Current Journal of Applied Science and Technology

39(11): 58-65, 2020; Article no.CJAST.55526
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Effect of Preventive Maintenance on the Production Line Machines and Systems Reliability: Case Study

A. M. Badiea[1*], A. A. Adel[1] and H. A. Aamer[1]

[1]Department of Industrial and Manufacturing System Engineering, Engineering & IT College, Taiz University, Yemen.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i1130648
Editor(s):
(1) Dr. Grzegorz Golanski, Czestochowa University of Technology, Poland.
Reviewers:
(1) Mohammed Hamdan, Jordan.
(2) Yash Dave, Dhar Polytechnic Mahavidhyalaya, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/55526

Case Study

Received 20 January 2020
Accepted 25 March 2020
Published 27 May 2020

ABSTRACT

The aims of this study are to introduce the appropriate preventive maintenance to the production line machines at the company to increase their reliability and reduction the shutdown, and to obtain more safety. Mean time between failure, mean down time and availability are investigated as the best indicators to generally evaluate all type of maintenance. Pareto diagram and Effect-Cause techniques both have been used for identifying where and what are the problems in the production lines. The big and serious way that the company staff was using was maintenance of run to failure. Many solutions in this paper are introduced to the company to follow the proper preventive maintenance. After one year monitoring to those production lines, their productivity increases by 15.47% and the reliability becomes high.

Keywords: Preventive maintenance; availability; Pareto diagram; cause-effect diagram.

**Corresponding author: E-mail: badeea5@yahoo.com;*

1. INTRODUCTION

This study mainly focuses on the failures accrues in the production line at snacks line, GENBack company. Recently preventive maintenance (PM) is one of the most roles which affects on the reduction of the breakdown in any system. The system reliability absolutely depends on PM and their perfect applications on that system.

The failures analysis follows many techniques such as MTBF, MTTR, Availability, cause and effect diagram and Pareto chart.

Sunday and Richard studied the implementation of preventive maintenance Program in power industry and thermal power plant [1]. Ahmad et al. [2] investigated the maintenance management decision model for preventive maintenance strategy on production equipment. Hasnida et al. [3] studied the effective preventive maintenance scheduling. Jian Zhang et al. [4] focused on proposing an optimal inspection-based preventive maintenance policy for three-state mechanical components under competing failure modes. Bruno et al. [5] studied the preventive maintenance development: A case study in a furniture company. A new model for solving the joint optimization of maintenance activity and inventory of spare parts since the model was implemented and tested on a set of benchmarks generated has been investigated by Anis et al. [6].

2. WORK STUDY

2.1 Effective Failure of Production Line

To choose the effective failure, the production lines for study have been analyzed by data collecting historically including mechanical & electrical failures for all production lines in this plant to choose the production line where the greatest problem occurs leading to breakdown. The mechanical and electrical downtime data was collected and are incorporated in Table 2.1. It is seen that the greatest problem among the lines was identified in the production line of snacks as 21.18% downtime of operating time.

2.2 Determination of Excessive Failure of Stage, Section and Machine

There are four main stages in snacks production line as shown in Fig. 2.1. Pareto diagram as statistical analysis tool was used in order to analyze and select the critical stage of failure at snacks production line as shown in Table 2.2 and Fig. 2.2. From the Fig. 2.3 it is found that the packing stage has the biggest downtime. To specify the bigger downtime at section of backing stage, pie chart was used as shown in Fig. 2.4. The maintenance performance indicators analysis of MTBF, MDT and availability are used to determine which the machine is required more attention for preventive maintenance scheduling. The availability plays the most important role in determination of the fatigue machine and can be calculated as the following equation:

$$\text{MTBF} = \frac{OT_{ac}}{N_{bd}} \quad (2.1)$$

$$\text{MDT} = \frac{TDT}{N_{bd}} \quad (2.2)$$

$$\text{A\%} = \frac{MTBF}{MTBF+MDT} \times 100 \quad (2.3)$$

Where MTBF is the mean time between failure, MDT is the mean downtime, OT_{ac} is actual operating time, N_{bd} is number of breakdown, TDT is the total downtime, and A is the availability.

Table 2.1. Percentage downtime of production lines according to operating time for line itself

Production lines	Mechanical downtime (%)	Electrical downtime (%)	Total downtime (%)
Lollipops	7.08	3.72	10.8
BarLine	4.79	3.78	8.57
Tahinia	7.56	1.85	9.41
Tahinia Bar	5.76	3.15	8.91
Spaghetti Pasta	6.56	6.17	12.73
Short Pasta	12.76	7.63	20.39
Snacks	9.63	11.55	21.18
Bafk	1.13	5.61	6.74
Bubble Gum	5.7	0.76	6.46

Table 2.2. Downtime of snacks production line stages

Snacks production line stages	Downtime (hr)	Downtime (%)	Cumulative (%)
Packing stage (PS)	2483.56	78.51	78.51
Final preparation stage (FPS)	411.50	13.01	91.52
Initial preparation stage (IPS)	172.34	5.45	96.97
Temporary storage stage (TSS)	95.85	3.03	100.00

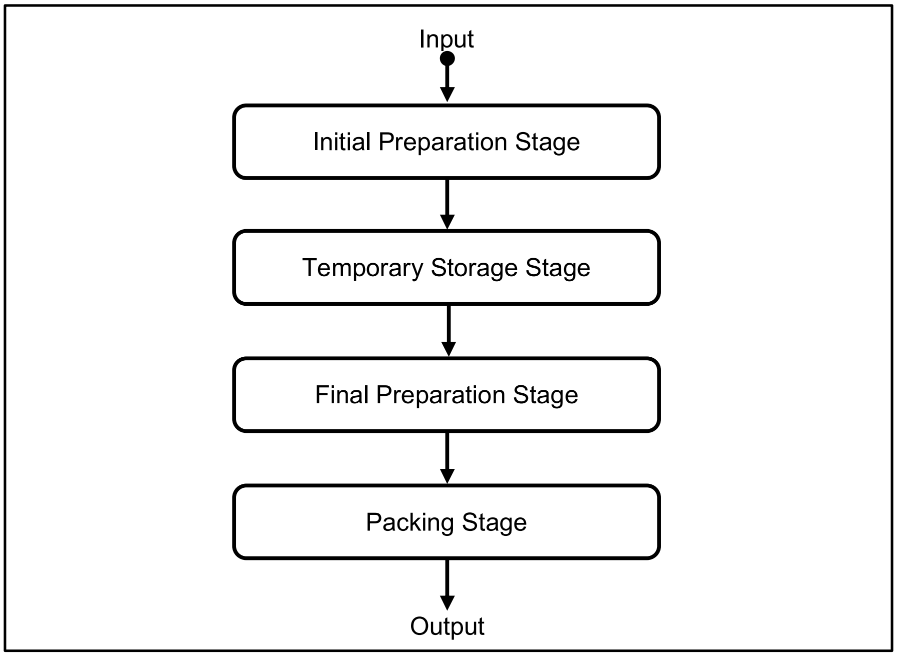

Fig. 2.1. The snacks stages for production line

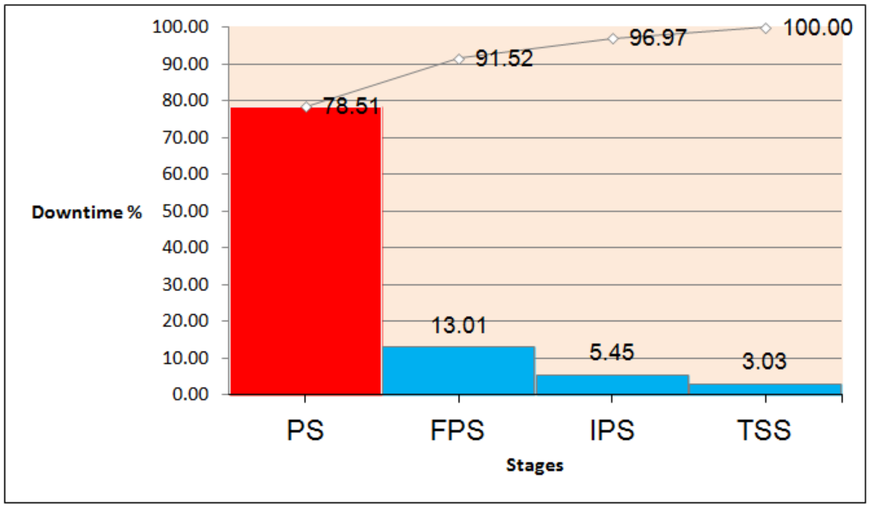

Fig. 2.2. Pareto chart for downtime of snacks production line stages

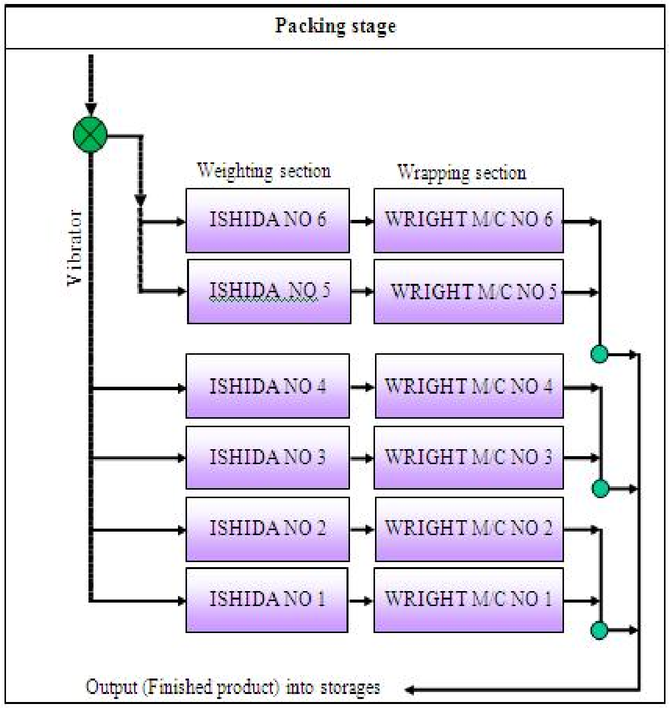

Fig. 2.3. The product flow at packing stage

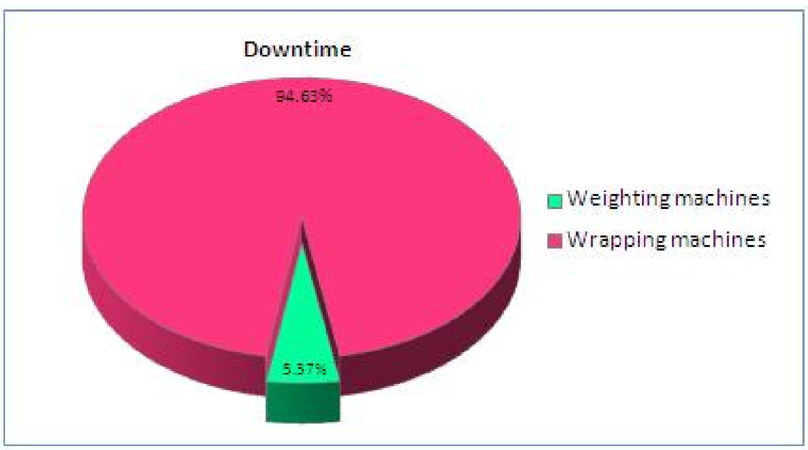

Fig. 2.4. Section downtime of packing stage machines

3. PROBLEM DEFINITION AND ANALYSIS

From the previous analysis process, it is deducted that the machine No. 6 (wrapping machine) has less availability during the operating hours. MTBF, MDT and availability have been calculated and are depicted in Table 3.1. The technique of cause-and-effect diagram is used to identify, sort, and display possible causes of a specific problem as shown in Fig. 3.1.

The possible causes related to the problem in machine No.6 have been investigated and found that all these causes were under the maintenance branch (Fig. 3.1). Moreover, Fig. 3.2 shows the parameters that affect the MDT, which significantly led to the reduction of machine availability. It is evident that the run to failure maintenance was mainly carried out in the company since the downtime of machine represent 58.24% of the total machine downtime. As well as the maintenance inventory was not planned therefore the downtime has taken place as a percentage of 25.4% of the total machine downtime.

Also by survey in the production machines at the company, approximately 21.93% of the repair time is spent to look for a maintenance tools and spare parts that are misarranged and cause confusion for the maintenance workers in the maintenance workshop. This proportion of the waste time is about 16.36% of the total machine downtime.

Table 3.1. MTBF, MTTR and availability for the production lines

Machine number	Machine code	MTBF (hrs)	MTTR (hrs)	Availability (%)
1	03340310	31.19	0.96	97.01
2	03340313	52.00	0.90	98.30
3	03340312	30.95	1.61	95.06
4	03340311	39.82	1.14	97.22
5	03340320	16.43	3.72	81.54
6	03340322	22.29	7.23	75.51

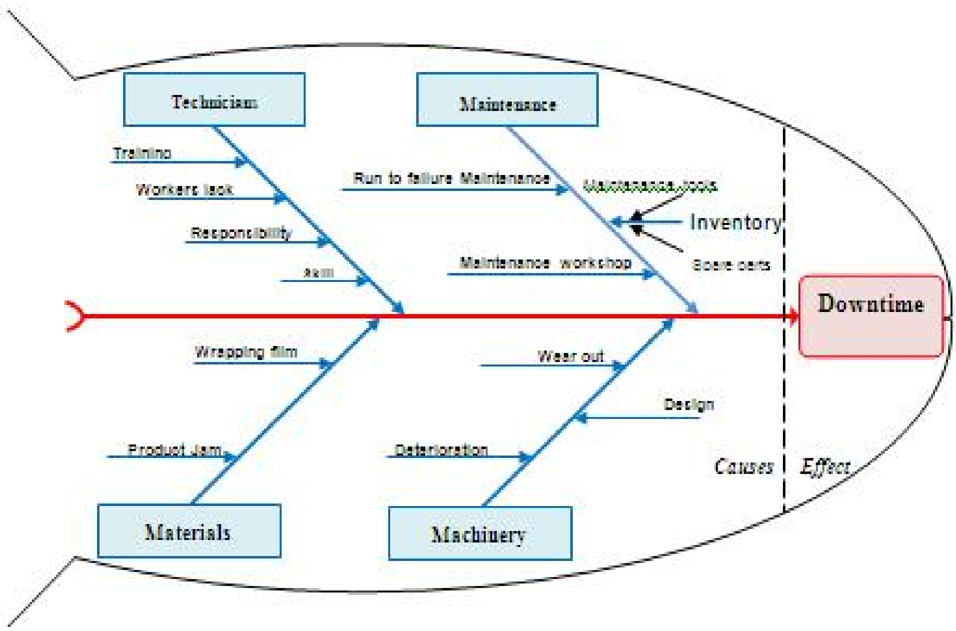

Fig. 3.1. Cause and effect diagram

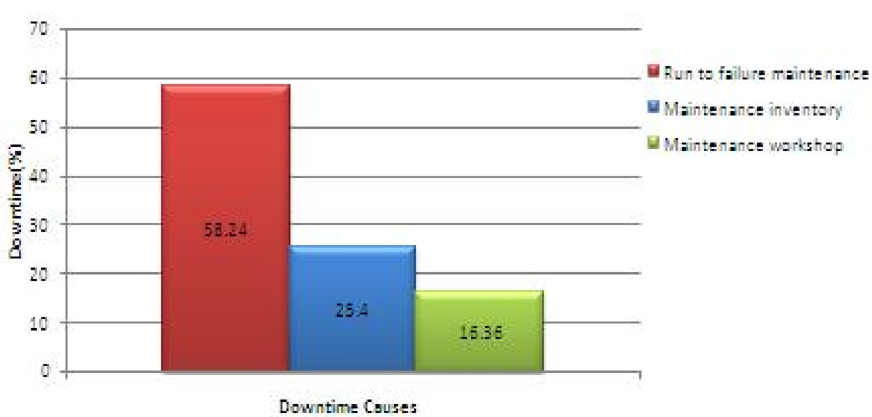

Fig. 3.2. Percentage of the affective downtime causes

4. STRATEGY OF APPROPRIATE SOLUTIONS

According to results of problems analysis, many solutions are suggested in order to treat and vanish the affective causes for the machine downtime. These solutions are as the following:

4.1 Implementing the Proper PM Scheduling Program

PM program based on study of the machine case, the historical data, and the other requirements in order to obtain the appropriate PM program to prevent the machine from

Table 4.1. Failure modes, root causes, preventive maintenance actions and their frequency for machine components

Components	Failure modes	Root causes	PM Actions	Frequency
Film reel holder	Bearing deterioration	No lubrication	Lubricate the bearing	Daily
	Screw looseness	Continuous rotation	Inspection of the bolts and spring	Monthly
Pulling rollers subassembly	Shaft wear out	Misalignment, Friction	lubrication of the rollers and bearings	Daily
	Bearings deterioration	No lubrication, Improper fixing	Check film rollers from jamming	Weekly
			Inspection of the bearings and shafts, and replace as necessary	Biannually
Pulling Motor	Coils combustion	Extreme load	Inspection, and recondition as necessary	Quarterly
	Bearings wear out	Improper fixing		
Gearbox	Oil seal impairment	Expiration	1- Open the gearbox and replace the Oil seal and change the oil. 2- Inspection of the gears and bearings, and recondition or replace as necessary	Annually
	Shaft wear out	Misalignment, Friction		
	Bearings deterioration	No lubrication, Improper fixing		
	Gears cracking	Friction, No lubrication		
Optical sensor (scanner)	Sensor impairment	Dirtiness	Inspection and servicing the sensor	Quarterly
	Thumb nuts looseness	Improper fixing		
Product chute	Knurled screws looseness	Vibration, Improper locking	Adjusting and cleaning the Product chute and fixing its bolts	Monthly
Packet former	Knurled nuts looseness	Vibration, Improper locking	Inspection, cleaning and straightness	Weekly
Sealer	Thermocouple dielectric smelting	Temperature increase	Inspection of the heating elements, thermocouple, and connector	Monthly
	Thermocouple separate	Electrical contact		
	Heating elements separate	Coil combustion		
	Connector separate	electrical contact		
Packet closer	Piston plunger rod breaking	Extreme load	Lubrication of the piston	Daily
	Plastic gears break or crack	Use expiration	Inspection of teeth for the Plastic gears	Weekly
	Tube closer breaking	Worn out	Inspection of the Tube closers	Monthly

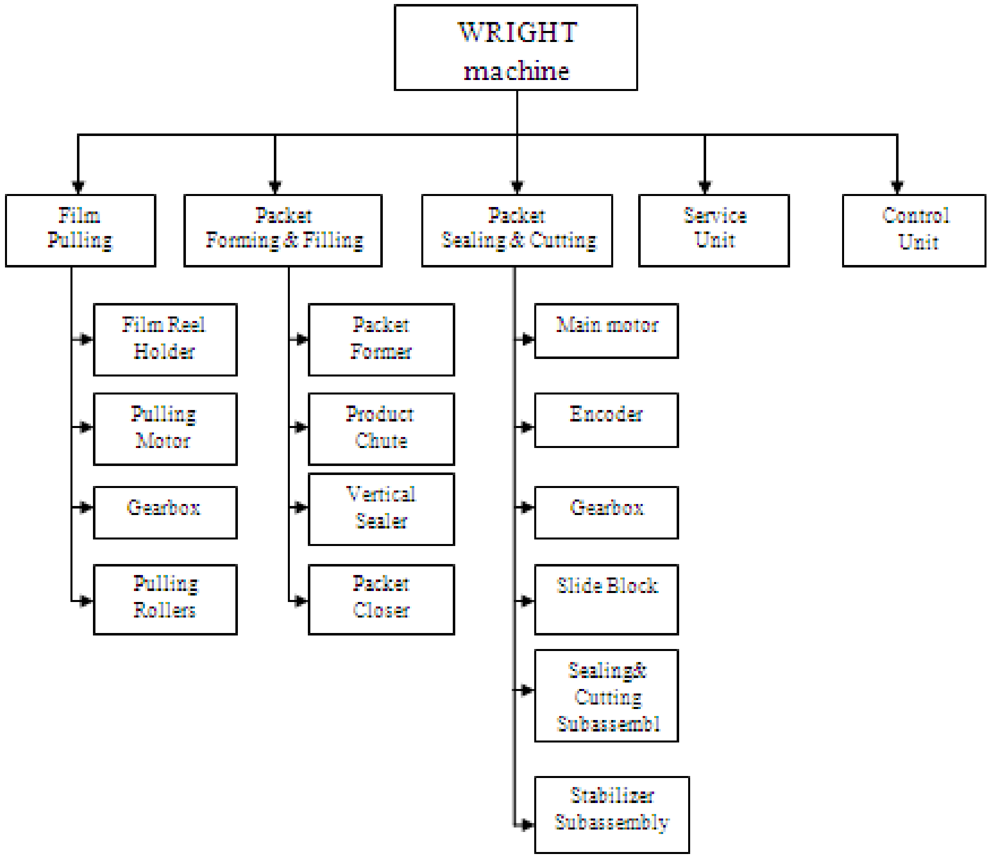

Fig. 4.1. Machine components

breakdowns that occur because of implementing the improper maintenance. This approach starts from the machine description (Fig. 4.1), identifying the machine failures modes, root causes, scheduling the PM tasks and their frequency are inserted Table 4.1, preparing the PM work orders and applying the PM program to the same characteristic machines.

4.2 Maintenance Inventory Planning

Planning of maintenance inventory based on the requirements of the maintenance tasks was suggested to the company in order to avoid lack of the maintenance inventory during planned time periods.

4.3 Maintenance Workshop Organizing

Modern approach to organize and arrange the maintenance workshop to make easy motion, more safety and minimize waste time. To reduce the long downtime, 5's method is suggested for using specific tools and clean place.

5. CONCLUSION

Pareto diagram as statistical analysis tool was used in order to analyze and select the critical stage of failure at snacks production line machines. It is clear that the company used to follow the run to failure maintenance as a wrong way. The Effect- Cause diagram analysis showed the three main effective causes on the breakdown on the production lines, are run to failure, unplanned maintenance inventory and non-organizing maintenance workshop. Proper preventive maintenance, appropriate maintenance inventory and organized maintenance workshop and skilled labors for maintenance are suggestions and recommendations were used to obtain high reliability.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sunday OO, Richard OF. A study of implementation of preventive maintenance program in Nigeria Power Industry—Egbin thermal power plant, case study. Energy and Power Engineering. 2011;3:207-220.
2. Ahmad R, Kamaruddin S, Azid I, Almanar I. Maintenance management decision model for preventive maintenance strategy on production equipment. J. Ind. Eng. Int. 2011;7(13):22-34.
3. Hasnida A, Livendran NJ, Ernnie IB, Nurul AH, Shahrul K. Effective preventive maintenance scheduling: A case study. Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management, Istanbul, Turkey, July 3 – 6; 2012.
4. Jian Z, Xiaoyan H, Youtong F. Optimal inspection-based preventive maintenance policy for three-state mechanical components under competing failure modes. Reliability Engineering and System Safety. 2016;152:95–103.
5. Bruno AC, Isabel SL. Preventive maintenance development: A case study in a furniture company. Proceedings of the World Congress on Engineering, July 1-3, London, UK. 2015;2.
6. Anis M, Rachid B, Hamid A. On thek joint optimization of the periodic preventive maintenance and the spare parts inventory problem. IFAC-Papers on Line. 2016;49-12:881–885.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/55526