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RESEARCH ARTICLE

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AVAILABILITY ANALYSIS OF FORGING PRESS USING QUALITY TOOLS

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ABSTRACT

The Pneumatic forging press is use for manufacturing of various automobile components. Availability is very important for forging press to achieve production demand. Forging press is working continuously in three shifts. Many times due to sudden breakdown the availability decreases, according to this the availability is more essential. The objective of this paper is to improve the availability of forging press. For this work different quality tools are used to analyze the root cause of failure and corrective actions are taken as required. The Pareto analysis is carried out for identification of critical sub system and its components, the root cause analysis or cause and effect diagram is used for identification of the cause of failure and the why-why analysis is used for corrective actions. The forging press failure data is collected and sorted to analyze the Availability, Mean Time between Failure (MTBF), Mean Time to Repair (MTTR), Repair rate (μ) & Failure rate (λ). After this Root Cause analysis maintenance is carried out and Performance analysis is performed. The results of availability, MTBF, MTTR failure rate and repair rates are compared. This work is helpful for maintenance engineer to plan and decide maintenance policy, also to increase the availability and to reduce the downtime.

Keywords— Availability, MTBF, MTTR, Repair rate, failure rate, Pareto analysis, Cause and Effect diagram, Why-Why analysis.

INTRODUCTION

The Pneumatic forging press mainly used to manufacture different automobile components like crank shaft, connecting rod, end yoke, tube yoke and gear blank fork etc. The Pneumatic forging press is mainly operated by pneumatic or hydraulic controllers. Such press has different rated capacities from 630 ton to 10,000 ton. Such press has main system and its sub systems. The forging press mainly used for mass production of different automobile components. During online production forging press failure occurs frequently due to different causes which make it unavailable for production and the production demand is not accomplished. The main objective of the paper is to improve preventive maintenance action plan with the application of quality tools. Some studies on the quality tools application for machine performance analysis are reviewed and some of them are provided below

Samadhan et al. (1) introduced quality improvement in manufacturing processes using SQC tools to apply and the find out the root causes of the quality problems related to manufacturing of mechanical seal. The work shows utility of quality tools to find the root causes of the problems and eliminate them. Pratik et al. (2) showed that

Application of Quality Control Tools in Taper Shank Drills Manufacturing Industry. Thus manufacturing processes can be improved. Dalgobind et al. (3) carried out a root cause analysis in improvement of product quality and productivity root-cause identification for quality and productivity related problems are key issues for manufacturing processes. Sanjay et al. (4) investigated Scrap Reduction by using total quality management tools. Marjorie et al. (5) using the quality tools for failure analysis in mechanical systems of Industrial Bench Drill Presses. The quality tools (Ishikawa, 5W+2H, Brainstorming) relative to the study will be pointed out, as well as the findings in a qualitative and quantitative manner and the action plan made out as a solution to identified damages. Pankaj et al. (6) introduced quality tools to reduce Crankshaft forging defects. Mohamed et al. (7) investigated on the use of the basic quality tools for the improvement of the construction industry. Kiran & et al. (8) used Root Cause Analysis for Reducing Breakdowns in a Manufacturing Industry. Root cause analysis is conducted to find the root cause of breakdowns and some parallel improvement opportunities were also identified for implementation so as to reduce the downtime. Praveen Kumar R & et al. (9) investigated on analysis of breakdowns and improvement of preventive maintenance on 1000 ton hydraulic press.

This paper carries the performance analysis of forging press breakdowns along with the critical parts, which were under breakdown condition. Also the reason for the breakdown are analyzed and inspected by the method of cause & effect diagram and why-why analysis. By this analysis and methods the root causes of the breakdowns were identified. This in turn helped to develop and improve a new Preventive maintenance checklist for the forging press. This is helpful for the reducing idle time of press.

PROBLEM IDENTIFICATION

1000 ton Pneumatic forging press is a critical system. Presently preventive maintenance schedule of Pneumatic forging press is done accordingly to the supplier instruction manual. This maintenance schedule is over exceeding the minimum acceptable level of breakdowns. Due to this frequent breakdown, there is decreasing in production capacity and availability ,MTBF, MTTR and also increases failure rate and repair rate Hence here an attempt has been made to overcome the above draw backs by incorporating new preventive maintenance schedule and increase availability using the corrective action.

DATA COLLECTION

The data is collected from Trinity Engineers Pvt. Ltd ,Chinchwad, Pune in maintenance log book from 1 Feb 2014 to 29 Sept 2014.The collected data is sorted and represented in below.

The failure data are about the causes of breakdown of Pneumatic forging press. The failure data is sorted according to the breakdown hours. The data should also include the failure reasons related to press system and subsystem components, the failure data is shown in Table 1.

DETAILS OF FORGING PRESS

Pneumatic forging presses are employed for many applications like hot close die forging, Cold die forging, Trimming and Padding operations .There are quite a few types of forging presses in the market. Each different forging press offers different features making them ideal for a number of applications. Mechanical forging press converts rotational energy from a flywheel into the linear motion of a ram, onto which the top forging die is mounted. The total distance of ram movement, which is called the stroke distance, is fixed. There is typically a clutch that connects the flywheel to the eccentric (or crank) shaft. The load capability and ram speed are dependent on the position of the ram during it's up and down movement. The forging deformation only occurs during the last portion of the downward movement of the ram.

Mechanical presses are used for most high-volume applications, including cold-formed fasteners and precision parts, cold- and warm-formed automotive applications, and hot-forged gears for automotive drive trains. Typical forgings produced on a forging press are crank shaft, connecting rod end yoke tube yoke, steering knuckle and gear blank. The size of the forged component is proportional to the size of the press; and deep cavities can be filled. The forging presses having various subsystems are Pneumatics Kick out system (a), Clutch & Brake system (b), Counter balance cylinder system (c), Wiring control system (d), Frame member, Bed yoke & Ram assembly system(e) and Lubrication system(f).

Figure.1 Pneumatic forging press (1000 ton)

Table 1: Forging press subsystems failure details

Sr. No	Subsystem	Break down in number	Break down in (hrs.)	Failure Details
1	Pneumatics Kick out system (a)	14	12.2	Bottom ejection problem, top ejection problem & Air pipe problem.
2	Clutch & Brake system (b)	9	9.8	Bearing temperature problem, ram stroke problem, over run problem, under run problem, cam setting problem.
3	Counter balance cylinder system (c)	16	6.45	Low air pressure problem & Air leakage problem.
4	Wiring control system (d)	5	3.9 5	Foot switch wire problem, motor sparking lug problem, Main motor problem
5	Frame member, Bed yoke & Ram assembly system (e)	2	2.6	Bed height problem, Ram stopped down position.
6	Lubrication system (f)	4	2.5	Press jam problem, water leakage problem & hydraulic pump problem.
	Total	50	37.5	

PERFORMANCE ANALYSIS OF FORGING PRESS

Root Cause Analysis is a method that is used to address a problem in order to get to the root cause of the problem. It is used to correct or eliminate the cause and prevent the problem. Root Cause is the factor that, when you fix it, the problem goes away and doesn't come back. root cause analysis are various tools such as Pareto diagram, Cause and Effect diagram & 5-why analysis

PARETO ANALYSIS OF FORGING PRESS

Pareto analysis is used for the selection of a limited number of tasks that produce significant overall effect. The idea that by doing 20% of the work we can generates 80 % of the benefit. In this paper, Pareto analysis of Pneumatic kick out system, Clutch and Brake system, Counter balance cylinder system, Wiring control system Ram assembly system and Lubrication system carried out and failure frequency of critical component is obtained. From the Table 1 data is sorted and using for Pareto analysis to find the critical subsystem.

A Pareto chart was constructed as per the frequency of occurrences of each causes of forging press systems breakdown. From the chart it is clear that counter balance cylinder system (c) and Pneumatic kick-out system (a) are the major causes

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of the breakdown of the forging press. The counter balance cylinder system is breakdown in number of 16 times with 32 % breakdown. it is clear that this system is frequently fail but repair time is minimum in second major critical component is pneumatic kick-out system is breakdown in number 14 times with 28 % breakdown . It is clear that these systems are rarely failed but take more time to repair. The other systems are rarely fail and minimum repair time so; it is not critical system as compare to above two systems (a) and (c).

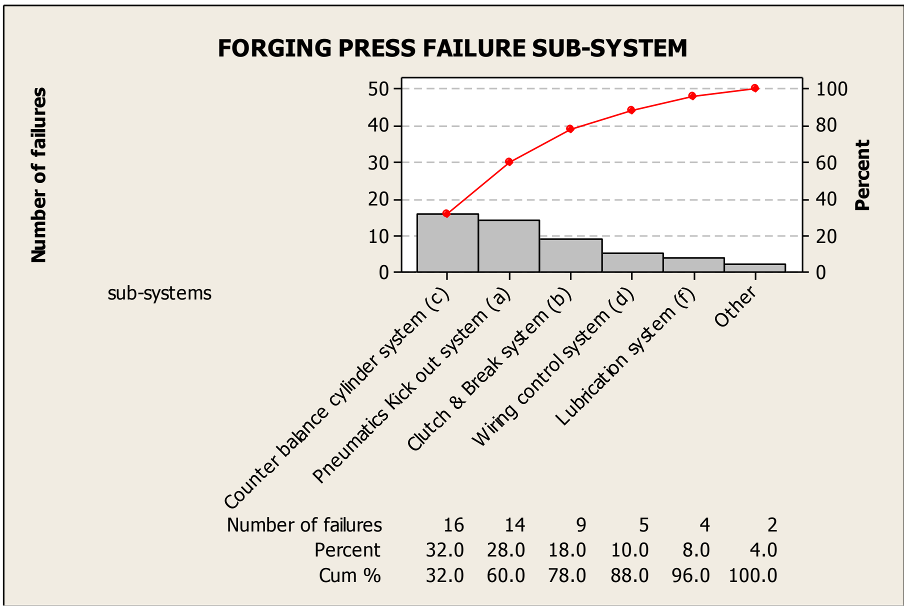

Figure.2 Pareto chart for Pneumatic forging press systems.

CAUSE AND EFFECT DIAGRAM

A cause and effect diagram, also known as an Ishikawa diagram or fishbone diagram which shows the graphically the defects and causes. Cause-and-effect diagram use under the six parameters likes Methods, Measurements, Man, Mother-Nature, Machine, Materials. While developing this diagram brainstorming technique very helpful because this technique involves more numbers of experts and it helps to identifying maximum number of causes. On fig.3 shows the Cause-and-effect diagram which defines the causes of margin of oversize during production Process with the help to brainstorming technique.

The Pneumatic forging press major failure problem are collected, and analysis cause of failure by using cause and effect diagram, details are represented in cause & effect diagram shown in fig. 3

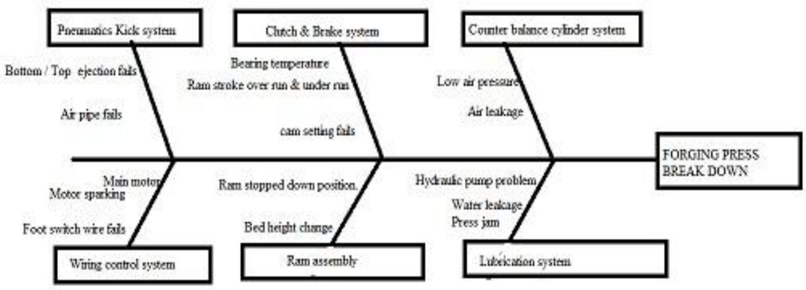

Figure.3 Cause & effect diagram of Pneumatic forging press systems

5-WHY ANALYSIS

Five why's is a root cause analysis tool. Not a problem solving technique. The outcome of a 5 Why's analysis is one or several root causes that ultimately identify the reason why a problem was originated. There are other similar tools as the ones mentioned below that can be used simultaneously with the 5 Why's to enhance the thought process and analysis.

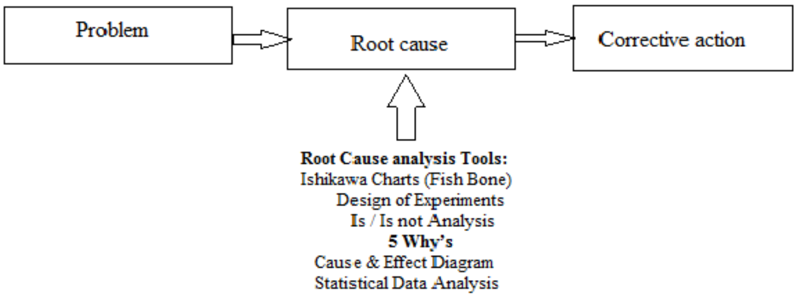

Figure.4 Steps of root cause analysis of Pneumatic forging press systems.

5- Why analysis of Pneumatic forging press is carried out & shown in Table 2 Similarly other type of problem can solve by using this method and identifying the root causes.

Table.2 why analysis of Pneumatic forging press

Problem. Press Jam		
Question	Answer	
What is your final action	maintain Grease up to level	
After : Press easily & smooth work	Yes	No
WHY	Answer	ACTION
Why1: Fill grease to press	Minimize Wear out	Fill grease
Why2: grease level down	ignore daily check up	Monitoring grease level
Why3: Press ram & bearing temperature increases	Sliding or direct contact increases	Fill grease between ram & bearing area

Table.3The corrective action on press subsystem

Sr. no	Problem	Correction action	Preventive action
1	Bottom ejection pin not work properly	The bottoms knock out system mainly operated by pneumatically. There is no. of sub components as pressure valve and ejection valve .The servicing done by cleaning and oiling .The pressure regulator monitor properly also maintain stroke length of ejection pin as per drawing dimension.	Pneumatic cylinder check pressure & stroke periodically
2	Top ejection pin not work properly	The pneumatic operated valve servicing done by cleaning and oiling. The monitoring pressure control valve properly	Pneumatic cylinder check pressure & stroke periodically
3	Press table main motor problem	The press table adjusted from motor driven. The motor has no. of components	All switch connection check daily & periodic maintenance done

		and wiring system will be line-up according to connection diagram and monitoring and check up done on contact kit properly.	
4	Over travel & under travel problem	The proximity sensory palace proper distance as per press ram stroke. The top and bottom stroke length monitoring and adjust properly. Also cam setting done.	Proper Turing of proximity sensor position distance from sensing board & check periodic proximity sensor cable
5	Low air pressure	The press mainly operated pneumatically by supply air from compressor. The air pressure line of leakage and joint check properly. Also air pressures adjust up to level.	Periodic maintenance of compressor & check daily air pressure up to level
6	Press jam	The press systems there are number of movable part each parts need greasing and oiling .The supply oil and grease by using pressure pump .Also monitoring grease level and leakage monitor properly	daily grease level & maintain periodically

FORGING PRESS PERFORMANCE ANALYSIS BEFORE AND AFTER RCA

The forging press performance analysis is carried out before and after RCA is as below details.

Forging press failure data is collected as following table 4.

Table.4 Production details forging press

	Before				After			
Period	February 2014	March 2014	April 2014	May 2014	June 2014	July 2014	August 2014	September2014
Press Available (hrs.)	460	493	485	503	512	528	502	505
Press uptime (hrs.)	292	278	260	283	330	350	340	330
Press Down time (hrs.)	168	215	225	220	182	178	162	175
Press failure in number.	8	8	7	6	5	5	6	5

The Availability, MTBF, MTTR, Failure rate & repair rate are calculated using the following formulae

$$Availability = \frac{\text{Up time}}{\text{Up time} + \text{Down time}} \times 100 \quad \ldots\ldots \qquad 1$$

$$\text{MTBF} = \frac{\text{Up time}}{\text{Numder of failure}}\ \text{hrs} \quad \ldots\ldots \qquad 2$$

$$\text{MTTR} = \frac{\text{Down time}}{\text{Numder of failure}}\ \text{hrs} \quad \ldots\ldots \qquad 3$$

$$\text{Failure rate } (\lambda) = \frac{1}{\text{MTBF}}\ \text{per hrs} \quad \ldots\ldots \qquad 4$$

$$\text{Repair rate } (\mu) = \frac{1}{\text{MTTR}}\ \text{per hrs} \quad \ldots\ldots \qquad 5$$

The availability, MTBF, MTTR, λ and μ are finding by using above formula and listed following table.

Table 5.Availability, MTBF, MTTR, Failure rate & repair rate Before & after Root cause analysis

BEFORE					
Period	Availability (%)	MTBF (hrs.)	MTTR (hrs.)	Failure rate(λ) per hrs	Repair rate(μ) per hrs
Feb 2014	63.47	36.5	21.0	0.027	0.047
March 2014	56.38	34.75	26.87	0.028	0.037
April 2014	53.60	37.14	32.14	0.026	0.031
May 2014	56.26	47.16	36.66	0.021	0.027
Average	57.42	38.88	29.16	0.025	0.035
AFTER					
Period	Availability (%)	MTBF (hrs.)	MTTR (hrs.)	Failure rate(λ) per hrs	Repair rate(μ) per hrs
June2014	64.45	66	36.4	0.015	0.027
July 2014	66.28	70	35.6	0.014	0.028
August 2014	67.72	56.66	27	0.017	0.037
Sept 2014	65.34	66	35	0.015	0.028
Average	65.94	64.66	33.5	0.015	0.03

The line graph is plotted using Table 5 for Availability, MTBF, MTTR, λ & μ before & after RCA. It is clear that more improvement in availability, MTBF, MTTR, λ & μ.

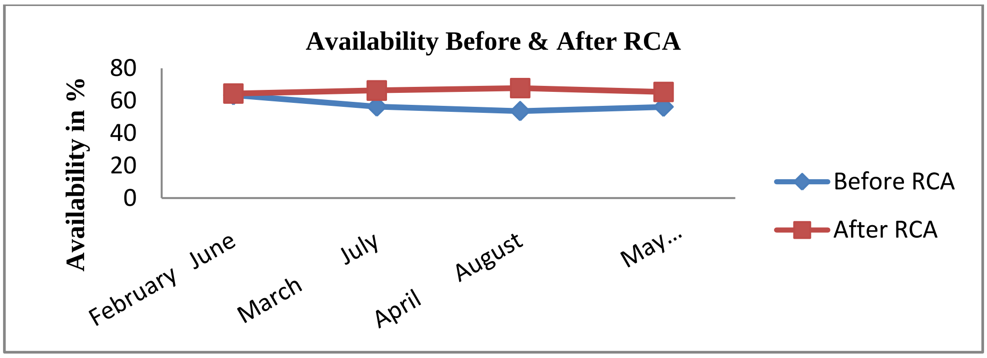

Fig.5 Availability before and after RCA

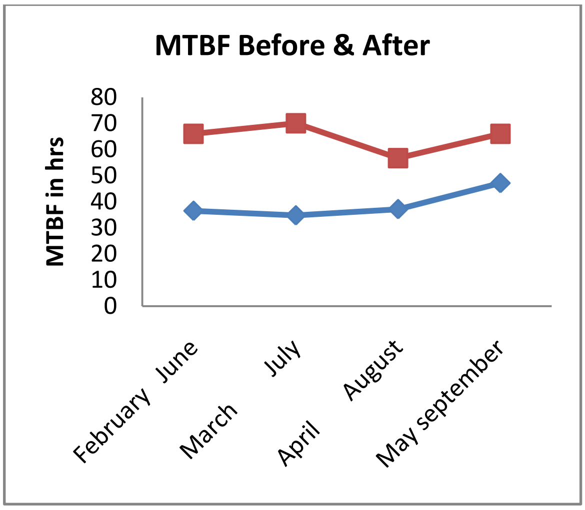

Fig. 6 MTBF before and after RCA

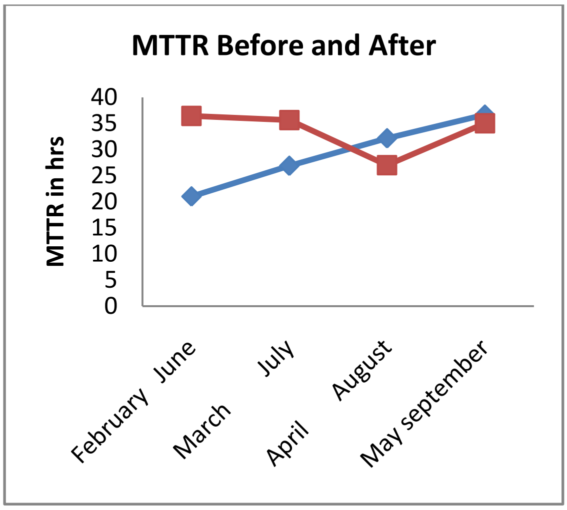

Fig.7 MTTR before and after RCA

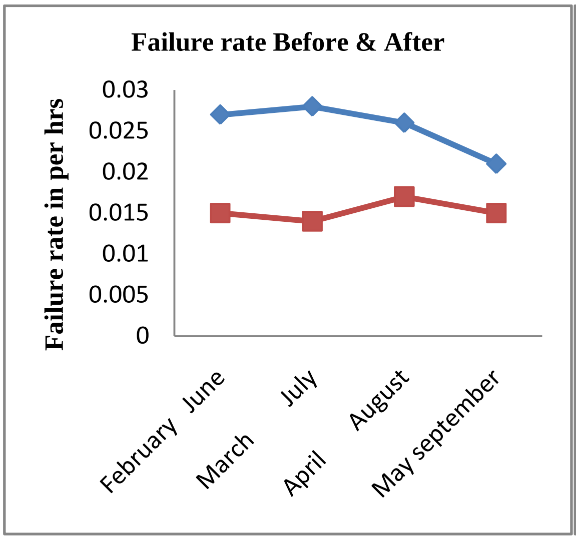

Fig 8 Failure rate before and after

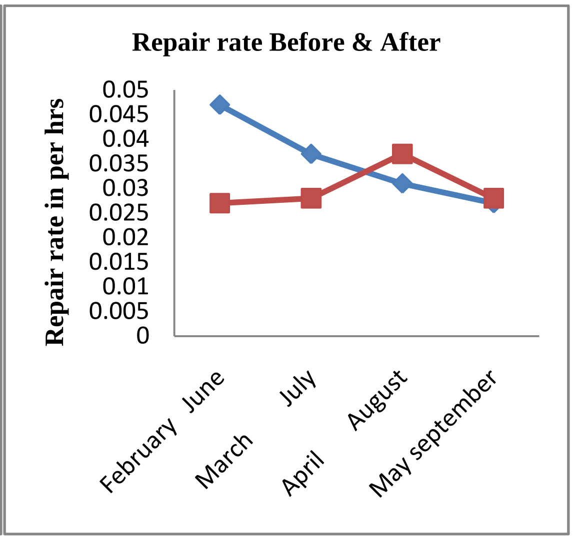

Fig.9 Repair rate before and after

RESULT & DISCUSSION

The forging press fails number of times during online production. The corrective action takes places online production but not long runs forging press take place again failure occur. So, availability of forging press is decreases and production and maintenance cost increases. The before corrective action the average availability = 57.42 %, Average MTBF = 38.88 hrs, Average MTTR = 29.16 hrs, Average Failure rate = 0.025 per hrs and Average Repair rate = 0.035 per hrs. The preventive maintenance policy and corrective action need to change because of to increase availability of forging press. By using corrective action the effects are observed as average availability = 65.94 %, average MTBF = 64.66 hrs, average MTTR = 33.5 hrs ,failure rate = 0.015 per hrs and repair rate = 0.03 per hrs. The comparison results are observed before and after RCA as following. Increase average availability = 8.52%. , Increase average MTBF = 25.78 hrs., Decrease MTTR but here increase average MTTR in minor amount = 4.34 hrs., Decrease average Failure rate = 0.01025 per hrs., Decrease average Repair rate = 0.0055 per hrs

CONCLUSIONS

This paper has been carried out on 1000 ton Pneumatic forging press performance analysis. The critical system & critical parts are identifying by using Pareto chart, which has been under breakdown condition is also identified and analyzed. Also the reason for the breakdown has been analyzed and some of the tools of root cause analysis like 5-why analysis, Cause & effect diagram are implemented to identify the actual cause of the breakdown. By this analysis and methods the root causes of the breakdowns were identified. This in turn helped to develop and improve a new preventive maintenance checklist for the press. This method is used to prevent the failure of equipment before it actually occurs. The average availability of critical press 1000 ton Pneumatic forging press after root cause analysis is increased to 8.52 %. Also the average MTBF of critical press after root cause analysis is increased to 25.78 hrs and MTTR is decreases but here minor amount of increases to 4.34 hrs and average failure rate decreases 0.01025 per hrs and average repair rate decreases 0.0055 per hrs respectively. After root cause analysis there is an improvement in the maximization of planned productivity. This is because of proper diagnosis of the existing system and by employing proper preventive maintenance schedule. Therefore whenever a breakdown occurs, the root cause of the breakdown has to be identified. Then some efforts should be made to improve this system using root cause analysis. It is also concludes that Availability, MTBF and MTTR is increases range and Failure rate and Repair rate is decreases range.

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