	0.907945	1	2.907945
14	3480	8.154788	917777.5	7484280	0.995129	1	2.995129
		86.55821	2585522	19849570			

Table 3 Cumulative plot test table-CD-313

Failure Number	**TTR**	**CTTR**	**Cause**	**HRS**	**CTBF**
1	16	16	OITDS	432	432
2	8	24	Periodical Maintenance	2784	3216
3	4	28	Air Leak	456	3672
4	18	46	SOS	408	4080
5	12	58	Ari Filter Cleaned	2328	6408
6	36	94	Suspension	3192	9600
7	8	102	Brake	6	9606
8	16	118	Brake	168	9774
9	12	130	Oil leak	840	10614
10	8	138	Machine topped	216	10830

Table 4 KME Method Table for CD-313

F.NO	OTBF	LN(OTBF)	TI(BEETA)	PRODUCT	CDF	PHI	SLOPE
1	6	1.791759	19.93024	35.7102	0.000139	3.6849E-06	0.000147
2	168	5.123964	5203.152	26660.76	0.035685	0.02259044	0.080866
3	216	5.375278	7916.583	42553.84	0.053786	0.02557248	0.104931
4	408	6.011267	22898.26	137647.6	0.147783	0.07866419	0.305111
5	432	6.068426	25191.72	152874.1	0.161324	0.07946089	0.320246
6	456	6.122493	27572.19	168810.5	0.175151	0.08011173	0.335375

7	840	6.733402	76479.74	514968.8	0.413809	0.21491177	0.843633
8	2328	7.752765	419625.2	3253256	0.946631	0.99236955	2.93137
9	2784	7.931644	565714.9	4487049	0.98076	1	2.98076
10	3192	8.068403	710861.5	5735517	0.993018	1	2.993018
		60.9794	1861483	14519373			

further analyzed and fitted into non-homogeneous Poisson process (NHPP) model. Power law process (PLP) model, one of the most popular and commonly used NHPP models can be used for such study.

If there is no trend, it confirms the independently and identically distributed (i.i.d.) assumption. The values obtained can be checked with some analytical tests such as Laplace test. The machines free from trend are further graphically analyzed through total time on test (TTT) plots. The exponential fit that confirms homogeneous Poisson process (HPP) models can be known from this analysis, otherwise can be categorized as renewable process (RP) model which is in accordance with Weibull pattern. The goodness of fit (analytical) tests can confirm this. . Thus, reliability characteristics and maintenance schedules can be estimated. Further, their reliability growth plots can also be drawn to estimate the improvements. Algorithmically, it is explained as given below and followed by a flow chart in Figure.

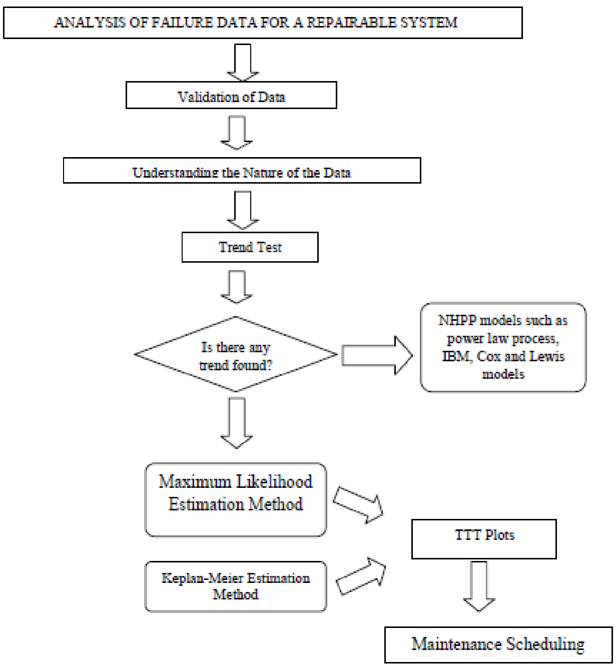


Fig.1 Flow chart of Method for Reliability Analysis

3. Results and discussion

As expected the dumpers operated at OCP-III, SCCL, Ramagundam are exhibiting high failure rate and low availability than other equipment. A systematic procedure/approach is established applying the relevant models available in literature on the field data collected to analyze the identified problem. After Ploting the graphs by the data colleceted for the dumpers C-374 and CD-313.

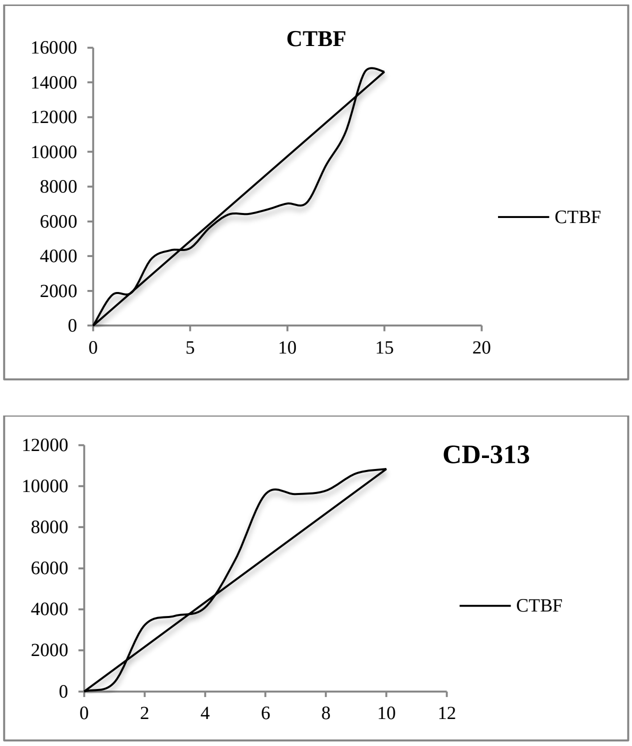


Fig.2 Graphs of cumulative plot test (Failure No Vs Cumulative Time between Failures)

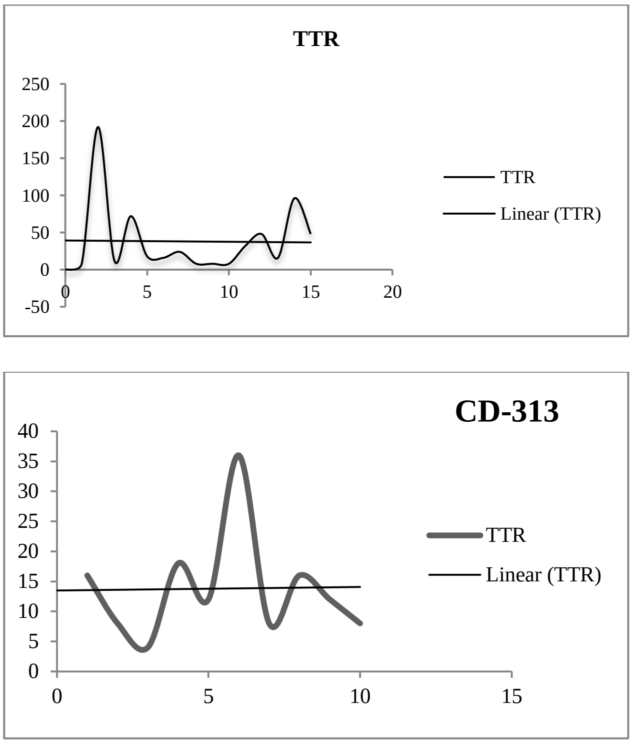
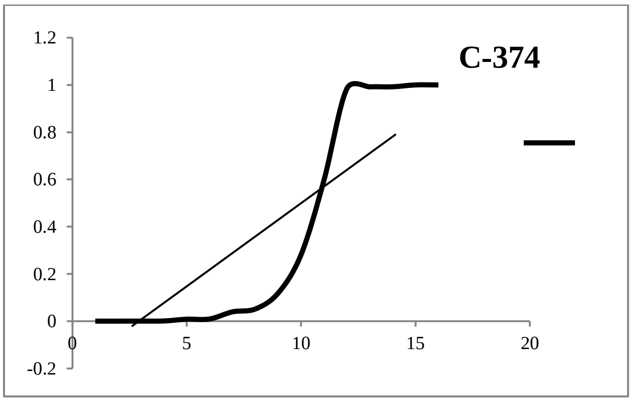


Fig.3 Graphs of eye-ball test (Failure No Vs Time Taken for Repair)

Table 5 Trend Analysis for dumpers C-374 & CD-313

S.No	Dumper No	Cumulative Trend Test	Eye Ball Trend Test	Trend
1	C-374	Weak +Ve Trend	No Trend	No Trend
2	CD-313	No Trend	No Trend	No Trend



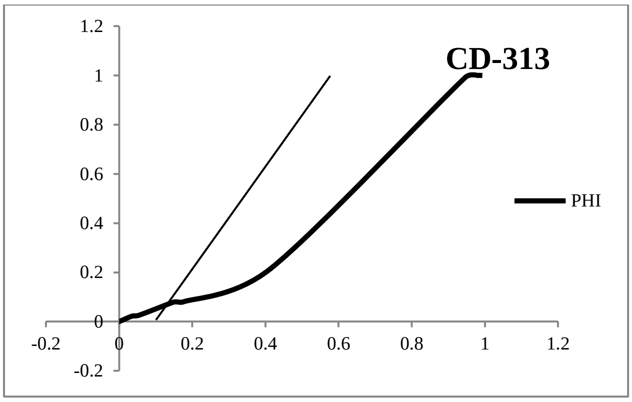


Fig.4 Graphs of Kaplan Meier Estimation (KME) Method (CDF Vs PHI)

The trend analysis shows that the two dumpers are showing no trend.The KME method has proven that both the dumpers are detoriating.

Conclusion

The present study is confined to a small no. of equipment i.e. 36T trucks. Data collection is not only time consuming and proper collection is possible only when the men concerned maintain proper log of failure/ repair reports is a systematic organized way. Equipment performance depends among other things than its age also. Failure/repair data, properly collected analyzed and stored can be used by the management for a(a) maintenance planning, (b) spare parts provision and (c) ordering new equipment depending upon the life of the project. Right now, cost of maintenance, equipment wise is not readily available for evaluation of effectiveness of maintenance. There is a need to provide a PC at the mine workshops to log the information and store for retrieval. The log sheets should properly be planned and reporting system has to be perfected. It is observed that there is vast scope for improving machine utilized hours in case of 85T dumpers by reducing the idle hours by properly reorganizing the

interfacing activities and maintenance plans. Performance of mine not only depends upon production equipment like shovels/dumpers but very much effected by availability and utilization of service equipment like dozers, scrapers, graders and other equipment. An integrated study of availability of all the equipment in a mine can only improve the productivity through enhanced utilization of production equipment in spite of their availability.

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