International Journal of Advanced Research Methodology in Engineering & Technology,
Volume 1, Issue 2, March 2017, ISBN 978-1-63535-889-6

Reliability Investigation Of Shaliwahana 12MW MSW Green Power Plant

Mr.A.Suresh
Research Scholar (part time), Department of Mechanical Engineering,
K.L.University, AndraPradesh, India
Head of the Department & Assistant Professor
Department of Mechanical Engineering,
SCIENT Institute of Technology, Hyderabad,
India, Email:suri0341@gmail.com

Dr. G.Diwakar
Professor, Department of Mechanical Engineering K.L.University Andhra Pradesh India. Email: diwakar4236@kluniversity.in

Abstract— The performance of the machine is an important consideration for the productivity of the system. Any machine or system that has less number of failures is preferable and it is of utmost importance. This paper examines and investigates the performance of the machines such as Boiler and Turbine, with an emphasis on the reliability and availability of these components of the Shaliwahana 12MW Municipal Solid Waste Power Plant. These components are subjected number of failures during its life cycle. All the failures of boiler and turbine were taken from four years. Then the trend analysis after that the reliability characteristics of boiler and turbine were estimated.

Keywords—Reliability; Availability; Boiler; Turbine;

I. INTRODUCTION

The reliability or availability of any machine can be evaluated based on the three types of failure states such as Number of failures, frequency of failures and cost of failures. Here this paper discusses the number of failures and frequency of failures based on these the reliability and availability calculations were done. For this the machine data is collected, here in this case the machine do refers the boiler and turbine of the Shaliwahana Municipal solid waste 12MW green power plant and the data is collected from the years 2010 to 2014. Each year failure data is calculated and thereby that data is so refined in order to calculate the Time Between failures (TBF's) and Time To Repair (TTR's). These two parameters are very essential to find the trend of the machines weather they are having a positive trend or negative trend or no trend in association with the machine life cycle that is Bath tub curve specifically in the condition where they are either in the infant age or Youth age or Old age. There by the suitable models were applied for them based on the trend test results. The procedure is as follows.[7,10]

Step1: Identification and definition of problem of setting the Hypothesis.

Step 2: Collection of relevant data

Step 3: Removal of inconsistencies and errors in data

Step 4: Trend tests and correlation tests

Step 5: TTT plots to examine exponential fit

Step 6: Fitting the suitable model

Step 7: Confirmation tests and goodness of fit

Step 8: Reliability cantered maintenance planning and scheduling.

II. PROCEDURE

A. The Trend tests (based on TBF)

The following graphical tests were used here to find the trend presented for the boiler and turbine.[5,14] They are Cumulative plot test, Eye ball test, Karl Pearson's correlation test in this again two types first (i) vs(i-1) and second (i) vs (i-2), Serial correlation test in this first (i) vs(i-1) and second (i) vs (i-2). This analogy of using TBF is further helpful in the calculation of the reliability of the machine.

B. The Trend tests (based on TTR)

The same tests as used for the trend tests conducted based on the TBF also used here to find the trend. This TTR based calculation is so needed for the calculation and assessment of the availability.

The graphs and tables of these tests were included in the annexure. In the above table 2010T refers to the turbine in the year 2010, it is taken as a unit like one turbine is taken as four units for the four consecutive years and likewise one boiler is considered as four units for the years 2010 to 2013. In the present work the turbine for four years and also boiler for four years were treated as machines[13,15].

Hence each machine is again analysed based on TBF for the calculation of reliability and been analysed based on TTR for the calculation of availability. The flow chart of this process is as follows. Generally a machine is failed means it can two possibilities one is repairable failure and the other is non repairable failure.[3,8,16] This work and these machines are treated as repairable machines. Once the machine is failed it can be repaired. So it takes some time to repair and also based on the failures the time between failures also computed there after the cumulative time between failures and cumulative time to repair and also mean values of the TBF and TTR also calculated for the calculation of the trend that is presented in the machines.

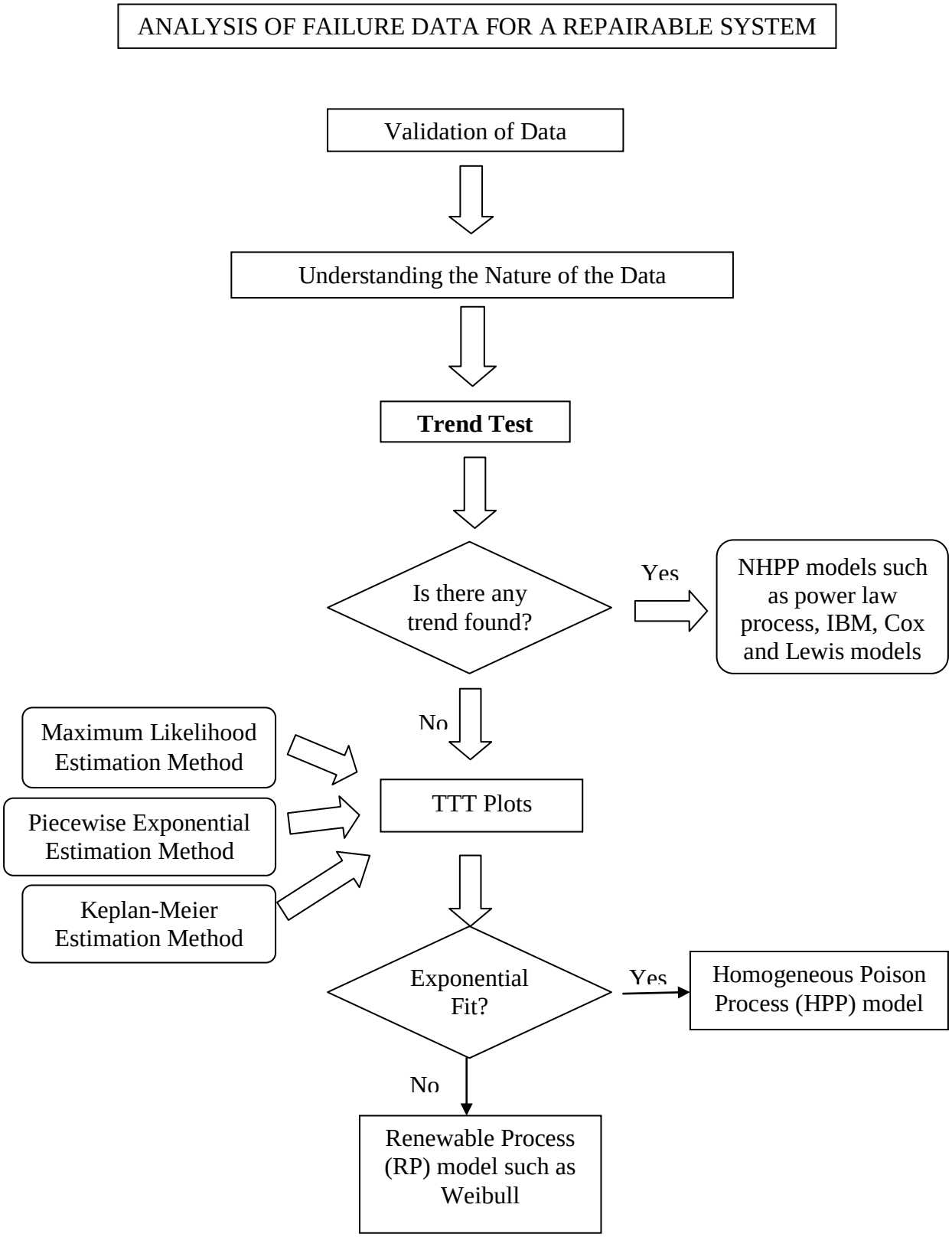

ANALYSIS OF FAILURE DATA FOR A REPAIRABLE SYSTEM
Validation of Data
Understanding the Nature of the Data
Trend Test
Is there any trend found?
Yes
NHPP models such as power law process, IBM, Cox and Lewis models
No
Maximum Likelihood Estimation Method
Piecewise Exponential Estimation Method
Keplan-Meier Estimation Method
TTT Plots
Exponential Fit?
Yes
Homogeneous Poison Process (HPP) model
No
Renewable Process (RP) model such as Weibull

Fig 1 Method of reliability analysis[2,17,18]

	TBF based						
Item	**Cumulative Plot Test**	**Eye Ball Test**	**Karl Pearson (i-1)**	**Karl Pearson (i-2)**	**Serial Correlation (i) vs (i-1)**	**Serial Correlation (i-1) vs (i-2)**	**Result**
2010 T	Weak - ve Trend	Weak + ve Trend	+ ve Trend	+ ve Trend	+ ve Trend	+ ve Trend	+ ve Trend
2011 T	No Trend	Weak + ve Trend	Weak + ve Trend	Weak + ve Trend	+ ve Trend	+ ve Trend	+ ve Trend
2012 T	Weak + ve Trend	Weak - ve Trend	Weak + ve Trend	Weak + ve Trend	Weak + ve Trend	Very Weak + ve Trend	+ ve Trend
2013 T	Weak - ve Trend	Weak + ve Trend	Weak + ve Trend	Weak + ve Trend	+ ve Trend	+ ve Trend	+ ve Trend
2010 B	Weak - ve Trend	Weak + ve Trend	Weak - ve Trend	Weak + ve Trend	Weak - ve Trend	very Weak - ve Trend	- ve Trend
2011 B	Weak + ve Trend	Weak - ve Trend	Weak + ve Trend	Weak - ve Trend	+ ve Trend	Weak - ve Trend	+ ve Trend
2012 B	Weak - ve Trend	Weak + ve Trend	Weak + ve Trend	Weak + ve Trend	Weak + ve Trend	Weak + ve Trend	+ ve Trend
2013 B	Weak - ve Trend	Weak + ve Trend	Weak + ve Trend	Weak + ve Trend	+ ve Trend	+ ve Trend	+ ve Trend
	TTR based						
Item	**Cumulative Plot Test**	**Eye Ball Test**	**Karl Pearson (i-1)**	**Karl Pearson (i-2)**	**Serial Correlation (i) vs (i-1)**	**Serial Correlation (i-1) vs (i-2)**	**Result**
2010 T	Weak + ve Trend	Weak + ve Trend	Weak - ve Trend	Weak - ve Trend	Weak - ve Trend	- ve Trend	- ve Trend
2011 T	No Trend	Weak - ve Trend	Weak - ve Trend	Weak - ve Trend	- ve Trend	weak- ve Trend	- ve Trend
2012 T	Weak - ve Trend	+ ve Trend	Weak + ve Trend	Weak - ve Trend	- ve Trend	weak - ve Trend	- ve Trend
2013 T	Weak - ve Trend	Weak + ve Trend	Weak - ve Trend	Weak - ve Trend	- ve Trend	weak - ve Trend	- ve Trend
2010 B	Weak + ve Trend	Weak - ve Trend	Weak - ve Trend	Weak + ve Trend	- ve Trend	Weak + ve Trend	- ve Trend
2011 B	No Trend	Weak + ve Trend	Weak - ve Trend	Weak - ve Trend	- ve Trend	weak + ve Trend	- ve Trend
2012 B	No Trend	No Trend	Weak - ve Trend	Weak + ve Trend	- ve Trend	- ve Trend	- ve Trend
2013 B	Weak + ve Trend	Weak - ve Trend	Weak - ve Trend	Weak - ve Trend	- ve Trend	Weak - ve Trend	- ve Trend

III. POWER LAW PROCESS

As all the machines were showing significant trend. Hence it can be taken under Non Homogeneous Poison Process (NHPP) as a part of that Power law process is considered for finding the reliability of the machines[4,11,12].

If data sets of repairable equipments or machines indicate presence of trend, NHPP can be used to model the failure data.

One of the most commonly used NHPP models is Power law process (PLP).

The estimate of reliability at age t when the random variable is, time to first repair, can be now estimated by

$$R_{(t)} = \text{Exp}\{-(t/\alpha)\}^{\beta}$$

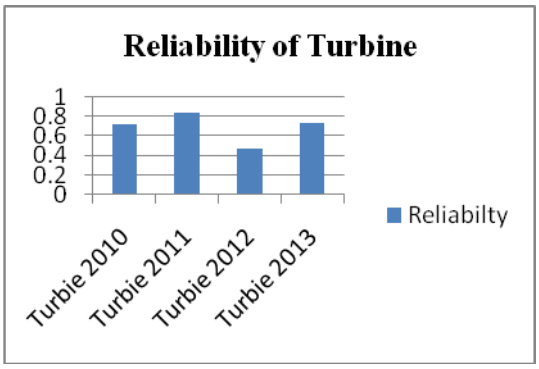
Reliability calculations

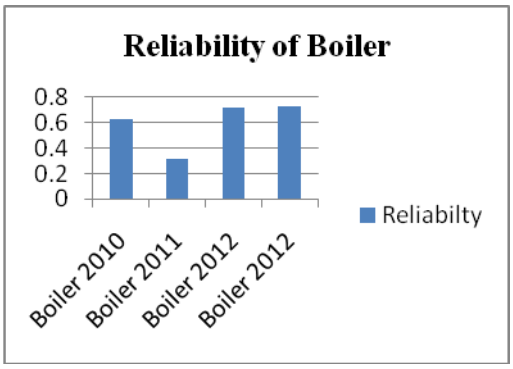
$$\alpha = \log t - \{ \log(\text{MCRF}) / \beta \} \; ; \; R(t) = \text{Exp}(-(t/\alpha))^{\beta}$$

The below table shows the calculations made based on the Time Between Failures.

Parameter	2010 T	2011 T	2012 T	2013 T	2010 B	2011 B	2012 B	2013 B
t	0.508	0.514	.511	.512	.52	.51	.508	.5125
Log t	-0.29	-.28	-.295	-.297	.284	-.292	-.294	-.290
Log(MCRF)	6.69	7.33	7.259	7.34	6.43	6.47	6.84	7.34
β	0.305	0.522	0.055	0.3	.181	-.022	.291	0.300
α	-22.22	-14.322	-132.91	-24.76	-35.24	294	-23.79	-24.75
R(t)	.729	.838	.478	.731	.627	.316	.7218	.731 6

And the comparison graphs are as follows:





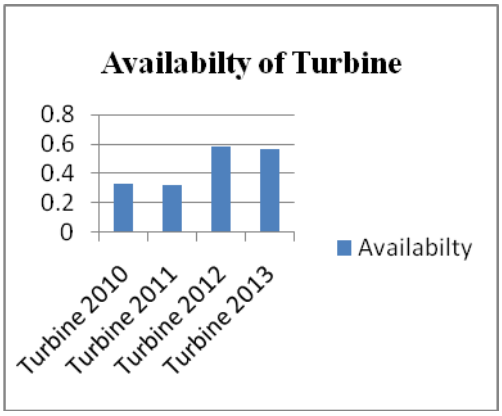
The maximum reliability is achieved by the machine unit Turbine 2011 that is 0.838 and the least reliability is for the machine unit Turbine 2012 that is 0.478. In the same way the maximum reliability is achieved by the machine unit boiler 2013 that is 0.731 and the least reliable machine is boiler 2011 that is 0.316. These are the working condition values and needs to be optimized further.

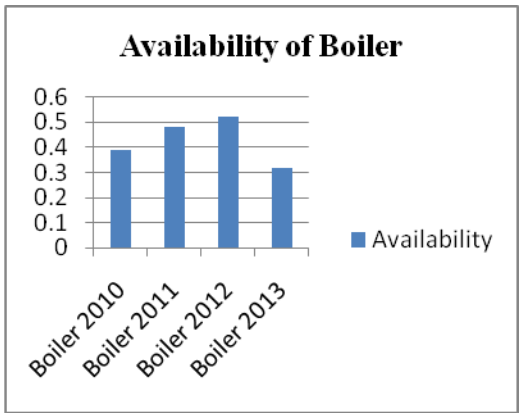
The below table shows the calculations made based on the Time To Repair.

Parameter	2010 T	2011 T	2012 T	2013 T	2010 B	2011 B	2012 B	2013 B
t	.515	.52	.51 1	.5125	.52	.5104	.508	.5
Log t	-0.288	-0.284	-.29	-.29	-.284	-0.29	-.294	-.3
Log(MCRF)	3.875	3.9	3.86	3.81	3.63	3.5	3.53	3.3

β	-0.019	-0.026	0.16	.137	-. 042	.07	.105	-.1
α	203.6	149.72	-24.415	-2 8.10	86.14	-50.94	-33.91	32.7
R(t)	.326	.313	0.5835	.561 1	.389	.484	.525	.318

And the comparison graphs are as follows:

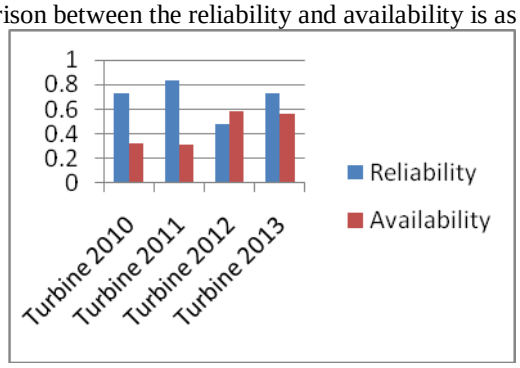


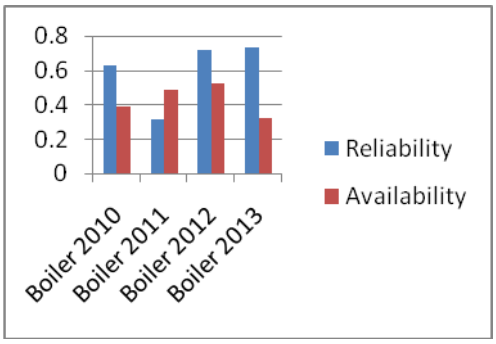


The maximum availability is achieved by the machine unit Turbine 2012 that is 0.5835 and the least availability is for the machine unit Turbine 2011 that is 0.313. In the same way the maximum availability is achieved by the machine unit boiler 2012 that is 0.525 and the least available machine is boiler 2013 that is 0.318. These are the working condition values and needs to be optimized further.

Furthermore the comparison of the reliability and availability were shown in the following graphs for the understanding of the gap between the reliability and the availability of the machines as the gap must be minimized in order to optimize the system and its performance hence it has a broad scope for the optimization of the reliability and availability. .

The comparison between the reliability and availability is as follows.





So much of variations have found in the machines between the reliability and availability. The maximum difference in the reliability and availability in the case of machine turbines is Turbine 2011. Likewise minimum difference is for the machine unit Turbine 2012. Similarly in the case of boilers also boiler 2013 has got maximum difference between its reliability and availability. And it is minimum for boiler 2011. These differences have to be optimized.

In addition to the above correlations the following ey parameters values have obtained like follows. These are needed for the optimization of the reliability and availability.[1,6,9]

T(mode)= $\alpha*(1-1/\beta)^{1/\beta}$ = $-22.22*(1-(1/0.305))^{1/0.305}$=330 days
T(median)= $\alpha*(-\ln 0.5)^{1/\beta}$ = $-22.22*(-\ln 0.5)^{1/0.305}$=6.68 days
T(optimal)= $\alpha*(1/(\beta-1))^{1/\beta}$=$-22.22*(1/(0.305-1))^{1/0.305}$=73.25 days

T(char) = α (its value is equal to alpha α) = -22.22 days
B1 life = $\alpha*(-\ln 0.99)^{1/\beta}$=$-22.22*(-\ln 0.99)^{1/0.305}$=.625 days
B.1 life = $\alpha*(-\ln 0.999)^{1/\beta}$=$-22.22*(-\ln 0.99)^{1/0.305}$=.324 days

Summary of results

Trend Analysis

- Based on Reliability(TBF)
  - 4 out of 4 turbine modules showing positive trend.
  - 3 out of 4 boiler modules showing positive trend.
  - 1 out of 4 boiler modules showing negative trend.
- Based on Availability(TTR)
  - 4 out of 4 turbine modules showing negative trend.
  - 4 out of 4 boiler modules showing negative trend.

Power Law Process

- Based on Reliability(TBF)
  - 4 out of 4 turbine modules are deteriorating.

- 1 out of 4 boiler modules are improving.
- 3 out of 4 boiler modules are deteriorating.
- Based on Availability(TTR)
- 2 out of 4 turbine modules are deteriorating.
- 2 out of 4 turbine modules are deteriorating.
- 2 out of 4 boiler modules are improving.
- 2 out of 4 boiler modules are deteriorating.

Acknowledgements

We thank the management of the Shaliwahana Municipal Solid Waste 12MW Green Power plant for their support and cooperation.

References

1. Log Books of Boiler and Turbine in Base Workshop Shaliwahana 12MW MSW green power plant, Sultanabad.
2. *Dr.N.V.S Raju,* Plant Maintenance and Reliability Engineering.
3. *Patrick D. T. O'Connor,* Practical Reliability Engineering, 2002,4th Edition,
4. *Paul A. Tobias and David C. Trindade,* Applied Reliability, 1995, 2nd Edition.
5. ***De Souza****, Gilberto Francisco Martha,* Thermal Power Plant Performance Analysis.
6. *Ajit Kumar Verma, Srividya Ajit, Durga Rao Karanki,* Reliability and Safety Engineering.
7. *Neville W. Sachs,* Practical Plant Failure Analysis: A Guide to Understanding Machinery
8. *Andrew K.S. Jardine, Albert H.C. Tsang* , Maintenance, Replacement, and Reliability: Theory and Applications.
9. *Neil Bloom,* Reliability Centered Maintenance (RCM) : Implementation Made Simple: Implementation Made Simple
10. *John E Oakey,* Power Plant Life Management and Performance Improvement.
11. *Mohammad Modarres, Mark P. Kaminskiy, Vasiliy Krivtsov,* Reliability Engineering and Risk Analysis: A Practical Guide, 2nd Edition
12. *Jasbir singh, MR. Ram avtar jaswal,* Evaluation of reliability parameter of thermal power plant by BFT . E-ISSN 0976-3945
13. *Sunday Olayinka Oyedepo, Richard Olayiwola Fagbenle,* A study of implementation of preventive maintenance programme in nigeria power industry—Egbin Thermal Power Plant,
14. *N.V.S. Raju and Prof.K.Narayana Rao,* Trend analysis- a tool for Reliability centered maintenance.
15. *Venkata Sesadri Kumar Karriu,* A theoretical investigation of Efficiency Enhancement in Thermal Power plants
16. *D. N. Dewangan, Manoj Kumar Jha, Y. P. Banjare,* Reliability Investigation of Steam Turbine used in Thermal Power Plant
17. *Mr.A.Suresh,* Design of Reliability for Heavy Earth Moving Machinery using Reliability Centered Maintenance. ISBN No: 978-93-83842-28-5
18. *D.N.Dewagan, Manoj kumar Jha, Y.P.Banjare,* Reliability investigation of steam power plant - ISSN: 2319-8753