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Maintenance Reliability Using Computer Managed Maintenance System in Bearing Manufacturing Industry

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Abstract— One of the important parameter in bearing manufacturing industry is high quality products with high precision, good surface finish and accuracy. To achieve production targets and quality standards in bearing manufacturing industry, one of the key department is maintenance, which maintain machines to perform up to its highest capabilities. Reliability is the quality of being trustworthy or performing consistently well. Reliability is also key tool to measure maintenance system performance and capability. Under reliability there are few pillars which decide reliability score. Some of that key pillars are computerized maintenance management system (CMMS), planned maintenance, redesigning, roles and responsibilities. In particular pillars also specific tasks are perform to increase reliability score. In this paper Failure mode effect analysis is proposed for grinding machines to detect critical machines and increase reliability of maintenance activities on these machines. CMMS is one of the main measures for reliability score. CMMS helps to reduce data gathering. It helps for data analyzing also. CMMS is tool that can use for maintenance planning as well. In this work, CMMS is used for improving reliability of maintenance activities.

Keywords*—CMMS, FMEA, Maintenance, Reliability*

I. INTRODUCTION

Maintenance consists maintenance activities such as unplanned corrective maintenance, planned maintenance, and condition based maintenance [1]. Reliability is defined as the quality of being trustworthy or performing consistently well [2]. It is closely related to availability, which is typically described as the ability of a component or system to function at a specified moment or interval of time.

Reliability is one of the tools to measure the performance effectiveness of department as well as process. It is actually measure in terms of availability of machine, performance of the machine and quality rate of machine. Reliability key pillars are the ones which will help to improve its efficiency. Key pillars include overall maintenance strategies such as planned maintenance, autonomous maintenance, corrective unplanned maintenance, computerized maintenance management system, etc. as shown in table 1.

Now if performance of each pillar is increased then overall reliability will be increased.

Table I Reliability Pillars

	Reliability				
Improvement	Spare Parts management	Communication	Cost Management	Continuous Improvement	EEM
	2	3	2	3	3
Stability	Competence	PM	UCM	CMMS	AM
	3	2	2		3
Foundation	Vision	Roles and Responsibilities	Safety and Environment	KPIs	5S
	3	2	2	3	3

1	2	3	4	5	6
Fire Fighting		Maintaining		Promot ing	Inno vatin g

CMMS engagement in maintenance system, improving redesigning ability within department to increase continuous improvement, improving level of autonomous maintenance, and increasing competence level. One of the methods to identify critical equipment for increasing reliability is Failure Mode Effects and Analysis (FMEA).

Some of the strategy by which reliability can be improved are clarifying roles and responsibilities of each and every employee of maintenance system, by providing effective planned maintenance, by increasing. It is method to identify potential failure, and problems from the system [3]. There are two types of FMEA: Design FMEA and Process FMEA. The Risk Priority Number (RPN) is obtained by performing FMEA by considering number and frequency of occurrence, severity of problem and difficulty in detection on the scale from 1-10 for each one. RPN = Severity X Occurrence X Detection.

Jun and Huibin [4] implemented the FMEA in aircraft maintenance reliability program. The operational reliability of the aircraft system was improved and the model of time calculations was proposed. Bobin et. al [5] researched on the use of Failure Mode Effects and Analysis (FMEA) for improving the reliability of sub systems in order to ensure the productivity which in turn improves the bottom line of a manufacturing industry. Severity values, Occurrence number, Detection and Risk Priority Number (RPN) are some parameters, which need to be determined. These were the steps taken during the design phase of the equipment life cycle to ensure that reliability requirements allocated and that a process for continuous improvement exists. Pareek et. al. [6] reports the description of FMEA methodology and its implementation in a foundry in reducing rejections of bushes. They analyses it as a tool to assure products quality and as a mean to improve operational performance of the process. They not only implemented FMEA they also shown its effect by providing modified RPN number. The problems identified in the various steps of core making process contributing for high rejection are studied and analyzed in terms of RPN to prioritize the attention for each of the problem. The monetary loss due to core rejectionist considered as measure of risk. Villarini et. al. [7] developed a system of assessment of Reliability focused Maintenance using a FMEA in solar photovoltaic systems. Data was taken from a database of real maintenance processes. Wienker et.al. [8] implemented computerized maintenance management system. They concluded that management of maintenance in a large industrial operation is complex and managing this process effectively without computer-based support is almost impossible, The research paper tried to present the causes behind the low success rate achieved and outlines the essential elements that must be included to ensure a disciplined and well-resourced program that can deliver success

Faccio et. al. [9] introduced a new guidelines to create policies related to maintenance cost models, based on CMMS. Bokrantz et. al. [10], studied the implementation of tools and methods integrated through CMMS in Swedish company and found that there is lot of scope of implementing the same in industries. In their paper, Guillen et. al. [11], proved that implementation of CMMS in condition-based maintenance solution is more effective since data gathering in condition based maintenance is automatic. But their method cannot be applied in preventive maintenance techniques due to manual intervention for data gathering. Nzukam et. al [12] established that rather doing individually separate maintenance for each component, combine grouping maintenance is more effective and cost saving in HVAC plant using CMMS system. .Lopes et. al. [13] **presented** about requirements to start CMMS system. They involves several activities such as: planning of planned maintenance activities; timing of activities considering available resources and planned production; managing parts; analysis of data to lower the occurrence of failures and to increase performance of the maintenance activities. Industry adopted information management systems (CMMS) to get accurate information. Lorenzo et. al. [14] proposed that number of software related to CMMS are available, but they are required to be tailored according to specific requirement of company. Their work aimed to develop a CMMS for a manufacturing company. Reliability is one of the important tools to measure performance and capability of maintenance department. It is not just depended on one measure. It is related to terms like planned maintenance, computerized maintenance management system, continuous improvement etc. So, main objective is to improve reliability of maintenance. Righinie et. al [15] proposed the method to plan preventive maintenance planning based on criteria of cost and reliability. After going through literature survey, it was found that there is lot of scope of implementing FMEA and CMMS in industry for effective implementation of maintenance program.

II. METHODOLOGY

Implementation of FMEA: Failure Mode effect analysis is tool for defining effective planned maintenance. It is also necessary for identifying critical machines which will cause the production rate directly. Channel-1 is selected as a pilot channel for FMEA purpose. Under channel-1, OD grinding, face grinding and bore grinding (ID grinding) machines are selected.

First of all, it required to have list of systems, subsystem and parts of machine. For after this, the FMEA procedure should carried out as per standard format. In FMEA, several new fields are added such as criticality rank, maintenance type, new RPN number as well as frequency. Table 2 shows the matrix to decide criticality score.

From FMEA, out of all machines selected Outer Diameter (OD) grinding machine RPN rank is 10015. After FMEA new RPN number is 3464. RPN number and new RPN number of ID grinding machine is 3889 and 1901 respectively. RPN and new modifying RPN number for Face grinding machine is 3520 and 1753 respectively.

Table 2 Criticality rank matrix

		Aspects and Consequences to be Assessed Safety, Quality, Delivery, Cost, Working Climate, Environment				
	Risk Scoring	**Catastrophic consequence 5**	**Medium consequence 4**	**Marginal consequence 3**	**Negligible consequence 2**	**No consequence 1**
Probability	**Certain to appear 5**	25	20	15	10	5
	Almost Certain to appear 4	20	16	12	8	4
	Possible it might appear 3	15	12	9	6	3
	Rarely to appear 2	10	8	6	4	2
	Almost Incredible to appear 1	5	4	3	2	1

Red = Non acceptable risk (N)	Critical and remove risk. Consider re-engineering
Orange = Undesired risk (U)	Critical and reduce risk to the lowest level practically possible (ALARP)
Green = Acceptable Risk	

It is concluded that RPN number of OD grinding machine is higher than Face grinding and ID grinding machine. So, OD grinding machine is more critical as compare to other machines.

After completion of FMEA work, it is quite easy to use that data for maintenance planning. Maintenance planning can be done with the help of basic instruction provided to resolve the failure cause. Frequency of the maintenance can also be decided with the help of FMEA.

It is easy to use these data to create planned maintenance check-sheet. These planned maintenance check-sheet is provided to operator to attend planned maintenance of machine. Here, OD grinding machine is discussed for FMEA. So, discussion of same machine is continued for maintenance planning. Based on FMEA, new check sheet was created which includes points regarding machine maintenance planning. New check sheet format includes sub systems based on FMEA, time required to attend checkpoint, spares required and standard condition. Based on new check sheet maintenance was attended. For OD grinding, according to FMEA several frequencies are decided to attend specific type of task. In which, daily, weekly, monthly, quarterly, yearly check-sheet were created. It was also decided to improve autonomous maintenance. So, for improving effectiveness of autonomous maintenance, daily and weekly check sheets are hand over to machine operator for maintenance. Both old and new check sheets are shown which are updated based on FMEA done on machine. Here on OD grinding machine, it is recognized from the experience that monthly and quarterly planned maintenance is more critical.

Implementation of CMMS: CMMS plays huge role for making maintenance effective. CMMS helps to gather data, simplifying data and analyze data. CMMS also helps to reduced daily data updating work. Industry uses commercial software as a tool of CMMS. Industry introduced CMMS activity for increasing reliability of department. Software is online software which includes all maintenance activity. It also connects production department. It consists of following work:- Work order generation, Work order closer, Job monitoring, Maintenance planning work, Work supply planning, Data updating based daily activities and Data analyzing for future planning. To carry out these works properly, it is required to construct a proper maintenance system. System should consider flow of activities carried by maintenance. Each task is constructed as work order. Each work order consists of information like: position key, job type, job code key, planned start date & end date, category, description and responsible person.

CMMS needs a proper structured way for using it. It will be helpful and effective, if it is used in organized manner. For that purpose, it is necessary to define a structure under which all maintenance activity is described in CMMS. So, the structure should consider job type like Corrective unplanned maintenance (CMU), corrective planned maintenance (CMU), Inspection Jobs, planned maintenance (PM) and other job. Structure should also consider Job codes key which are subcategorized under job type. Structure is shown in figure 1.

Figure 1 Structure based on CMMS Job type

As shown in figure 1, structure is created based job type and job code key. But it does not describe individual roles and responsibilities. To describe that it is necessary to construct a structure which will connect CMMS activity as well as roles of each employee. So, mainly assistant managers take responsibilities of job controller, planner and execution. Under which all the operator level employees work. Manager is there to support whole department and takes responsibilities of all activities of department. Structure is closed loop, to find out loop holes and solve that loop holes.

As shown in figure 1, maintenance activities are categorized in CMU, CMP, PM, Inspection, CBM and other work. Other than that all other activities are part of CMMS system. Each CMMS activities or job code key is provided with an employee who is responsible for that activity. Other than that it also specifies detailed activities of CMU job. CMU job is nothing but breakdown only. CMU work order is created by production department also considered as customer for maintenance department. CMU activities assess by execution team of maintenance. After that if it is required then, it will be transfer to CMP. In CMP it is also categorized as shown in figure 1. After attending the CMU work. It is segregated based on time taken to complete breakdown. If it takes less than 2 hours then work order should be closed. If it takes 2 to 4 hours then it is considered for Why-Why analysis and why-why analysis should be carried out for finding reason and corrective action plan for breakdown. If breakdown resolving considers more than 4 hours, then breakdown elimination analysis should be done and corrective actions are added to work-order.

As a corrective action, there should be another work-orders generated as an outcome of breakdown. It will be CBM revision, run time failure, PM revision, AM revision, weak design etc. Among all PM revision is most important. Planned maintenance activity consists of PM planning, PM work order generation etc. CMMS help PM as reminder for PM date to execute. It is once feed into the CMMS where we can choose intervals like daily, monthly, quarterly, yearly etc. After completion of PM task, there will be close loop actions that are also again generated as PM task revision. After that, PM work order is closed. All jobs start from work order generation and end at work order close. Every closed work order is added to work order history.

Based on structure, software structure is also updated. Firstly it is channel and employee oriented. After that it is job type oriented. Both before and after images of dashboard are shown in figure 2 and figure 3 respectively.

Figure 2 Old CMMS dashboard

Figure 3 New CMMS dashboard

The dashboard will help to focus on main job type like CMU, CMP, Inspection and PM. Other details are also updated like spares, electrical and mechanical work orders. Previously, as discussed, PM is carried out with help of PM check sheet which consist of work instruction of each task. That check-sheet is firstly made in spread sheet only. After that, these check sheets are printed. These check sheets are to be stored in box file for data gathering. To eliminate data gathering issue, PM check-sheet is uploaded in CMMS. These uploaded check-sheet consists of information like work instruction, spares, time required to complete. After completion of PM the work instruction points are just to be tick in the checkbox provided. Here, both mechanical and electrical work instructions points are uploaded as shown in figure 4.

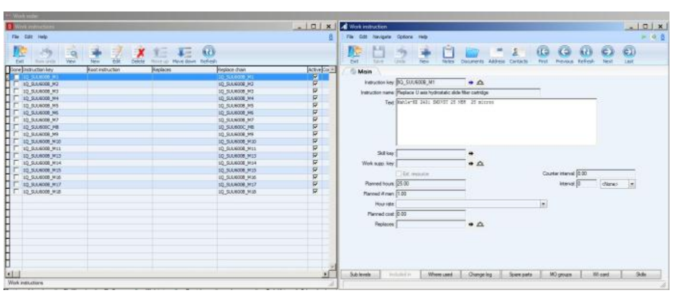

Figure 4 work instruction as PM check point

If any check-point is not completed then that check-point can be added to CMP work as shown in table 3.

Table 3 PM information

MO NAME: CH1_SUU600B EXTERNAL GRINDER	Revision No
	Revision Date
	Document Name
MO Key: 1-SUB-20	
DATE: 3/26/2018	PM FREQUENCY 3 M

III. RESULTS AND DISCUSSION

Reliability score improvement: Main focus of work was to improve reliability of maintenance. Reliability depends on all its reliability pillars. As a part of work, reliability pillars like PM, roles and responsibilities, CMMS and continuous improvement were focused. Under which work related to that pillar was carried out. The previous scores of each pillar are shown in Table 1. These score is marked at time of last assessment. As in PM firstly reliability score is 2. Under these project FMEA on channel 1 machines were carried out. Also maintenance planning was made effective also. So, Score for PM channel 1 jumps to 3 as shown in table 4. At the time of last assessment CMMS did not had much data to showcase. So, after this work CMMS score increases. In CMMS previous score was 1. After that whole system is developed. New structures are created to support system. CMMS engagement is increased by making planned maintenance work CMMS base. So CMMS score jumps to 3 from 1. As roles and responsibilities are also clarified based on these CMMS work, roles and responsibility score also jumps to 3.

IV. CONCLUSION

From, FMEA it can be concluded that OD grinding machine is more critical and sever among face grinding and bore grinding. So, there should be effective maintenance planning for the system. Maintenance strategy like PM, AM or run time failure has to be clear while doing maintenance planning. Based CMMS it is concluded that it is a system which can use for data collection and data analyzing. It can also use to reduce paper work and daily logbook of work.

Table 4 Improved Reliability score

2.86	Reliability				
Improvement	Spare Parts management	Communication	Cost Management	Continuous Improvement	EEM
	2	3	2	↗.5	3
Stability	Competence	PM	UCM	CMMS	AM
	3	↗.5	2	↗3	3
Foundation	Vision	Roles and Responsibilities	Safety and Environ	KPIs	5S

			ment		
	3	↗3	2	3	3

1	2	3	4	5	6
Fire Fighting		Maintaining		Promoti ng	Innov ating

It is concluded that reliability of maintenance is a measure of different terms like planned maintenance, continuous improvement and CMMS. It is not just defines as trustworthy and quality of performance, but it also define as to maintain trustworthy and quality of performance along with efficiently resolving issues. It is also concluded that reliability is increased by not just a single measure. It connected to each and every measure. For an example, if one focused to increase level of CMU, then chances of reducing PM level. So, all reliability measures are commonly important. It is also concluded that reliability is enough to assess performing capability and work effectiveness of maintenance department.

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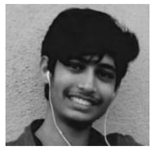

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