Analysis of Reliability and Availability of Iron-ore Vibrating Screen

Kritesh Hirwani and Sanjay Kr. Singh

Abstract: In this paper reliability and availability analysis is done of an iron-ore vibrating screen. According to the previous failure data, the reliability is calculated using weibull-fit in mat-lab, by analyzing previous failure and restores time of machine; the availability is calculated at mean time to restore and minimum time to restore, after these calculation some maintenance and management factor are discussed by which the reliability and availability can be improved.

Key-words: Availability, MTBF, MTR, Reliability.

Acronyms

MTBF	Mean time between failures
MTR	Mean time to restore
TBF	Time between failures
TR	Time to restore

Notation

T	Time (Hrs)
β	Shape parameter
η	Scale parameter
R(T)	Reliability at time T
A	Availability

1.1 INTRODUCTION:

The required performance of a machine or system is essential for the production. Reliability and the availability is the main character of a machine, on which the production, the reputation before the customer and in market is depended.

Reliability is a very essential aspect on the current developing industrialization. If the machines reliability is more, than automatically there is well production system with some cost reduction. To maintain or improve the reliability; maintenance of the machine is very important thing, on the performance of effective maintenance schedule; a more reliable machine or system can achieve.

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Basically there are two types of maintenance performed: a- corrective maintenance, b- preventive maintenance. Corrective maintenance is performed on the failure of the machine and preventive maintenance is performed to avoid the failure, usually preventive maintenance is performed on the basis of experience, corrective maintenance associated cost is more than the preventive maintenance.

By proper scheduling of preventive maintenance, the frequency of corrective maintenance and its cost can be reduces. If the corrective maintenance frequency is minimized, it can be said that the reliability is improved. When a machine is taken into consideration, it works with some essential component, on the failure of any component; the machine stop working. So the failure of any component means the machine is fail, so it is essential to calculate the reliability of each component, for the reliability of that particular machine.

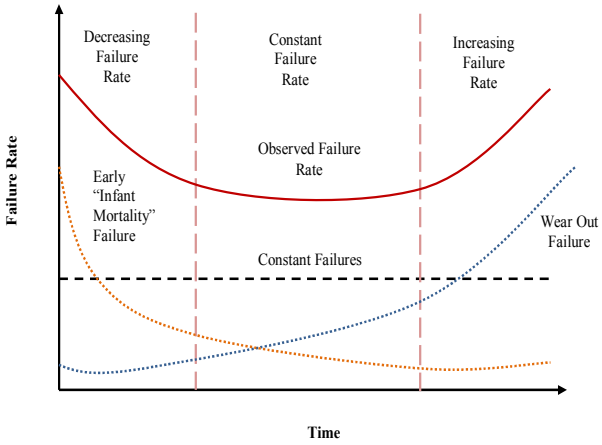
In this paper Iron-ore Vibrating Screen is taken for study, which failure data is collected for each component, the mechanical component's failure follow the Weibull distribution, so using the failure data in Weibull-fit (mat-lab) and Weibull failure distribution the reliability is calculated for a particular time. On the performance of proper scheduled preventive maintenance the occurrence of failure is less, which means its reliability is improved and associated cost is reduced.

1.2 Reliability is defined as the probability to characterize an item for proper functioning till useful life, under given conditions and time-intervals. When we extend its definition, it can be say that reliability is the ability of an item/equipment/machine to perform its function properly in some time interval at stated conditions which is generally specified by the manufacturer. Some time-interval refers to, the item performs its required function for certain time and that time can be completed with some intervals, and the stated conditions refers to the condition of ambient and item itself which is predefined by the designer and manufacturer of the item. Basically the opposite of failures is; reliability. The maintenance is done on the occurring of some types of failure means the maintenance can be done on the basis of reliability [1].

1.3 The Bathtub curve:

The failure of the component with respect to time occurs in a curve shape, due to the shape of curve, it is known as bathtub curve. At the beginning or first run time (after installation) the probability of failure is higher, due to the improper installation of machine like low strength

foundation, machine parts design problems itself etc, at this



time the failure rate is decreases as shown in fig.1.

Fig: 1- Bath Tub Curve

If it runs properly then the machine works as their durable life with proper maintenance, in this time the failure rate is constant. At the end time of life machine can fail frequently due to wear & tear, at this time the failure rate increases.

Mathematical expression for the failure & Reliability [1]:

$$f(T) = \frac{\beta}{\eta}\left(\frac{T}{\eta}\right)^{\beta-1} e^{-(T/\eta)^{\beta}}$$

$$R(T) = e^{-(T/\eta)^{\beta}}$$

1.4 Availability is defined as the probability to characterize an item for continuous functioning over a period of time under given conditions. When we extend its definition, it can be say that availability is the ability of an item/equipment/machine to perform its function proper and continuously for given period of time at stated conditions which is generally specified by the manufacturer. If the component/system fails and need maintenance its availability is evaluate till that point so availability means to continuous function without any failure.

Availability affects directly from reliability and maintainability, and is expressed by [2]:

$$A = \frac{up\ time}{down\ time + up\ time}$$

In down time if we consider MTR, than now:

$$A = \frac{MTBF}{MTTR + MTBF}$$

1.5 Vibrating screen is used to separate the large particles as the requirement of further processes. In this paper iron-ore vibrating screen is analyzed for its reliability and availability. This screen is used to separate the large particles of iron ore for the furnace. It consist various important parts, which maintainability and availability are important for the analyzing the screen assembly. The main components of vibrating screen assembly are as shown in fig. 2.

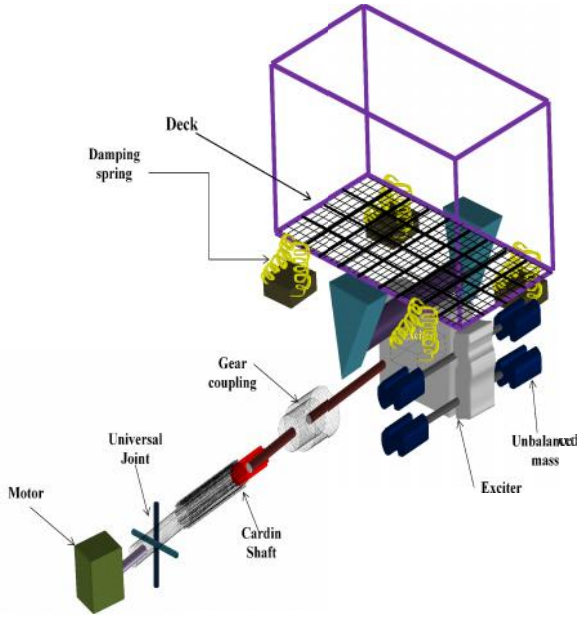


Fig. 2- Vibrating Screen Component

2. Methodology:

2.1 Collect the previous failure data and using weibull-fit in mat-lab, calculate β & η, at put it in the formula of reliability to get the reliability of each component.

Table 1					
Failure Data (Cumulative) Of Screen Assembly (Hrs)					
Sl No.	**Deck**	**Exciter**	**Spring**	**Gear coupling**	**Cardin Shaft**
1	3722	3723	3724	3725	3726
2	7394	9045	11684	14209	12680
3	11083	14308	19268	21857	19032
4	15645	19946	27255	28694	26395
5	20371	24250	33238	35632	33848
6	24400	29662	39077	42860	40776
7	28638	35173	45530	50508	47509
8	33540	40866	52168	58355	54791
9	37151	46018	59566	65292	62426
10	41538	50605	67049	72131	69358
11	46021	55292	74687	79314	75841
12	50674	60980	82271	86598	83204
13	54910	65856	90218	94182	91122
14	58802	71501	97065	102021	98749
15	62988	77045	104348	109219	106232
16	67470	82391	110735	116202	113800
17	72032	86858	117220	123041	120632
18	75924	93536	123978	129824	127505
19	79984	98102	131241	136806	134243
20	84264	103224	137814	144069	141437

2.2 Weibull-fit code for deck, similarly make this code for other components and get the result as shape and scale parameter.

```
disp('DECK')
D=xlsread('SCR.xls',1,'I4:I25')';
D=D(D~=0);
parameter=wblfit(D);
eta=parameter(1)
beta=parameter(2)
```

The value of shape & scale parameter:

	Deck	**Exciter**	**Spring**	**Gear coupling**	**Cardin Shaft**
beta = β	1.7462	1.7308	1.6875	1.7411	1.6873
eta = η	48905	59517	79289	84202	81230

2.3 Calculation of Reliability for ½ yr. and 1 yr.

	Deck	**Exciter**	**Spring**	**Gear coupling**	**Cardin Shaft**
beta = β	1.7462	1.7308	1.6875	1.7411	1.6873
eta = η	48905	59517	79289	84202	81230
R (T) = e^[-(T/η)^β					
R (4320) [6 MONTH]	0.985658	0.989382	0.992657	0.994337	0.992945
R(8640) [12 MONTH]	0.952694	0.96519	0.976541	0.981195	0.977458

2.4 Collect the previous data of restore time and calculate the MTR [table 2] and MTBF [table 3], and using the availability formula calculates the availability at MTBF with MTR and TBF (max) with TR (minimum).

Table 2					
Restore Time Of Screen Assembly Component (Hrs)					
Sl No.	**Deck**	**Exciter**	**Spring**	**Gear coupling**	**Cardin Shaft**
1	7.40	14	1.40	1.90	1.00
2	8.40	15	1.30	2.00	0.95
3	7.30	13	1.60	2.10	0.85
4	8.60	16	1.70	2.20	0.75
5	9.30	14	1.50	2.30	0.80
6	8.80	15	1.50	1.90	0.85
7	8.60	14	1.50	1.80	0.60
8	9.20	13	1.40	1.80	0.55
9	8.50	15	1.60	1.90	0.68
10	9.10	15	1.70	1.80	0.77
11	8.40	14	1.80	2.00	0.95
12	8.70	14	1.60	2.20	0.98
13	7.90	13	1.30	2.00	0.87
14	7.80	16	1.40	2.30	0.65
15	8.40	16	1.40	1.90	0.87
16	9.30	15	1.50	1.90	0.68
17	8.40	14	1.60	1.80	0.60
18	8.50	13	1.40	2.10	0.75
19	8.60	16	1.70	2.20	0.80
20	9.00	15	1.40	2.20	0.70
Standard Time For Restore 'T'(Hrs)	8	14	1.5	2	0.75
MTR (Hrs)	**8.51**	**14.5**	**1.515**	**2.015**	**0.7825**
TR (min)	**7.3**	**13**	**1.3**	**1.8**	**0.55**

Table 3					
Failure Data Of Screen Assembly Component (Hrs)					
Sl No.	Deck	Exciter	Spring	Gear coupling	Cardin Shaft
1	3722	4482	5746	6847	5847
2	3672	4563	5938	7362	6833
3	3689	5263	7584	7648	6352
4	4562	5638	7987	6837	7363
5	4726	4304	5983	6938	7453
6	4029	5412	5839	7228	6928
7	4238	5511	6453	7648	6733
8	4902	5693	6638	7847	7282
9	3611	5152	7398	6937	7635
10	4387	4587	7483	6839	6932
11	4483	4687	7638	7183	6483
12	4653	5688	7584	7284	7363
13	4236	4876	7947	7584	7918
14	3892	5645	6847	7839	7627
15	4186	5544	7283	7198	7483
16	4482	5346	6387	6983	7568
17	4562	4467	6485	6839	6832
18	3892	6678	6758	6783	6873
19	4060	4566	7263	6982	6738
20	4280	5122	6573	7263	7194
MTBF	4213.2	5161.2	6890.7	7203.45	7071.85
TBF (max)	4902	6678	7987	7847	7918

2.5 The value of MTBF, TBF (max), MTR and TR (minimum):

Table 4					
Calculated Data Of Screen Assembly Component (Hrs)					
	Deck	Exciter	Spring	Gear coupling	Cardin Shaft
MTBF	4213.2	5161.2	6890.7	7203.45	7071.85
TBF (max)	4902	6678	7987	7847	7918
MTR	8.51	14.5	1.515	2.015	0.7825
TR (min)	**7.3**	**13**	**1.3**	**1.8**	**0.55**

2.6 Calculated value of A:

A at MTBF & MTR	0.9979	0.9971	0.9997	0.999720	0.99988
A at TBF(max) & TR(min)	0.9985	0.9980	0.9998	0.999770	0.99993

3. Result:

	Deck	Exciter	Spring	Gear coupling	Cardin Shaft
R (4320) [6 MONTH]	0.985658	0.989382	0.992657	0.994337	0.992945
R(8640) [12 MONTH]	0.952694	0.96519	0.976541	0.981195	0.977458
A at MTBF & MTR	0.9979	0.9971	0.9997	0.999720	0.99988
A at TBF(max) & TR(min)	0.9985	0.9980	0.9998	0.999770	0.99993

4. Dissuasion:

1. Time to Restore can be minimized by:
   - Proper planning and ready for the repair.
   - Effective spare parts management.
   - Co-ordination b/w machine operator and maintenance department.
2. Time between failures can maximize by proper maintenance of the machine and its components.

5. Conclusion:

- Reliability can improve by proper scheduling of maintenance.
- Comparing the result for Availability; by improving the life of machine with proper maintenance with reduction in restore time the availability of the machine can be increased.

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