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IMPLEMENTATION OF RELIABILITY CENTERED MAINTENANCE IN LAMP MANUFACTURING UNIT

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ABSTRACT

In today's competitive environment many organizations are required to reduce their overall cost while maintaining the value and reliability of their assets. Reliability centered maintenance (RCM) helps organization to develop a systematic maintenance plan, meeting these requirements in a cost effective manner. This paper presents a case study of mechanical based failures in lamp manufacturing unit, which has significantly benefited through the successful implementation of RCM. Due to consistent low machine efficiency, there was an urgent requirement for analysis of the maintenance system. The results of study suggested that as regards to down time of mechanical failures are concerned in lamp manufacturing unit; sealing, mounting, threading, pumping and stem machine contributes 27%, 23%, 15%, 10% and 7% respectively. The uptime efficiency for mechanical failures has been improved by 2% through the implementation of RCM.

Key words: *Reliability centered maintenance, lamp manufacturing, down time, maintenance plan.*

1. Introduction

Over the past twenty years, maintenance has changed, perhaps more so than any other management discipline. The changes are due to a huge increase in the number and variety of physical assets (plant, equipment and buildings), which must be maintained throughout the world, much more complex designs, new maintenance techniques and changing views on maintenance organization and responsibilities [1]. In the face of this avalanche of change, managers everywhere are looking for a new approach to maintenance. They want to avoid the false starts and dead ends, which always accompany major upheavals. They seek a strategic framework, which synthesizes the new developments into a coherent pattern, so that they can evaluate them sensibly and apply those likely to be of most value to them and their companies. The philosophy, which provides just such a framework, is called Reliability Centered Maintenance (RCM) [2]. RCM may be defined as a process used to determine the maintenance requirements of any physical asset in its operating context [3-4]. The purpose of RCM is "to determine the maintenance requirements of any physical assets in its operating context". This is accomplished by answering seven questions about the equipment in order to determine what type of maintenance strategy to employ for the asset. RCM provides a flow diagram that tells you what type of maintenance to use based on the answers to the questions [5-6].

2. Case Study

For the present research work a leading lamp-manufacturing unit has been selected for the case study. In this bulb manufacturing unit three lines were running at a speed of 4250 bulbs/hour under general lighting services (GLS) manufacturing. Table 1 show over view of lamp making process [6]. The machine efficiency of all the three lines was not up to the mark due to probable flaws & gaps in the maintenance system. Due to consistent low machine efficiency, it results into the increase in the cost of production and as a result of which company finds it difficult to meet the production targets. Therefore there was a requirement for analysis & up-gradation of the maintenance system; hence RCM has been applied in order to improve the machine efficiency.

3. Objectives of Study

i. Identification the vital items which would contribute significantly in improving the machine efficiency.
ii. To improve the machine efficiency of GLS lines by application of RCM.

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Table 1: Bulb Making Process

Input	Process	Output
Flare Tube	Flare Making	Flare
Flare, L.I.W, Ext. tube	Stem Making	Stem
Stem, coil & emitter	Mount Making	Mount
Coated Shell, Mount	Sealing	Sealed Lamp
Sealed Lamp	Pumping	Pumped Lamp
Cap Cement	Cap Filler	Cemented Cap
Cemented Lamp	Capping	Capped Lamp

4. Methodology

The present work was carried out based upon MEDIC approach. A standard MEDIC format has been used for efficient problem solving.

M Map & Measure
E Explore & Evaluate
D Define & Describe
I Implement and Improve
C Control and Confirm

4.1 Map and measure

In M phase problems and various aspects related to problems were measured and put on paper. In order to identify type of problem last eight months data has been collected, analysed and presented by Run charts and Pareto charts. For the present case study,

Total Production Hours = 24 hrs/day
Machine efficiency = {24 – (Breakdown Maintenance + Preventive Maintenance) }/ 24

Line is stopped once in fortnight for PM for 12 hours. Fig. 1- 5 shows run chart for machine efficiency, break down maintenance (BM), preventive maintenance (PM), mean time to repair and mean time between failures respectively before RCM implementation. Fig. 6-8 shows trend analysis plots for PM, BM and machine efficiency. Forecasting reveals that with existing maintenance actions the PM & BM will keep on increasing and the machine efficiency will keep on dropping.

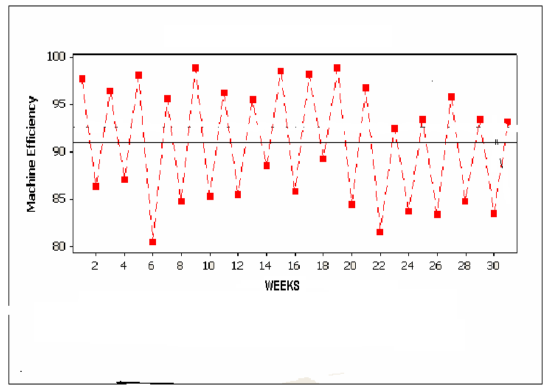

Fig. 1 Run Chart for Machine Efficiency

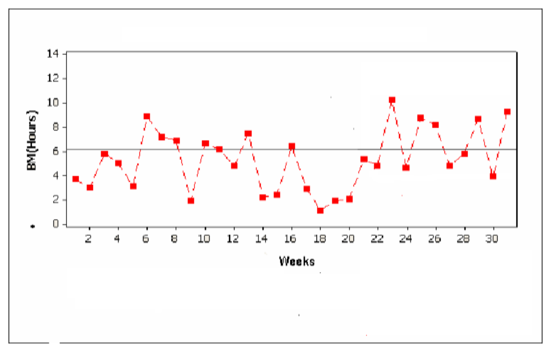

Fig. 2 Run Chart for Breakdown Maintenance

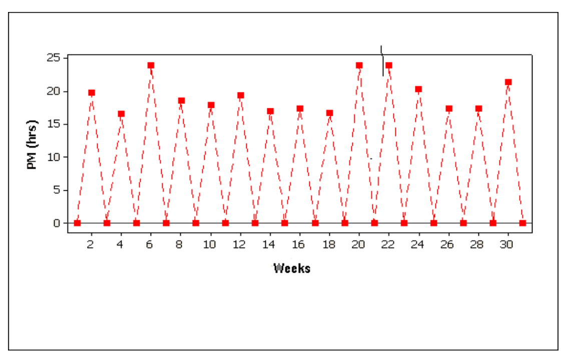

Fig. 3 Run Chart for Preventive Maintenance

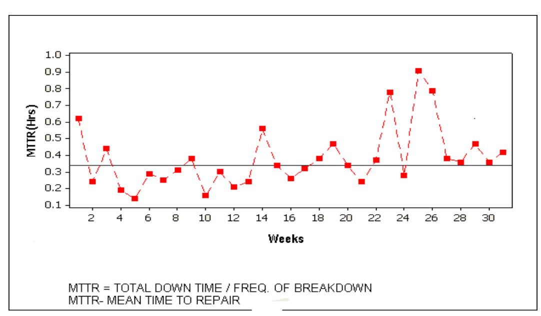

Fig. 4 Run Chart for Mean Time to Repair (MTTR)

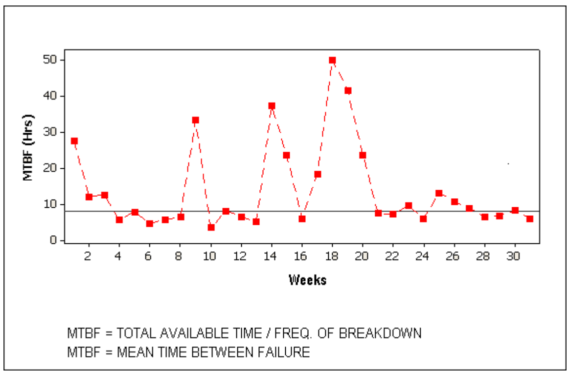

Fig. 5 Run Chart for Mean Time Between Failures (MTBF)

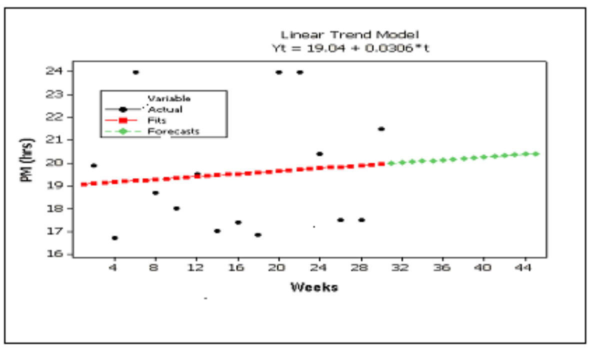

Fig. 6 Trend Analysis Plot for PM

4.2 Explore and evaluate

Pareto Chart

Pareto analysis was performed to separate the "vital few" from the "trivial many" sources of failures. These charts are based on the Pareto principle, which states that 80% of the problems come from 20% of the causes [7-8]. A Pareto chart is a special form of a histogram where the items have been sorted from most important to least important. Figure 9-13 shows Pareto chart for GLS line.

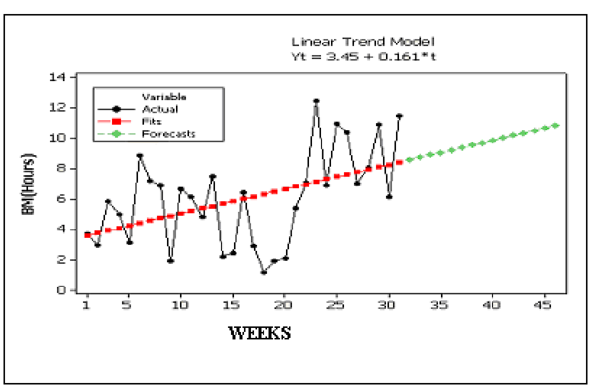

Fig. 7 Trend Analysis for BM

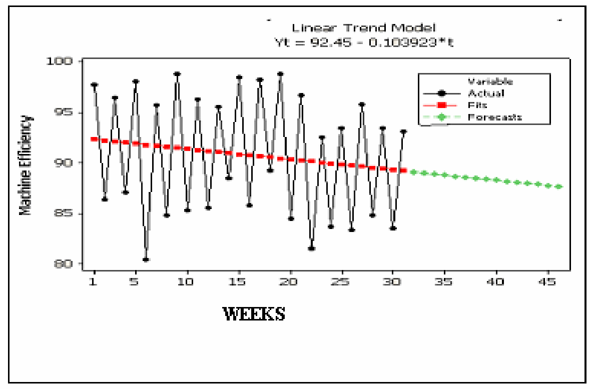

Fig. 8 Trend Analysis for Machine Efficiency

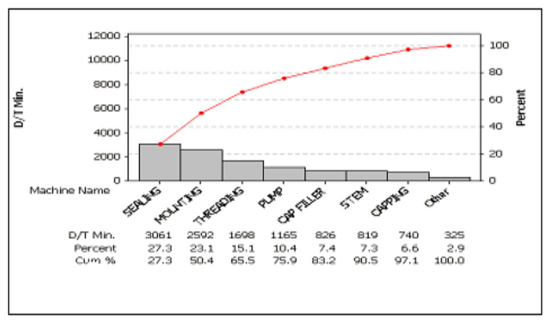

Fig. 9 Pareto Chart for Line

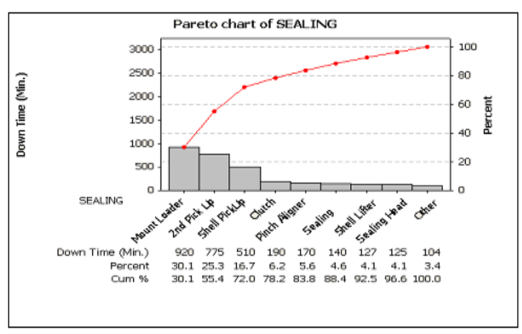

Fig.10 Pareto Chart for Sealing

After Pareto analysis the items were ranked based upon the down time.

Cause & Effect Diagram

Cause and effect diagram used to explore key sources which were responsible for the functional failure of significant items. Figure 14 shows the cause and effect diagram for mount loader.

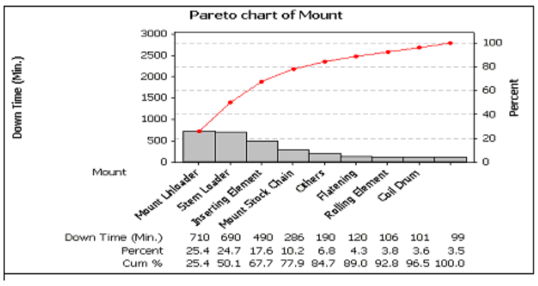

Fig. 11 Pareto Chart for Mount

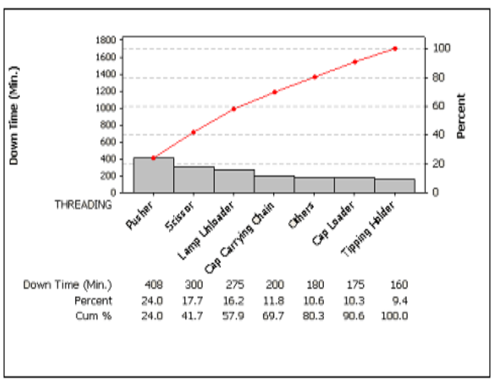

Fig. 12 Pareto Chart for Threading

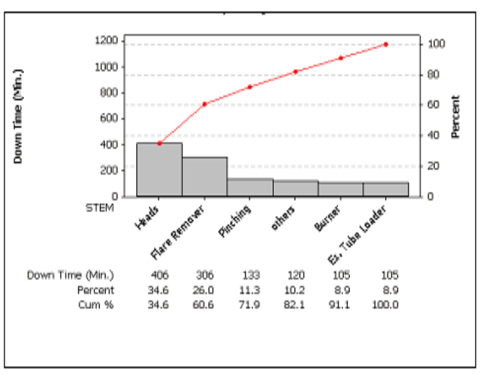

Fig. 13 Pareto Chart for Stem Machine

Similarly cause and effect diagram for other machines have been developed.

RCM Information Worksheet

RCM process has been applied on the significant mechanical items. The data collected of the significant items were filled in specially designed information worksheets. To identify the failure modes and failure effects, a failure mode and effect analysis (FMEA), form is usually used [9-10]. The basic idea in FMEA is to systematically identify the possible failure

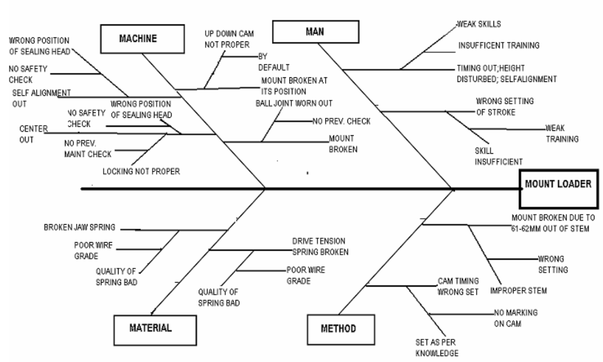

Fig.14 Cause & Effect Diagram for Mount Loader

mechanisms and their effects on the system and list them in tabular form as specially designed worksheets. Table 2 shows RCM information work sheet for mount loader. Similar work sheets for other machines have been developed.

4.3 Develop and describe

RCM Decision Logic Scheme

The RCM decision logic scheme was used to evaluate the maintenance requirements for each significant item in terms of the failure consequences and selected only those, which satisfied these requirements. The input to the decision logic scheme was RCM information worksheets of significant items and got output in the form of decision worksheets. The decision worksheets was prepared of the significant items based on the task selection tree (Ref. table 3)

4.4 Implement and improve

A preventive maintenance schedule was prepared based on RCM methodology. Immediately after the review has been completed for each asset by the RCM team, senior managers with overall responsibility for the plant equipments have evaluated the decision made by the team, a procedure called auditing. After each review is approved, maintenance department implemented the recommendations.

4.5 Control and confirm

Down time analysis of critical items

The result of the study suggested that as regards to down time (in bulb manufacturing unit- GLS) certain machines were critical. Table 4 shows critical machines of GLS-BII line along with their %age contribution in downtime during past eight months. Table 5 shows item level classification of significant items contributing in down time of critical machines.

Table 2: RCM Information Worksheet for Mount Loader

Function	Function Failure (Loss of Function)		Failure Mode		Failure Effects
To transfer mount from mount stock chain to sealing spindle at 4250 pieces/hr	A	Cannot transfer at all	1	Broken Mount Loader turning spring	M/C will stop; downstream process will stop, will require 30 min to change spring by one mechanic & operator
			2	Broken Jaw spring	M/C will stop; downstream process will stop, will require 30 min to change spring by one mechanic & operator
			3	Stuck Jaw opening shaft	M/C will stop; downstream process will stop, will require 15 min to restore the condition by lubrication and cleaning
			4	Stuck up down shaft	M/C will stop; downstream process will stop, will require 20 min to restore the condition by lubrication and cleaning
	B	Transfer lamps less than 4250pcs/hrs	1	Mount broken due to center out problem	M/C will stop; downstream process will stop; will require 30min to center the assly. by highly skilled mechanic
			2	Timing out of up down & jaw opening cams	M/C will stop; downstream process will stop; will required 60 min to match the timing again by 2 skilled mechanics
			3	Assembly self alignment out	M/C will stop; downstream process will stop; will require 30min by one mechanic to change the assembly.
			4	Worn out ball joint	M/C will stop; downstream process will stop; will require 60 min. by one mechanic in order to change unit
			5	Worn out bushes of up down shaft	M/C will stop; will require 60 min. to change the bushes.
			6	Assembly height disturbed	M/C will stop; downstream process will stop; will require 30 min by 1 mechanic to set the height

Table 3: RCM Decision Worksheet for Mount Loader

F	FF	FM	E	S	E	O	1 I	2 O/H	3 D	Proposed Task	Initial Interval	Can be done by
1	A	1	Y	N	N	Y	N	Y	N	Scheduled overhauling by changing spring; Discuss with supplier for consistent quality of springs; double spring may be provided; Check spring (failure finding)	12 week 2 week	Mech. Dept.
1	A	2	Y	N	N	Y	Y	N	N	Scheduled overhauling by changing spring; Discuss with supplier for consistent quality of springs; double spring may be provided; Check spring (failure finding)	12 week 2 week	Mech. Dept.
1	A	3	Y	N	N	Y	N	N	N	No scheduled maint.; cleaning and lubrication by the operator; Guard may be provided so that dust & glass could not go inside	-	HK (Engineer)
1	A	4	Y	N	N	Y	N	N	N	No scheduled maintenance; cleaning & lubrication by the operator; Guard may be provided so that dust & glass could not go inside	-	HK
1	B	1	Y	N	N	Y	N	N	N	No scheduled maintenance; Up Down cam design can be improved; training to the fitter	-	HK
1	B	2	Y	N	N	Y	Y	N	N	Safety is to be checked in every maintenance; Training to the fitter	2 week	Mech. Dept.
1	B	3	Y	N	N	Y	Y	N	N	Safety is to be checked in every maintenance; Training to the operator	2 week	Mech. Dept.
1	B	4	Y	N	N	Y	N	N	Y	Discard ball joint assy.	24 weeks	Mech. Dept.
1	B	5	Y	N	N	Y	N	Y	N	Change bushes of up down shaft	16 weeks	Mech. Dept.
1	B	6	Y	N	N	Y	N	N	N	No Scheduled Maintenance; Training to the operator		HK

Here: F: Function, FF: Function failure, FM: Function mode, E: Failure effect, S: Safety, O: Operation, I: Inspection, D: Scheduled discard, OH: Over hauling

Table 4: Critical Machines of GLS Line

GLS LINE (Down time analysis from Jan - Dec.2008)		
Machine	**Down Time (%age)**	**Cum (% age)**
Sealing	27	27
Mounting	23	50
Threading	15	65
Pump	10	75
Stem	7	82

Uptime machine efficiency improvement

The data collected after implementation of RCM based preventive maintenance schedule and found considerable improvement in machine efficiency. Uptime efficiency has improved by 2% (i.e. from 90.5 to 92.3%). Table 6 shows saving/month by improvement in uptime efficiency.

Table 5: Significant Items Contributing in the Machine Down Time

Machine	Sub Assembly	Down Time (%age) in terms of M/C	Cumulative (%age)
Sealing	Mount Loader	30	30
	2nd Pick up	26	56
	Shell Pick up	17	73
	Clutch	7	80
Mount	Mount Loader	26	26
	Stem Loader	25	51
	Inserting Elem.	18	69
	Mount Stock Chain	11	80
Threading	Pusher	24	24
	Scissor	18	42
	Lamp Unloader	17	59
	Cap carrying chain	12	71
Pumping	Clamp closer	26	26
	Good lamp chain	16	42
	Brass cup	13	55
	3rd pick up transfer Arm	10	65

Table 6: Realized Saving/month by Improvement in Up-time Efficiency

Speed of GLS Line	4250 Lamps/hr
Reduction in BD & PM hrs (by implementation of RCM)	24hrs
Extra production/GLS Line	102000 Lamps
Saving/Lamp	Rs 0.6/-
Saving/month/GLS Line	Rs 61200/-
No. of GLS Lines	3
Realized Saving/month	**Rs 183600/-**

5. Conclusion

Reliability Centred Maintenance helps in improving the understanding of equipment failure and their impact on the machine performance. The following conclusion can be made from the present work:

i) RCM methodology can be applied gainfully in Lamp manufacturing unit.

ii) The result of the study suggested that as regards to down time (in bulb manufacturing unit) Sealing, Mounting, Threading machine, Pump and Stem contributes 27%, 23%, 15%, 10% and 7% respectively. In the present case study m/c efficiency has been improved from 90.5% to 92.6% by implementation of RCM preventive maintenance schedule.

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