Analysis of Availability of Crusher Assembly

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***Abstract*— This paper consist the analysis of the availability with some physiological aspects. In industry these factor of the machine are very important aspects to achieve the required production and to reduce the cost. Some important types of availability are discussed .For the analysis; crusher machine is considered, to evaluate the availability of crusher machine, the availability of each essential component of crusher is required. For the availability of each component; the failure data and previous repair time is collected. By effective maintenance program the time between failures can improve and the mean time to repair is minimized and the availability can be improved. On the performance of effective maintenance, the failure frequency time is reduced thus the machine is more reliable and the cost of maintenance can be reduces.**

Key-words: Maintenance, Availability, Inherent Availability, Operational Availability, Achieved Availability.

I. INTRODUCTION

The overall cost associated with a equipment may termed as total life cycle cost, which include purchasing, installation, operation, maintenance and disposal cost. With proper installation it could be reduces, but in a general survey the maintenance and other supporting cost reach to 60-70 % cost of total life cycle cost. So to reduce the cost minimization in maintenance cost is required. The cost of maintenance depends on the type of maintenance performed [1].

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 said that availability is the ability of an item/equipment/machine to perform its function properly and continuously for given period of time at stated conditions which are generally specified by the manufacturer. If the component/system fails and needs maintenance its availability is evaluated till that point so availability means to continuously function without any failure [2].

The total time in the operative state (also called up time) is the sum of the time spent in active and standby use. The total time in the non-operative state (also called down time), is the sum of the time spent under active repair and waiting for spare parts, paper work etc.

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

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

A. Inherent Availability:

Inherent availability is the steady state availability when considering only the corrective downtime of the system. It is defined as the expected level of availability for the performance of corrective maintenance only. Inherent availability is determined purely by the design of the equipment. It assumes that spare parts and manpower are 100 percent available with no delays [7]. It excludes logistics time, waiting or administrative downtime, and preventive maintenance downtime. It includes corrective maintenance downtime. Inherent availability is generally derived from analysis of an engineering design. Inherent availability fulfills the need to distinguish expected performance between planned shutdowns for a System it is written as:

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

B. Operational Availability:

Operational availability is a measure of the average availability over a period of time and it includes all experienced sources of downtime, such as administrative downtime, logistic downtime, etc. It is the probability that an item will operate satisfactorily at a given point in time when used in an actual or realistic operating and support environment. It includes logistics time, ready time, and waiting or administrative downtime, and both preventive and corrective maintenance downtime. The operational availability is the availability that the customer actually experiences. It is essentially the a posteriori availability based on actual events that happened to the system. The previous availability definitions are a priori estimations based on models of the system failure and downtime distributions.

Operational availability is the ratio of the system uptime and total time. Mathematically, it is given by:

$$A = \frac{\text{UP TIME}}{\text{OPERATING CYCLE}}$$

$$A = \frac{\text{MTBF}}{\text{MTBF} + \text{MTR}}$$

Where; MTR= mean time waiting for spares + Mean administrative time + mean time for repairs

The operating cycle is the overall time period of operation being investigated and uptime is the total time the system was functioning during the operating cycle. Operational availability is required to isolate the effectiveness and efficiency of maintenance operations. It is the actual level of availability realized in the day-to-day operation of the facility. It reflects plant maintenance resource levels and organizational effectiveness. Operational availability is required to isolate the effectiveness and efficiency of maintenance operations. Operational availability is the

bottom line of performance. It is the performance experienced as the plant operates at a given production level.

The difference between achievable and operational availability is the inclusion of maintenance support. Achieved availability assumes that resources are 100 percent available and no administrative delays occur in their application.

C. Achieved Availability:

The probability that an item will operate satisfactorily at a given point in time when used under stated conditions in an ideal support environment (i.e., that personnel, tools, spares, etc. are instantaneously available). It excludes logistics time and waiting or administrative downtime. It includes active preventive and corrective maintenance downtime. Achieved availability is defined as the achieved level of availability for the performance of corrective and preventive maintenance. Achieved availability is determined by the hard design of the equipment and the facility [7]. It also assumes that spare parts and manpower are 100 percent available with no delays. Achieved availability is very similar to inherent availability with the exception that preventive maintenance (PM) downtimes are also included. Specifically, it is the steady state availability when considering corrective and preventive downtime of the system. It can be computed by looking at the mean time between maintenance actions, *MTBM* and the mean maintenance downtime,

$$A = \frac{MTBM}{MTBM + \overline{M}}$$

A deteriorating production system subject to random machine breakdowns, repair and replacement activities, is investigated. The machine manufactures one type of product, and when a breakdown occurs; either a repair or a replacement action is chosen. The machine is replaced with a new one if the replacement option is selected, and no repair action is considered in such a situation [3].

When designing support equipment, availability should be a high priority. As requirements for the system flow down to the assemblies we can see that one factor would be time [4].

Industrial psychology is the study of behavior of employees with available working environment conditions and relation between the workers/employees to improve the production in various aspects. Our aim is to improve the reliability and maintainability, so here some psychological aspects are explaining in brief, which are helpful for our object [5].

- Lack of co-ordination between the various department and the co-workers.
- Lack of seriousness for work.
- Lack of confidence for work.

The above mentioned aspect is due to:

- Improper working environment condition. (Temperature, humidity, air-circulation etc.)
- Improper training program.
- Lack of motivations
- Lack of effective safety program and safety kits.

These are the main factor which have to be consider in today scenario, it can be vary with industry to industry.

Monitoring of physiological variables such as heart rate (HR), blood pressure, or blood glucose has been widely applied for this purpose. However, the wellbeing of the individual includes physiological, psychological, and social factors, all of which are interacting as determinants of health. In fact, behavioral and social factors explain more than 50% of health outcomes. Hence, there is a need for comprehensive health monitoring approaches including both psycho-physiological and Behavioral components. However, only relatively few studies have been published that deal with mutual relationships between these variables in long-term real-life settings. [6].

An important psycho-physiological phenomenon is stress, as work-related stress and burnout are major public health problems. In Finland, about 7% of employees suffer from severe work-related burnout. Another study concludes that 2.5% of employees in Finland suffer from severe burnout and about 24% from mild burnout. [6].

In today's strategic management, emotional intelligence in organizations of Iran plays a main role among manager and employees worldwide. The paper is undertaken to understand the roles of strategic behavior and motivation with relationship between managers' emotional intelligence and employees to improve communication effectiveness and job satisfaction in organizations of Iran. The aim of this is the emotional intelligence with communication effectiveness and motivation as moderator in Agricultural Bank. Additionally emotional intelligence influenced by strategic behavior in this relationship. The result shows a strong correspondence between motivation with the relationship between emotional intelligence and communication effectiveness, and also communication effectiveness with job satisfaction [3].

The construction and working of the crusher in brief:

The main components of the crusher are: Frame, jaw plate, Eccentric shaft, toggle-toggle plate, Fly-wheel, Pulley, Belts, tension spring and motor as shown in figure 1. In figure left frame is fixed while right one is movable. Right frame consist an eccentric shaft arrangement connected with flywheel and pulley. The flywheel and motor is connected through pulleys and belts.

The motor rotate the fly-wheel through 3-grooves pulley and belt, the flywheel store energy and transmit it to the eccentric shaft which motion cause to vibratory movement of right movable frame with Jaw plate. On the vibratory motion of movable jaw toggle plate and toggle rod provide some motion and the tension spring tries to retain the position of movable jaw. The jaw plates are adjusted from the frame according to the required size of the output material. When material which is to be crushed enters from upper side, material get stroked between fixed and movable jaw plate and crushed to the small pieces.

Maintenance aspects of the components:

a) The jaw plates can be welded with parent metal as the dressing of plates and can be replaced.

Sl No.	Jaw Plate	Toggle	Belt (All - 3)	Eccentric shaft	Spring (Damping)
1	4576	5366	3273	9483	9387
2	3797	5948	2982	9383	10288
3	4087	5738	2948	10293	10298
4	5400	5343	3094	12938	11276
5	4281	6272	3563	10293	12773
6	5221	5873	3672	11298	13827
7	4827	5992	2938	12837	12928
8	4728	6125	3602	12736	9383
9	3948	5637	3547	12837	10282
10	5282	5902	2837	11272	11288
11	4857	5839	2537	9387	12827
12	4625	6213	2837	11938	11827
13	4928	5635	2938	11726	9282
14	5120	5638	2736	9387	8992
15	3901	5839	2638	8373	10292
MTBF	**4638.5**	**5824**	**3076.1**	**10945**	**10996.67**
MTBF(max)	**5400**	**6272**	**3602**	**12938**	**13827**

b) Tension spring can be replaced due to low stiffness.

c) Toggle plate and rod arrangement can be replaced. And eccentricity of shaft is not adjustable then it can be replaced.

d) The pulley required alignment with shaft, it can be replaced when it brake.

e) The belts are changed when it tear out, all belts are replaced at a time.

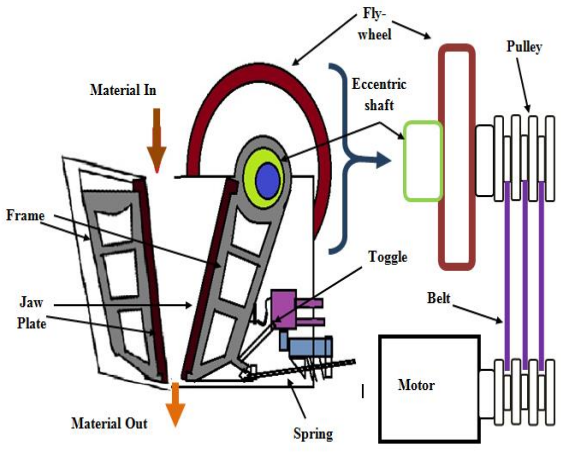

Fig. 1 Crusher

II. METHODOLOGY

A. *Calculation of Availability:*

Collection of previous data of failure and repair time and obtain the MTBF, TBF (max), MTR and TR (minimum).

B. *Failure Data of Crusher (hrs)*

TABLE 1: FALIURE DATA OF CRUSHER (HRS.)

TABLE II :MEAN TIME TO REPAIR OF CRUSHER (HRS)

Sl No.	Jaw Plate	Toggle	Belts	Eccentric shaft	Spring
1	6.45	0.95	0.45	1.20	0.70
2	6.75	0.86	0.50	1.50	0.65
3	6.15	0.94	0.35	1.60	0.85
4	5.95	0.75	0.30	1.75	0.75
5	7.50	0.70	0.55	2.10	0.45
6	7.75	0.95	0.65	1.90	0.55
7	6.85	1.10	0.55	1.80	0.56
8	6.35	1.20	0.48	1.75	0.64
9	6.47	1.15	0.52	1.30	0.80
10	6.83	0.95	0.47	1.20	0.67
11	7.15	1.20	0.33	1.45	0.84
12	7.65	1.45	0.47	1.55	0.66
13	7.00	1.30	0.33	1.35	0.76
14	6.00	0.95	0.60	1.90	0.45
15	7.40	1.05	0.50	1.85	0.55
MTTR	**6.82**	**1.03**	**0.47**	**1.61**	**0.66**
TTR (min)	**5.95**	**0.70**	**0.30**	**1.20**	**0.45**

TABLE III BY USING AVAILABILITY FORMULA, AVAILABILITY IS CALCULATED:

Sl No.	Jaw Plate	Toggle	Belts	Eccentric shaft	Spring (Damping)
MTBF	4638.5	5824	3076.1	10945.4	10996.7
MTBF(max)	5400	6272	3602	12938	13827
MTTR	6.82	1.03	0.47	1.61	0.66
TTR (mini)	5.95	0.70	0.30	1.20	0.45
A at MTBF & MTTR	**0.9985**	**0.99982**	**0.9998**	**0.99985**	**0.99994**
A at MTBF (max) & MTTR (min)	**0.9989**	**0.99989**	**0.9999**	**0.99991**	**0.99997**

III. RESULTS

TABLE IV THE OBTAINED AVAILABILITY

Sl No.	Jaw Plate	Toggle	Belts	Eccentric shaft	Spring (Damping)
A at MTBF & MTTR	**0.9985**	**0.99982**	**0.9998**	**0.99985**	**0.99994**
A at MTBF (max) & MTTR (min)	**0.9989**	**0.99989**	**0.9999**	**0.99991**	**0.99997**

IV. DISCUSSIONS

Time to Repair can be minimized by:

- Proper planning for the maintenance work.
- Effective spare parts management.
- Co-ordination b/w machine operator and maintenance department.

To manage the psychological factor for improvement of the production and the Availability of the equipments/system, And for a healthy working environment we can implement following schemes:

- There should be a proper working environment condition (Temperature, humidity, air-circulation etc.), these should be maintained which is required for employee/worker and the types of performing wok.
- Proper training program is planned for new recruitments and there should be training program for new technology available in the organization.
- Effectively and periodically motivational programmes and plans should be organized.
- There should be safety program are organized timely for the employee/workers and them proper safety kits.

V. CONCLUSIONS

- On the comparing the result for Availability, by increasing failure frequency and reducing repair time the availability can be increased.
- By effective analysis and implementation of physiological, psychological and motivational aspects; the workers/maintenance-persons and working environment conditions can be enhanced for the better productivity.

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