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Estimation and Evaluation of Reliability, Availability of Ball Mill in Paint manufacturing Unit

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Abstract**—** Reliability is one of engineering indicators for describing the performance of an item or a system by probability functions. It is the probability that an item or system is capable of performing, its intended function in a specified time under given working conditions. In modern world every industry is involved in using modern machineries to achieve profit and rank in the present market. Production of several simple and complex components in production process involves more involvement of machinery. So, to maintain a good productive strategy the machines incorporated should be maintained accordingly. Every machine has its specific role so the maintenance of every machine is essential. In the present research paper the machine breakdown data of paint industry have been collected and analyzed. This paper presents the maximum likelihood method for estimating reliability and availability of equipment using Weibull distribution.

Keywords**—** Availability, reliability, maintenance.

I. INTRODUCTION

Machinery of different types whether cheap or costlier, heavy or small, simple or complex is prone to breakdowns. So, a definite maintenance schedule should be considered during the capacity planning and activity scheduling in modern industries whether manufacturing, transport, railways and supply [1]. The main objective of maintenance is to increase the performance of equipment by definitely reducing the failures, faults or breakdowns [2]. Breakdown leads to increased downtime and reduced uptime which in turns effect the productivity of the unit. By adopting suitable maintenance schedule breakdowns can be effectively controlled [3]. During literature survey various studies had been conducted for the development and implementation of various mathematical models for maintenance schedules [4-5]. In field of machines reliability, maintenance is defined as an activity carried out for better machine performance [6]. In our case study, we are going to evaluate the reliability and availability of Ball Mill used in a paint manufacturing plant. For such calculative analysis, the break down time is calculated from paint industry maintenance data. The data collected for machinery is analyzed and reliability of machine has been evaluated by using Weibull distribution. In actual practice, the real tool life rarely matches with the forecasted values. In various mechanical failures it has been observed that machines degrade according to severity. If the fault is diagnosed at early stages, major repairs can be controlled or prevented [9]. It has been observed that the greatest risk of failures occurred at the early period of its installation.[10] If component survived through this phase then it enters into stable phase with fewer failures, the stable period does not long fully but a final stage comes when the chance of failure starts again. On plotting these stages, the curve obtained is known as "Bath tub curve" [11]. In this case study we pay our attention toward the paint industry as these types of production unit are highly prone to failure. The plant consist of different essential components but in our study we pay a confined attention toward Ball Mill. The main objectives of this research is to emphasis on the reliability and availability of the system that play a very vital role in the successful and proper growth of the manufacturing unit. This study helps us to determine "Probability distribution functions", "Life time distributions" "Fitting Reliability distributions using Hazard Plotting", "Provide an understanding of life data analysis", "Failure forecasting and prediction", "Evaluating corrective action plans", "Maintenance planning and cost effective replacement strategies". This study will help many of the leading organization as this study will act as a benchmark for them and the can plan their maintenance schedule based on the outcomes of this study.

II. METHODOLOGY

Weibull distribution is very flexible and can through an appropriate choice of parameters and model many types of failure rate behaviors. This distribution can be found with two or three parameters; scale, shape and location parameters. Over the years, estimation of the shape and scale parameters for a Weibull distribution function has been approached through number of methods, some are graphical and others are analytical. For predicting the machines or tool life Weibull distribution has been selected as the best model [7]. The primary advantage of Weibull analysis is the ability to provide reasonably accurate failure analysis and failure forecasts with extremely small samples. Solutions are possible at the earliest indications of a problem without having to "crash a few more." The Weibull plot is extremely useful for maintenance planning, particularly reliability centered maintenance. Beta, (β) tells the analyst whether or not scheduled inspections and overhauls are needed. If β is less than or equal to one, overhauls are not cost effective. With s β greater than one, the overhaul period or scheduled inspection interval is read directly from the plot at an acceptable probability of failure. For wear out failure modes, if the cost of an unplanned failure is much greater than the cost of a planned replacement, there is

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an optimum replacement interval for minimum cost. Weibull Distribution, is an empirical relation that relates the data of the machines working with time. Weibull distribution includes two important parameters shape factor **(β)** and scale parameter **(α)**.The trace of physical failures is represented by factor β and time to failure by scale factor (α). The slope β also indicates the behavior of failure. This distribution is useful when parts fail due to random external influences and not due to wear out. In this paper an attempt is made to estimate the system reliability using Weibull distributions method and computation is made using "Minitab 17" software.

III. Reliability Prediction

Reliability is the probability for the machine that it will not fail and one of the measure of quality [12]. The probability function mathematically is defined as:- **F (t) =1-=** $e^{-(t/\eta)^{\beta}}$ [13]. Mean down time is defined as average time while which the machine fails or breakdowns; where mean down time between failures is defined as expected average time between breakdowns.[15**]** **MTTR** = $\int_0^{\omega} R(t)\,dt$ $=\int_0^{\omega} e^{-\lambda t}$ **dt.** Availability defines or measures the performance of a unit or machine. It is also defined as the probability that a system or unit or machines does not fail and perform better [16].Reliability is very useful in risk analysis. The risk analysis helps in defining the cause of failures and how to improve availability of a unit or system [17]. The technique or procedure of restoring the machine into full running condition after a failure or breakdown is known as maintainability. In order to achieve the goals like Reliability, Availability and Maintainability (RAM); it is essential to realize the utility of probability.[18]

Relation between Reliability, Availability and Maintainability (RAM) [19]

Reliability	**Maintainability**	**Availability**
Constant	Decrease	Decrease
Constant	Increase	Increase
Increase	Constant	Increase
Decrease	Constant	Decrease

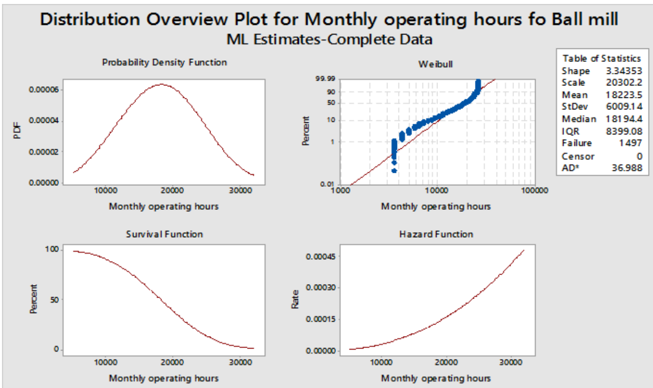
Machine maintenance is gaining importance in industry because of the need to increase reliability and availability and to decrease the possibility of production loss due to the machine breakdown. The primary objective of maintenance is to achieve the specified availability as long as possible by using the methods of replacement, repair, service and modification of the components. Reliability prediction is the process of analyzing and computing the failure rate of the machines/components. For the reliability prediction some essential parameters MTBF, MTTR and Availability are evaluated [14]. It has also been observed from literature that various manufacturing units the main cause of decreased production is breakdown. In our case study we select a paint manufacturing unit. After that we prepared a questionnaire and go through a pilot survey. On the basis of this survey we collect the data form the maintenance department of the manufacturing unit. It has been found that the unit comprises of various machines which are frequently prone to the failure. After observing the data that was collected from the survey we started working on the case study that how can be the availability and reliability of the machine can be improved, so that the unit can achieve its maximum productive goal.

IV. Data Collection And Interpertation

It is the first step which is to be taken when we are planning and implementing a case study because when collected data is incomplete, the researcher is often face with difficulties in analyzing the data, which can lead to a the quality of the intended research been poor. For the effectively collection of the data we go through a “Maintenance Effectiveness Survey” in this we prepare a “Questionnaire” for the effective and accurate collection of data. The availability of accurate breakdown maintenance data is one the essential requirement for reliability and failure analysis. For the present analysis, the maintenance data of paint manufacturing plant for the three years [2011 January to December 2013] has been collected. The data collected contains machine breakdown, causes of failures and machinery involved and previous remedial measures adopted by maintenance personnel’s of manufacturing units for breakdowns. The failure data collected from the paint manufacturing unit shows a number of failures /breakdown correspondingly to individual machinery are tabulated as under.

V. Result And Analysis

After statistically examining and evaluating the data using “MINITAB 17”, it is found that the value of the SHAPE FACTOR (β) is 3.34 for ball mill. These values of the shape factors (β) > 1 which predicts that the components are highly prone to failure which is not acceptable.The Reliability estimation of different components of the paint industry going through frequent breakdowns are obtained for the values of shape factor; It focuses the performance of Ball Mill, Horizontal Sand Mill and Cooling Tower during the period of January, 2011 to December 2013.



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Estimation of Availability for Ball Mill															
S. No.	Month	Running Time (Hrs)	Down Time (Hrs)	No of Failure	MTBF (Hrs)	Hazard Rate	MDT (Hrs)	Aop	MTTR HRS	Ain	Cumulative monthly operating time (Hours)	Down Time	No. of failures	% Failures	Cumulative Failures
1.	Jan 11	744	0	0	***	0	**	1	0	1	744	0	0	0	0
2	Feb	672	0	0	***	0	**	1	0	1	1416	0	0	0	0
3.	Mar.	744	0	0	***	0	**	1	0	1	2160	0	0	0	0
4.	April	720	0	0	***	0	**	1	0	1	2880	0	0	0	0
5.	May	744	54	5	138	.0072	54	.71	10.2	.93	3624	54	5	19.23	19.23
6.	June	720	0	0	***	0	**	1	0	1	4344	0	0	0	19.23
7.	July	744	20	1	724	.0014	20	.97	20	.97	5088	20	1	3.84	23.07
8.	Aug.	744	0	0	***	0	**	1	0	1	5832	0	0	0	23.07
9.	Sept	720	0	0	***	0	**	1	0	1	6552	0	0	0	23.07
10	Oct	744	0	0	***	0	**	1	0	1	7296	0	0	0	23.07
11	Nov	720	0	0	***	0	**	1	0	1	8016	0	0	0	23.07
12	Dec	744	0	0	***	0	**	1	0	1	8760	0	0	0	23.07
13	Jan 12	744	40	1	704	.0014	40	.94	40	.94	9504	40	1	3.84	26.91
14	Feb	672	0	0	***	0	**	1	0	1	10176	0	0	0	26.91
15	Mar	744	38	2	353	.0028	38	.90	19	.94	10920	38	2	7.69	34.6
16	April	720	0	0	***	0	**	1	0	1	11640	0	0	0	34.6
17	May	744	0	0	***	0	**	1	0	1	12384	0	0	0	34.6
18	June	720	0	0	***	0	**	1	0	1	13104	0	0	0	34.6
19	July	744	0	0	***	0	**	1	0	1	13848	0	0	0	34.6
20	Aug.	744	45	2	349.5	.0028	45	.88	22.5	.93	14592	45	2	7.69	42.29
21	Sept	720	20	1	700	.0014	20	.97	20	.97	15312	20	1	3.84	46.13
22	Oct	744	20	1	724	.0013	20	.97	20	.97	16056	20	1	3.84	49.97
23	Nov	720	0	0	***	0	**	1	0	1	16776	0	0	0	49.97
24	Dec	744	0	0	***	0	**	1	0	1	17520	0	0	0	49.97
25	Jan 13	744	20	1	724	.0013	20	.97	20	.97	18264	20	1	3.84	53.81
26	Feb	672	0	0	***	0	**	1	0	1	18936	0	0	0	53.81
27	Mar	744	0	0	***	0	**	1	0	1	19680	0	0	0	53.81
28	April	720	30	2	345	.0028	30	.92	15	.95	20400	30	2	7.69	61.5
29	May	744	0	0	***	0	**	1	0	1	21144	0	0	0	61.5
30	June	720	0	0	***	0	**	1	0	1	21864	0	0	0	61.5
31	July	744	0	0	***	0	**	1	0	1	22608	0	0	0	61.5
32	Aug.	744	18	1	726	.0014	18	.97	18	.97	23352	18	1	3.84	65.34
33	Sept	72	58	9	73.5	.013	58	.56	6.4	.91	24072	58	9	34.56	99.9
34	Oct	744	0	0	***	0	**	1	0	1	24816	0	0	0	99.9
35	Nov	720	0	0	***	0	***	1	0	1	25536	0	0	0	99.9
36.	Dec	744	0	0	***	0	**	1	0	1	26276	0	0	0	99.9

Cumulative Failures of Ball Mill							
S.No	Month	Monthly Operating Time (Hours)	Cumulative monthly operating time (Hours)	Down Time	No. of failures	% Failures	Cumulative Failures
1.	Jan 11	744	744	0	0	0	0
2	Feb	672	1416	0	0	0	0
3.	March	744	2160	0	0	0	0
4.	Apr	720	2880	0	0	0	0
5.	Ma	744	3624	54	5	19.23	19.23
6.	Jun	720	4344	0	0	0	19.23
7.	Jul	744	5088	20	1	3.84	23.07
8.	Aug	744	5832	0	0	0	23.07
9.	Sept	720	6552	0	0	0	23.07
10.	Oct	744	7296	0	0	0	23.07
11.	Nov	720	8016	0	0	0	23.07
12.	Dec	744	8760	0	0	0	23.07
13.	Jan12	744	9504	40	1	3.84	26.91
14.	Feb	672	10176	0	0	0	26.91
15.	Mar	744	10920	38	2	7.69	34.6
16.	April	720	11640	0	0	0	34.6
17.	May	744	12384	0	0	0	34.6
18.	June	720	13104	0	0	0	34.6
19.	July	744	13848	0	0	0	34.6
20.	Aug	744	14592	45	2	7.69	42.29
21.	Sept	720	15312	20	1	3.84	46.13
22.	Oct	744	16056	20	1	3.84	49.97
23.	Nov	720	16776	0	0	0	49.97
24.	Dec	744	17520	0	0	0	49.97
25.	Jan13	744	18264	20	1	3.84	53.81

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26.	Feb	672	18936	0	0	0	53.81	
27.	Mar	744	19680	0	0	0	53.81	
28.	April	720	20400	30	2	7.69	61.5	
29.	May	744	21144	0	0	0	61.5	
30.	June	720	21864	0	0	0	61.5	
31.	July	744	22608	0	0	0	61.5	
32.	Aug	744	23352	18	1	3.84	65.34	
33.	Sept	720	24072	58	9	34.56	99.9	
34.	Oct	744	24816	0	0	0	99.9	
35.	Nov	720	25536	0	0	0	99.9	
36.	Dec	744	26276	0	0	0	99.9	

S. No.	**Name of the Different Machines**	**Shape Parameters from weibull Plot (β)**	**Mean Operating hours (t)**	**Reliability R(t)**	**Failure Probability F(t)**
1.	BALL MILL **[1]**	3.34	18223.5	49.9%	50.0%

VI. CONCLUSION

In this study the main objective is to estimate the reliability and availability of specific components of a paint manufacturing unit. Keeping in view all aspects of unit's performance with particular reference to machine breakdown, it is of great interest to formulate the accurate maintenance policy to reduce the breakdown, reduce downtime and increase the productivity of the manufacturing plant. In the initial stage of the analysis the past breakdown data of the unit's components of ball mill wasas selected. It has been observed during the reliability and availability analysis of the ball mill, cooling tower, and horizontal sand mill due to components failure the reliability comes out to be 49.9%. Further it has also been observed that due to continues failure of the spare parts breakdown occurs and hence decreases reliability, availability and productivity of the unit. It can be concluded that in order to sustain in the competition era or to achieve maximum production goal and a long term commitment continues monitoring of the maintenance technology is required. By implementing a proper maintenance schedule and making full use of maintenance employees in the production process the improvement can be expected in these manufacturing units.

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