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Study and Investigations of RCM Methodology in Manufacturing Industry to Minimize Breakdown Maintenance

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Abstract – *The objective of the work is to improve the preventive maintenance schedule, increase the avaibility of machines, saving of total down time & production cost as compared to the current maintenance. The work is carried out in the industry manufacturing the parts of the refrigeration & air-conditions, where the operations like spinning, cutting to appropriate length, shaping & testing of these part are performed. The work is planned initially to find the all breakdown occurred with their frequency of occurrence, after that it is analyzed by the tools FMEA.This helps to develop and improve a new preventive maintenance checklist for the machines. This method is used to prevent the failure of equipment before it actually occurs. The work is finally leads to reducing sudden breakdown and increasing availability machines. This has been achieved by optimal utilization of time for maintenance, inspection frequency by considering manufacturer recommendation and previous experience. By all these procedures the availability of the machine will increases to a certain extent and also increases the production capacity, minimizes the maintenance cost and Reduces the down time.*

Keywords- *Breakdown, Down Time (DT), Preventive Maintenance (PM),*

INTRODUCTION

Maintenance is generally identified as a single largest controllable cost and status quo represents a challenge for leading managements to re-evaluate their maintenance strategies, decision making work attempts to understand different maintenance policies making for better maintenance of asset.

The definition of maintenance often stated maintenance as an activity carried out for any equipment to ensure its reliability to perform its functions. Breakdown maintenance is one of the earliest maintenance programs being implemented in the industry. The approach to maintenance is totally reactive and only act when the equipment needs to be fixed. This strategy has no routine maintenance task and also described as no scheduled maintenance strategy. To rectify the problem, corrective maintenance is performed onto the equipment. Thus, this activity May consist of repairing, restoration or replacement of components.

RCM is a systematic approach to determine the maintenance requirements of plant and equipment in its Operating. It is used to optimize preventive maintenance (PM) strategies.

The developed PM programs minimize equipment failures and provide industrial plants with effective equipment. RCM is one of the best known and most used devices to preserve the operational efficiency of the system.

RCM philosophy employs preventive maintenance, predictive maintenance (PdM), real-time monitoring (RTM), run-to-failure (RTF) and proactive maintenance Techniques is an integrated manner to increase the probability that a machine or component will function in the required manner over its design life cycle with a minimum of maintenance.

This work focused on causes of failure of machine by Tribological aspects, associated remedial action and accordingly generates a maintenance model that based on the RCM technique and preventive methodology rather condition based maintenance, for the worked manufacturing industry. This technique should be able to minimize the downtime (DT) and improve the improve

the availability of the plant components. Also, it should benefits to decrease the spare parts consumption.

PROBLEM INDENTIFICATION

Production may be stopped due to many reasons like breakdown of machine, maintenance work, labor problem, insufficient material supply, problems in the method of production and many more.

Excluding all other factors like materials, method, man, measurements, it is necessary to reduce the breakdown of the machine or equipment's in the industry for the efficient nonstop production to meet the demands.

Breakdowns are the most common causes of efficiency and production loss in manufacturing. Eliminating unplanned down time are critical to improving Overall Equipment Efficiency. It is not only important to know how much down time your process is experiencing (and when) but also to be able to attribute the lost time to the specific source or reason for the loss. Work was conducted on the breakdowns of machines or equipment's of the industry and to find out the root causes of these breakdown so as to eliminate them and to decrease the downtime caused due to these.

WORK METHODOLOGY

This work was carried out in manufacturing unit located in the Jalna MIDC manufacturing the parts of refrigeration & air-conditioning by automated machines like CNC spinning, end forming machine, cut length machine & some manually operated machine like manual bending machine. All produced parts are gone through the leak testing machines.

- Data Collection
- Data Analysis
- FMEA
- Preventive Maintenance Check List

Initially failure mode, reason of failure from man, material machine, measurement and method, frequency of breakdown occurrence has been collected and according to this failure a proper maintenance strategy to reduce down time (DT), idle time and improvement in the overall equipment effectiveness (OEE) is increased and finally a proper preventive maintenance checklist have been designed for the worked industry.

DATA COLLECTION

Data Collection is an important aspect of any type of research study. Inaccurate data collection can impact the results of a study and ultimately lead to invalid results. Data is essential for investigating the Root Cause of the problem.

Failure Data Collection: The following information is collected as per the discussion with maintenance people and from the maintenance log books or sheets,

- The data about the causes of breakdown
- Breakdown hours
- Repair time, inspection time and maintenance action taken
- Parts replaced the data should also include the failure reasons related to machine, material, process, environment etc.

Data collection includes the probable causes of breakdown in all machines in the plant with their frequency of failures for the machines like CTL, CNC Spinning, End shaping machine etc., as all these machines having the same elements like hydraulic, pneumatic system it's conveying part, electrical motors controlling panels, different controlling elements, FRL unit, pump bearings etc. and the breakdown occurred in these components effect more. For the down time, idle time, lost in production & increase in the associate cost. The breakdown data was collected for last six month from January-2016 to June-2016 from the maintenance log book & from the discussion with maintenance people & operator; it is tabulated as per following,

Table-1- Breakdown & its Occurrence Frequency

Sr. No	Breakdown	Frequency
1	Disturbances in Sensor setting	27
2	Handle pressure down	25
3	Lower the Pneumatic pressure	25
4	Lower Clamping Pressure	22
5	Cutting length variation in CTL	17
6	Oil leakage through guider	17
7	Guider Screw not working	16
8	Strippers becomes loose	15
9	Stoppers not properly working	15
10	Cutter wear down earlier	11
11	Clamping/decamping Pedal not working	11
12	Failure of hydraulic system	11
13	Spindle Speed goes down	7
14	Contamination in Filter	7
15	Sealing agents wear, stretched, loosed	5
16	Belt slippage, cracked, frayed,	4
17	Electrical Controllers Failed to receive or send feedbacks	3

18	Failure of gear train	2
19	Bearing Failures	1
20	Failure of Electrical system (Misalignment, Imbalance, looseness)	1

DATA ANALYSIS

Collected data is analyzed by the following tools,

- Breakdown & Time Required to Recover
- Pie Chart for Time Required to Breakdown Recover
- FMEA

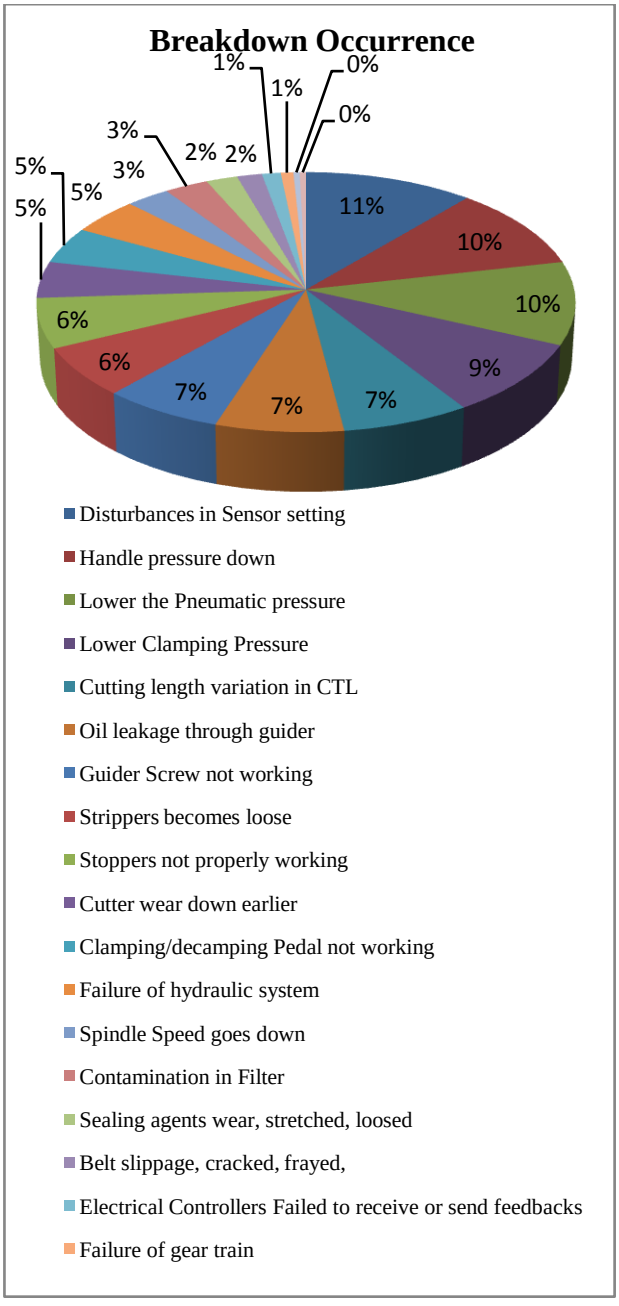

Fig.1. Pie Chart of Frequency of Occurrence

From the data collected it is clear that, disturbances in sensor setting (27) accounts for the most of the breakdown causing production loss to the company. Handle pressure down (25) lower the pneumatic pressure (25) etc. are other major breakdowns in the industry. Above failure occurrence is maximum but when seen it found that, it's recover time is minimum, hence the sensor setting disturbances, handle pressure lower etc. Does not consume more time more to repair, hence causes less for breakdown of machines, 2 as per the data collected, times spend for getting back the equipment,

Table-2- Time Spend for Recover the components

Sr. No	Breakdown	Time Spend (Min.)
1	Disturbances in Sensor setting	10
2	Handle pressure down	15
3	Lower the Pneumatic pressure	40
4	Lower Clamping Pressure	22
5	Cutting length variation in CTL	12
6	Oil leakage through guider	12
7	Guider Screw not working	17
8	Strippers becomes loose	5
9	Stoppers not properly working	11
10	Cutter wear down earlier	5
11	Clamping/decamping Pedal not working	15
12	Failure of hydraulic system components	70
13	Spindle Speed goes down	40
14	Contamination in Filter	30
15	Sealing agents wear, stretched loosed	20
16	Belt slippage, cracked, frayed	20
17	Electrical Controllers Failed to receive or send feedbacks	15
18	Failure of gear train	60
19	Bearing Failures	60
20	Failure of Electrical system (Misalignment, Imbalance, looseness)	40

Above details of time spend is for single failure only, shows that recovering time for hydraulic system, electrical system, bearing, gear train & pneumatic system are more compared to the others hence here to prevent the failure of these components are more concentrated & analyzed, The percentage wise details of recovering time has been shown by the pie chart to closely study the percentagewise occurrence of breakdown.

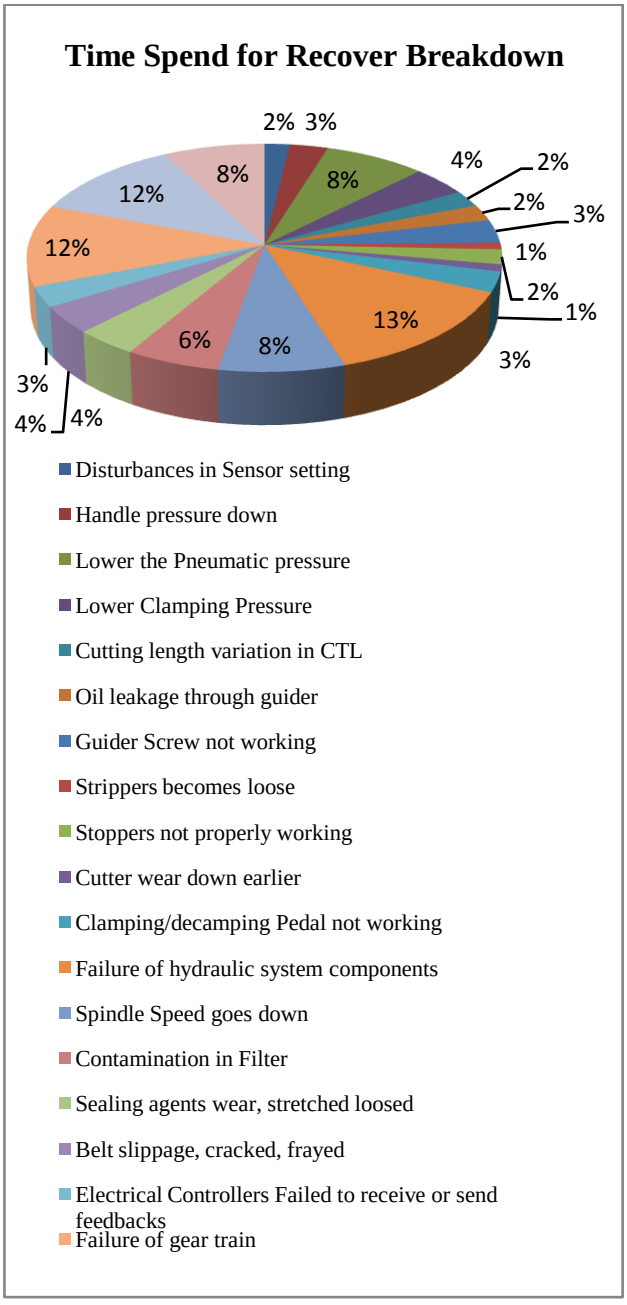

Fig. 2. Time Spend for Recover Breakdown

From the data time required to recover the failure in Hydraulic, pneumatic, gear train & electrical systems are maximum, thus these system & its associated failure need to find out and setting the proper preventive maintenance schedule to avoid the failure of these is important. Hydraulic & pneumatic system mainly having the same type of components like control elements, conveying components (pipes, hoses), filter, except the power source, Fig. 2 gives the percentages of time spend for different breakdown maintenance. The failure of electrical system (11%) accounts for the major time loss of production. bearing failure (8%) and failure of gear train (8%) also accounts for a considerable loss of production for the industry. Hence in this work contains the detail analysis of this system by FMEA.

Design FMEA is to identify the known failure modes and then ranking failures according to the relative impact on the product.

FAILURE MODE & EFFECT ANALYSIS (FMEA)

The objective of Process FMEA is to improve the existing process and find out how it can affect the system, environment and human. A product is considered to be failed when it does not give desired result or when it malfunctions in some way. It is not necessary that failures can happen only because of design or process failure but also can happen because of the operator error.

FMEA is to eliminate the root cause effect of any failure so as to improve the process and make ensure 100% customer satisfaction.

Process. FMEA is an effort to prevent failures due to process before they happen so as to assess the risk associated with that failure mode, to rank the issues in terms of severity, occurrence and detection and hence find the alternative measures to prevent the failure.

Process FMEA considers five main elements of the process namely: People, Materials, Equipment, Methods and Environment.

Design FMEA: Analyses a new process, product or service design before rollout to understand how it could fail once released. Exposes problems that may result in safety hazards, defects in product or service production processes.

Process FMEA: Used to improve existing transactional and operational processes to understand how people, materials, equipment, methods and environment cause process problems.

System FMEA: Analyses systems and subsystems in the early stage of concepts and design.

Table-3- Phases of FMEA

Phase	Question	Output
Identify	What can go wrong?	Failure cause and effect
Analyse	What is the number failure has occurred and what are the consequences	Risk Priority Evaluation= (severity*occurrence*detection)
Act	What can be done to eliminate the failure	Design solution, make plans, etc.

Table-4- FMEA Chart for Hydraulic & Pneumatic System

Components	Potential Failure Mode	Potential Failure Effects	Potential Causes	Action recommended	Action Taken
Directional Control Valve – Solenoid operated, 4/2, 3/2 type, forward & backward movement of it allows compressed air/pressurized oil go into the way (5/2 in case of pneumatic)	Failed to allow compressed air/ pressurized oil to go into the way of the valve or amount of suction & compression goes down.	There is no movement in the directional control valve and the leakage of air/oil	Pressure outside parameter	Replace dirty filters, clogged inlet line	Replacement
			Incorrect assembly during maintenance	Check all the connections from the start	Repair the faulty part
			Water in the air/oil supply line	Check Filter, Regulator, Lubrication	Repair the FRL unit
			Wear of part	Replacement	Replacement
			No signal/No gas supply	Replacement	Hose replaced
			Spring problem	Check there is no leakage in the system	Replacement of the spring
			Leakage	Replacement	Replacement
			Crack in housing	Replace or Repair	Repair
Flow Control Valves-It influence the volume of the flow of compressed air/pressurized oil in both the direction	Unable to sense the volume of compressed air/pressurized oil to be send to the airway	There is malfunctioning/no movement of the valve	Pressure outside parameter	1.Replace dirty filters, clogged inlet line \ 2.Tighten leaky connection	Replacement
			Diaphragm failure	Check there should be no crack in the diaphragm	Replacement of the diaphragm
			Mechanical failure	Check the spring/ball in minute detail	Replacement of the spring
			Incorrect assembly during maintenance	Check all the connections from the start	Repair the faulty part
			Water in the air/oil supply line	Check Filter, Regulator, Lubrication	Repair the FRL unit
			Wear in parts No signal/No gas, supply	Replacement	Replacement
			No signal/No gas supply	Check there is no leakage in the system	Hose replaced
			Cracking of housing	Replace or Repair	Replacement

			Pressure failure	Replace dirty filters, clogged inlet line	Cleaning of inlet line
Tubing/Hoses- It is used to transport the compressed air/pressurized oil to the desired destination	Compressed air/ pressurized oil is unable to reach its desired destination	Insufficient/Excessive pressure	Bending	Replacement	Replacement
			Clogging (Blocking)	1.Clean clogged inlet line 2.Change system fluid	Cleaning of inlet line
			Leakage	Tubing material ruptured	Replacement
			Fault in connection	Replace or repair	Replacement
Pressure Regulators- It reduces a high input pressure to a low working pressure and provides a steady output, despite changes in the input pressure	Failed to maintain the range of pressure required for the operation	Insufficient/Excessive pressure	Diaphragm failure	Replacement	Replaced
			Leakage	1.Check the hose and pipe 2.Replace or Repair	Replacement
			Intake/Exhaust port failure	1.Replace dirty filters, clogged inlet line 2.Tighten leaky connection	Leaky inlet connections tightened
			Pressure switch not working	Replacement	Replaced
			Cable connector	Mechanical failure-broken or damaged connector	Cable connector repaired
			Electrical power failure	Check the electrical panel for proper connections	Electrical connections are corrected
Tubing/Hoses- It is used to transport the compressed air to the desired destination	Compressed air/pressurized oil is unable to reach its desired destination	Insufficient/Excessive pressure	Bending	Replacement	Replacement
			Clogging (Blocking)	1.Clean clogged inlet line 2.Change system fluid	Cleaning of inlet line
			Leakage	Tubing material ruptured	Replacement
			Fault in connection	Replace or repair	Replacement
Filters- It removes moisture and debris	Contamination problem is encountered	Icing or freezing of the exhaust air, causing the pump to cycle erratically	Water in the compressed air/pressurized oil supply	Check FRL (Filter, Regulator and Lubrication unit)	Replacement
			Lockout valve failure	Mechanical failure-handle jammed	Replacement
			Clogging	Clean the pores	Replacement
Lubricators- It injection oil mist to help lubricate the moving parts of the system	Insufficient oil in the system	Difficulty in operation of moving parts	Clogging/ Blocking	1.Clean clogged inlet line	System fluid changed
			Duct blocked	Cleaning	Replacement of ducts
			Contamination	Cleaning	Cleaning
Reservoirs - It stores the	Failed to store the compressed	Insufficient/Excessive pressure	Cracking of housing	Replace or Repair	Replacement

compressed air.	air		External leak in the system	Tighten leaky inlet connection	Leaky inlet connections tightened
Electric controllers- it used to monitor a process condition in a machine and according give feedback	Failed to receive or send feedback for the closing and opening of switch	The operation of control valve is incomplete	Electrical power failure	Check the electrical panel for proper connections	Connections corrected
			Proximity sensor failure	Component failure inside proximity senor	Sensor Replaced
			PLC failure	Check the wiring of PLC	Snubber circuit can be used

Detailed analysis of component with causes of failure, their effects & action to be taken has been done to reduce its breakdown rates, and this activity will alert the operator or maintenance personnel to what, how & where the maintenance activity is to be perform. Accordingly a preventive maintenance schedule can easily planned as well as training to operator & daily maintenance plan also can designed. In this work according to the breakdown a preventive maintenance schedule is herewith designed which includes the daily, weekly, half yearly, & yearly pattern of maintenance.

PREVENTIVE MAINTENANCE

The most important reason for a PM program is reduced costs as seen in the following ways:

- Reduced production downtime, resulting in fewer Machine breakdowns.
- Better conservation of assets and increased life expectancy of assets, thereby eliminating premature replacement of machinery and equipment.
- Reduced overtime costs and more economical use of maintenance workers due to working on a scheduled basis instead of a crash basis to repair breakdowns.
- Timely, routine repairs circumvent fewer large-scale repairs.
- Reduced cost of repairs by reducing secondary failures. When parts fail in service, they usually Damage the other parts.
- Reduced product rejects, rework and scrap due to better overall equipment condition.
- Identification of equipment with excessive Maintenance costs, indicating the need for corrective maintenance, operator training, or replacement of obsolete equipment.
- Improved safety and quality conditions.

Table-5- Preventive Maintenance Activity

Sr. No	Problem	Correction Action/cause	Preventive Action
1	Disturbances in Sensor setting	Relocate the sensor, calibration status need to be checked, clean it	Daily checking for proper installation, cleaning
2	Handle pressure down in manual bending machine	Checked for looseness & pneumatic pressure & set back	Tightening & greasing, oiling the moving parts
3	Lower the Pneumatic pressure in various components (Air tank, FRL, Valve & Conveying line)	Removed the contamination , Looseness, recovered the leakages	Proper filtration, sealing & cooling system to maintain
4	Lower Clamping Pressure	Checked for looseness & pneumatic pressure & set back	Tightening & greasing, oiling the moving parts
5	Cutting length variation in CTL machine	Tighten the shaft with key & roller	Daily inspection for looseness required & set
6	Oil leakage through guider	Wear rate minimized by proper lubrication	Oiling level to maintain
7	Guider Screw not working as required	Handling was poor, made it	Visual inspection

	in CTL machine	automat	
8	Strippers becomes loose	Extra pressure & fluctuation	Avoid the pressure fluctuation
9	Stoppers not properly working	Sensor problem recovered	Cleaning & checked for detection power
10	Cutter wear down earlier in CTL machine	Poor lubrication	recovered
11	Clamping/decamping Pedal not working	Blockage at hinge, jammed the air	Uncovered the enclosed parts
12	Failure of hydraulic system components (DCV, PCV, FCV etc.)	Leakages, contamination , heat, & water droplets	Set the filter for proper meshing, wear, scratches
13	Spindle Speed goes down	Remedial for misalignment	Replacement of worn parts
14	Failure of Limit switch	Loose connection	Replacement
15	Contamination in Filter	Sealing agents proper	Replacement
16	Power Fluctuations	Connection problem	Daily visual inspection needs
17	Sealing agents wear, stretched or get loosed	Replaced	Replaced is done
18	Oil Leakages through components of hydraulic systems (hoses, pump, valve etc.	Sealing failure, contamination , wear	Replacement ,proper fittings
19	Belt slippage, cracked, frayed, glazed or showing the sign of wear	Replaced	Replaced is done
20	Electrical Controllers Failed to receive or send feedbacks	Checking for connection	Daily to be inspected
21	Failure of gear train	Misalignment , wear, lubrication	Need to done & inspect weekly
22	Bearing Failures	Misalignment , wear, lubrication	Need to done & inspect weekly
23	Failure of Electrical motor (Misalignment, Imbalance, looseness, winding burnt etc.)	Power fluctuation, installed properly	Tightening & well setting is required

As per the requirement & minimize breakdown maintenance care should be taken that, components not fails during operation, hence the concept of preventive maintenance is important. To avoid this, before taking the Charge/starting machine a proper preventive maintenance activities should be performed, so that, actual status of every components before failure can be known.

Most of failure comes by not cleaning, not regular inspection, no proper or on time lubrication/greasing, heat generation, misalignment, looseness, therefore a preventive maintenance is required & it is suggested for the worked industry as follows, it is designed as per the failure causes observed in the machines & its equipment's.

Table-6- Preventive Maintenance Checklist

Sr. No.	Activity	Frequency
1	Check cleanliness of machine	Daily
2	Check the slide lubrication oil level	Daily
3	Check the slide lubrication	Daily
4	Check the hydraulic oil leakage in the pipe line	Daily
5	Pneumatic pressure 4 to 7 kg/cm2	Daily
6	Check the main motor terminal	Weekly
7	Check press oil level	Daily
8	Check automation oil level	Daily

9	Handle pneumatic pressure & misalignment in parts	Weekly
10	Sensor installation setting	Daily
11	Clamping Pressure & it's setting	weekly
12	Check of Guider screw setting	Daily
13	Checking stripper misalignment	Weekly
14	Check wear of cutter	Daily
15	Contamination of filter	Weekly
16	Pneumatic pressure at conveying lines & connectors	Weekly
17	Belt looseness, slippage	Weekly
18	Electrical motor coil burnt, misalignment	Weekly
19	Cleaning of Pedal assembly, filter	Weekly
20	Checking Bearing for all associated components looseness, cleaning	Weekly
21	Cleaning of machine compartment & spindle	Weekly
22	Checking installed tool wear & tear	Daily
23	Checking of cooling system to heat generation	Daily
24	Checking speed of spindle	Weekly
25	Check Control elements to all inlet & outlet lines	Weekly
26	Aware the operator to all these activity	Daily
27	Training to all workers	Half yearly

CONCLUSION

In this work all repeated breakdowns were Analyzed along with the critical parts, which has been under breakdown condition is also identified and analyzed. The reason for the breakdown has been analyzed by The RCM techniques 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 machine. This method is used to prevent the failure of equipment before it actually occurs. The average availability of critical machine after root because analysis & followed of preventive maintenance schedule is increased.

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 preventing maintenance and counter measures, such that similar type of breakdown can be reduced.

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