International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE) ISSN: 2349-7947
Volume: 2 Issue: 6 057 - 063

Preventive Maintenance and Cost Benefit Analysis of Splicing Machine

Naveen Kumar K L(1)
M.Tech Scholar, Department of Industrial &Production Engineering The National Institute of Engineering Mysore, India
e-mail:Naveen.nk45@gmail.com

M.S Sham Prasad(2)
Associate Professor, Department of Industrial &Production Engineering the National Institute of Engineering, Mysore, India
E-mail: shamprasad_nie@yahoo.com

Abstract— maintenance is undoubtedly the most important shop floor support function for production. It is necessary to ensure that available machines are utilized to maximum capacity and breakdowns kept to a minimum. Preventive maintenance believes in the principle "a stitch in time saves nine". It seeks to eliminate possible breakdowns through planned maintenance checks, production schedules were continually upset due to frequent breakdowns of machines keeping the above problem in mind; we have tried to formulate a feasible preventive maintenance schedule for 14 splicing machines to eliminate breakdowns. We have attempted to predict future breakdowns and devised a preventive maintenance programme to avoid these breakdowns. The prediction of future breakdowns has been done on the basis of statistical of past available breakdown data the actual preventive maintenance schedule has been formulated with mean time between failures and maintenance personnel availability as constraints**.**

Keywords-*production scheduling,cost benefit analysis,splicing machine*

*****

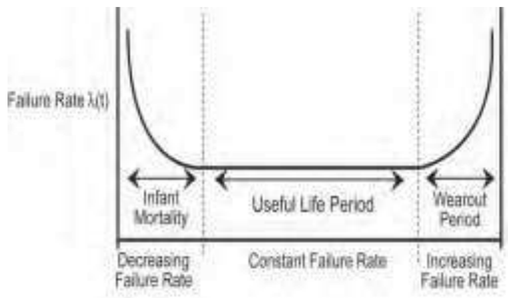
I. INTRODUCTION

Maintenance is the actions associated with equipment repair after it is broken. The dictionary defines maintenance as follows: "the work of keeping something in proper condition; upkeep." This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order. Unfortunately, data obtained in many studies over the past decade indicates that most private and government facilities do not expend the necessary resources to maintain equipment in proper working order.

For example, equipment may be designed to operate at full design load for 5,000 hours and may be designed to go through 15,000 starts and stop cycles.

The need for maintenance is predicated on actual or impending failure – ideally, maintenance is performed to keep equipment and systems running efficiently for at least design life of the component

As such, the practical operation of a component is time-based function. If one were to graph the failure rate a component population versus time, it is likely the graph would take the "bathtub" shape shown in figure. In the figure the y axis represents the failure rate and the x axis is time. From its shape, the curve can be divided into three distinct: infant mortality, useful life, and wear-out periods.



Component failure rate over time for component population

The initial infant mortality period of bathtub curve is characterized by high failure rate followed by a period of decreasing failure. Many of the failures associated with this region are linked to poor design, poor installation, or misapplication. The infant mortality period is followed by a nearly constant failure rate period known as useful life. There are many theories on why components fail in this region, most acknowledge that poor O&M often plays significant role. It is also generally agreed that exceptional maintenance practices encompassing preventive and predictive elements can extend this period. The wear-out period is characterized by a rapid increasing failure rate with time. In most cases this period encompasses the normal distribution of design life failures.

A. Reactive Maintenance

Reactive maintenance is basically the "run it till it breaks" maintenance mode. No actions or efforts are taken to maintain the equipment as the designer originally intended to ensure design life is reached Advantages to reactive maintenance can be viewed as a double-edged sword. If we are dealing with new equipment, we can expect minimal incidents of failure. If our maintenance program is purely reactive, we will not expend manpower dollars or incur capital cost until something breaks.

B. Preventive Maintenance

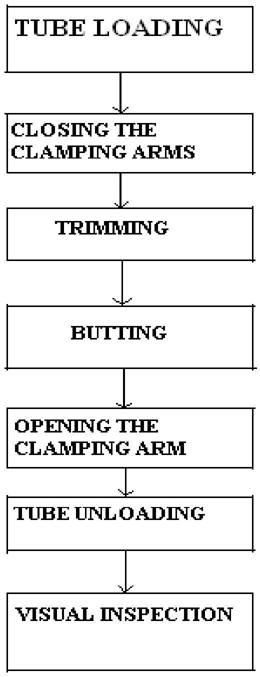
Preventive maintenance can be defined as follows: Actions performed on a time- or machine-run-based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level.

By simply expending the necessary resources to conduct maintenance activities intended by the equipment designer, equipment life is extended and its reliability is increased by performing the preventive maintenance as the equipment designer envisioned, we will extend the life of the equipment closer to design.

C. **Predictive Maintenance**

Predictive maintenance can be defined as follows: Measurements that detect the onset of system degradation (lower functional state), thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component physical state. Results indicate current and future functional capability. The advantages of predictive maintenance are many. A well-orchestrated predictive maintenance program will all but eliminate catastrophic equipment failures. We will be able to schedule maintenance activities to minimize or delete overtime cost. We will be able to minimize inventory and order parts, as required, well ahead of time to support the downstream maintenance needs. We can optimize the operation of the equipment, saving energy cost and increasing plant reliability

II. WORKING OF SPLICING MACHINE



Tube loading: this is the first step in splicing operation in which the tube is loaded manually by the operator between the two jaws, leaving some portion of the tube (usually 5 to 10 mm) to project from the two ends of the jaws, which is trimmed leaving a small length of the tube from the jaw ends (0.5 to 1mm) called overhang for facilitating butting operation.

B. Closing of clamping arms: in this stage, the tube being loaded in the previous stage is held firmly by means of clamping arms. The firmness is obtained by locking the handle of the clamping arms to the table halves so that trimming operation becomes easier and smoother.

C. Trimming:

Immediately, after closing the clamping the clamping arms, the machine are switched on by the operator. The blade carriage unit carrying a pair of blades swings down to the horizontal position from its initial vertical position, and the blades start moving linearly on the side surfaces of the blade carriage unit. At the point where the blade starts trimming the tube, the blade is heated initially to a higher temperature and then maintained constant and finally the temperature is decreased at the end of cut when the blades is switched off by means of limit switch or proximity switch. And in the next instant the blade carriage unit swings up to its initial vertical position.

D. Butting:

Immediately after trimming the tube ends, they are joined or spliced to obtain an endless tube. Initially the right half of the jaw holder slides at a constant velocity towards the left half of the jaw holder and butting action takes place for 3.5 to 13 sec depending upon the size of the tube.

For butting action to take place perfectly, the tube ends being trimmed must be free from dust, dirt and it must be smooth enough for joining them.

E. Opening of the clamping arms:

Once the butting phase is completed the clamping arms are first unlocked from the table and opened by lifting them up to the vertical position about the hinge provided at the base of the clamping arms, manually.

F. Tube unloading:

Immediately, after opening the clamping arms, the spliced tube is unloaded from the machine manually by the operator.

G. Visual inspection:

After unloading the spliced tube from the machine, it is inspected visually for any problems such as side step, width step, overhang and the tube is kept a side and problem is rectified if exists. Otherwise the operation cycle is repeated as explained above for next tube and so on.

III. DESCRIPTION OF THE PROBLEMS ANALYZED ON SPLICING MACHINE

Major problems analyzed are:-

- Step problem
- Jaw problem
- Overhang problem
- Entry open problem
- Blade carriage problem
- Electrical problem

A. Step problem:-

Is the major problem encountered on splicing machine, which occurs quite frequently, it is caused due to misalignment of jaws When jaw is vertically misaligned it is called as vertical step problem, and when jaw is horizontally misaligned it is called as side or width step problem. These problems can be easily identified when the tube is visually inspected. This problem can be avoided by providing shims at the base of the jaws (shims are nothing but thin metal plates or paper strips).these shims must be uniformly distributed on both jaws to avoid bending of the clamping arms.

B. Jaw problem:-

Jaw is the vital component of the splicing machine because it is used to guide the tube during splicing operation. The width of the jaw depends upon the width of the tube spliced. The male part of the jaw is bolted in y shaped clamping arms and the female part is bolted in respective jaw holders. Each part (i.e., female and male part) is provided with rubberized faces for guiding the tube during butting operation. These rubber faces are sometimes smeared with green tube, due to improper chalking. This smeared jaw affects the spliced tube during butting and this in turn leads to bad joint. This problem can be avoided by cleaning the rubberized faces if the jaw, at regular intervals. Sometimes jaw itself (i.e., rubberized faces of jaw) gets cut by the blades during trimming operation. This problem is due to loosening of the blades, when the bush holding them melts away. Hence this can be avoided by replacing the jaws so that the blades travel the desired path during trimming operation.

C. Overhang problem:-

Overhang is an extra amount (or length) of the tube projected from the ends of the rubberized faces of jaw after trimming operation is completed. This is provided for facilitating the butting operation and to obtain a good or optimum joint. The length of the overhang varies from 0.5 to 1mm. When overhang is insufficient, the join becomes weak and depressed joint is formed. When overhang is sufficient or optimum then a good joint is formed. When overhang is excess, then the tube around the joint gets thinned and this results in a weak joint.

This increase or decrease of overhang is due to improper cutting by slackened blades. The slackening of blades is due to vibrations exerted by the blade carriage unit during its swinging operations. This problem can be avoided by tightening the blades, so that they are held firmly during trimming operation and required amount of tube is left as overhang. This problem is indentified by visually inspecting, after unloading the tube from the machine. The bushes and nuts used to hold the blades are checked and replaced if required.

D. Entry open problem:-

This is another major problem identified at the entry point of the blade during trimming operation. The tube gets opened at the point where the blade starts the trimming operation due to excessive heat generated in the blades at that point. And because of this excess heat, the tube gets cured and does not join thereafter. This problem can be avoided by regulating the current flowing through the blades by adjusting the resistance of the variable rheostat.

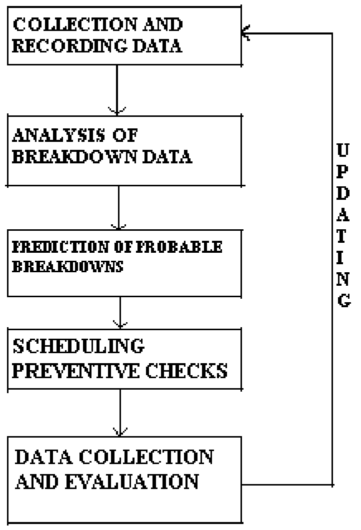
E. Blade carriage problem:-

Blade carriage unit consists of straight metal bar with guiding wheels for facilitating the smooth movement of the blades during trimming operation. Since the blades are also fastened on the blade carriage itself they get slackened along with the whole straight bar. This slackened movement of blade carriage unit reflects as jerky movement of blades during trimming operation and this in turn results in saw cut tube. Because of this saw cut, a bad joint is generated. This problem can be prevented by regularly checking the tension of the chain drive and by appropriately tightening its links.

F. Electrical problems:-

The main reason for this problem is due to frequent changeover from genset to keb (Karnataka electricity board) and vice-versa. Since for every width of the joint the current varies and hence it should be adjusted to require value frequently as and when required. And also due to loose contact of cables and due to more number of joints in the cable, leakage of current is more. This problem can be avoided by replacing the jointed wire by new joint less wire.

IV. METHODOLOGY OF BREAKDOWN DATA ANALYSIS



A. Collection and recording breakdown data:

The break down data was collected from previous available maintenance log books. then the problems were categorized into six major heads namely step problem, jaw problem, blade carriage problem and electrical problem.

B. Analysis of breakdown data:

The breakdown data was grouped into weekly statistics. The problems were occurring very randomly and there was no definite pattern. Since breakdowns were occurring randomly Poisson distribution is best suited for making predictions.

C. Prediction of probable breakdowns:

Mean number of breakdowns per week is calculated. The standard deviation is then calculated. The mean and standard deviation are added to get the upper limit of the break down range.

It is assumed that one preventive check will avoid the probability of occurrence of one problem. For e.g.: if the probability of occurrence of five or less than five problems per week is 97%.by having five preventive checks, the probability of eliminating the problem occurrence is 97%

D. Scheduling preventive checks:

Scheduling is defined as the assignment of work to a facility and specification of the time and the sequence in which the work is to be done. after deducing the number of preventive checks for all problems and for all machines. Two alternatives schedules are devised considering the following constraints.

- The time interval between the preventive checks should not exceed the mean time between failures.
- Total time of preventive checks (on splicing machines) per shift should not exceed 2.5 man hours.
- Each machine should have a comprehensive check per week.

Or

- Each machine should have a comprehensive electrical check and a comprehensive mechanical check per week.

E. Data collection and evaluation:

This system must be updated as we proceed for making better predictions. E.g.: the previous available data is used for making the nth week predictions. For making the (n+1) week predictions the breakdowns data of nth week must be collected and must be used.

V. STATISTICAL INPUTS AND BREAK DOWN ANALYSIS

Statistics is the science of the collection and classification of facts as a basis for induction. Probability is the science of quantitatively determining the chance that a certain result will occur from a specified process.

"Statistics is the process of getting the facts and probability is the process of predicting results based on those facts".

A. Mean:

An average of a series of quantities or values specifically their sum divided by number of items in series called mean. Mean is given by

Observations will be denoted by n.

$$M = \frac{\sum_{i=1}^{n} xi}{n} = \frac{x1+x2+x3+\cdots\ldots\ldots xn}{n}$$

∑ represents the summation

X, represents observed values

N represents number of observed values.

B. Standard deviation:

A measure of average dispersion of numbers, computed as the square of the average of the difference between the number and their arithmetic mean.

$$(S.D) = \sqrt{\frac{\sum_{i=1}^{n}(xi-m)}{n}}$$

Where

S.D=standard deviation

Xi =observed value

m=average

n=number of observed values

C. Variance:

The variance is the square of the standard deviation it is equal to the mean squared deviation of the variable from its mean.

$$v = (S.D)^2 = \frac{\sum_{i=1}^{n}(xi-m)}{n}$$

Where

V= variance

S.D= standard deviation

Variance is the second moment about the mean. Moment is an important characteristic of a set of test scores. A moment can be referenced to any point on the measurement axis. The origin and the mean are the two most common reference points. Probability distribution is a mathematical formula that relates the valves of the characteristics with their probability of occurrence in the population.

The mean (m) and the standard deviation of the sample are calculated for making predictions about the unknown universe. A sample is a limited number of items taken from a large source. A population is a large source of items from which sample is taken.

D. Probability distributions are of two types:

1. Continuous distributions
2. Discrete distribution

a. Continuous distributions

When the characteristic being measured is not a whole number, that is, it can take any value, and then its probability distribution is called as continuous probability distribution.

Example: the diameter of the shaft being produced, weight of eggs, heights of adult males.

The most commonly used continuous probability distributions are-

- Normal distribution
- Exponential distribution
- Weibull distribution

b. Discrete distribution:

When the characteristic being measured can take on only whole numbers like 0,1,2,3, etc its probability distribution is called discrete probability distribution Example: number of breakdowns/weeks, no. Of faulty tube in a samples of 1000, etc.

The commonly used discrete probability distributions are

- Hyper geometric distribution
- Binomial distribution
- Poisson distribution

VI. CALCULATIONS

Specimen calculation for splicing machine 2

- Total number of step problems over 43 weeks = 136
- Mean number of breakdowns per week =m= 136/43=3.16

According to Poisson distribution

Standard deviation = S.D = √ 3.16 = 1.78

Breakdown range = m + S.D

=3.16+1.78

=5or 2

According to Poisson distribution, probability of problem occurring exactly 'x' times, given by

$$P(x) = (e^{-m}\, m^{x}) / x!$$

Probability of getting exactly zero problem = $(e^{-1.16}\, 3.16^{0}) / 0!$

= 0.0424

= 4.24 %

S Similarly

- P(1) = 13.38 %
- P(2) = 21.16 %
- P(3) = 22.31 %
- P(4) = 17.64 %
- P(5) = 11.16 %
- .'. Probability of getting exactly five or less than five problems
- p (5 or < 5) = p (0) + p (1) + p (2) + p (3) + p (4) + p (5)
- P(5or < 5) = 4.24+13.38+21.16+22.31+17.64+11.16 =89.89%
- .'. By having five preventive checks probability of eliminating the step problem is 89.89%

PARTICULARS	STEP	JAW	OVERHANG	ENTRY OPEN	BLADE CARRIAGE	ELECTRICAL
NUMBER OF BREAKDOWNS	136	22	18	12	42	39
MEAN	3.16	0.51	0.41	0.279	0.976	0.91
STANDARD DEVIATION	1.78	0.71	0.66	0.528	0.98	0.96
BREAKDOWN RANGE	5	2	1	1	2	2
TOTAL TIME LOST DUE TO BREAK DOWN	6316	2736	580	1176	2636	1436
TIME LOST/WEEK	146.8	63.6	13.6	27.3	61.3	33.4
TIME REQUIRED FOR PREVENTIVE CHECK / WEEK	75	20	10	2	20	20
TIME SAVED/WEEK	71.8	43.6	3.6	25.3	41.3	13.4

P(X)= PROBABILITY OF EXACTLY ELIMINATING X NUMBER OF BREAKDOWNS

	STEP	JAW	OVERHANG	ENTRY OPEN	BLADE CARRIAGE	ELECTRICAL
P(0)	4.24	59.86	65.79	76.65	37.66	40.37
P(1)	13.38	30.67	27.54	21.11	36.78	36.62
P(2)	21.16	7.85			17.96	16.66
P(3)	22.31					
P(4)	17.64					
P(5)	11.16					

VII. PREVENTIVE MAINTENANCE SCHEDULING

Preventive maintenance scheduling after deducting the number of preventive checks the next step is to schedule these preventive checks. In devising the schedule following constraints are considered.

1) The time interval between the preventive checks should not exceed the mean time between failure (MTBF).for e.g.: consider a problem with MTBF of 24hrs.a preventive check now will avoid the problem from occurring for the next 24hrs.Therefore it is necessary to have another preventive check latest at the 24th hour or before that.

Total working time per week =6 days
=6 * 3 = 18 shifts
=18 * 8 = 144 hours

MTBF = (total number of operating time/week) / (total no of Breakdowns/week)

For, six problems/week; MTBF = 144/6=24hrs

Similarly

For five problems per week, MTBF = 28.8 hrs,
For four problems per week, MTBF = 36 hrs
For three problems per week, MTBF = 48 hrs
For two problems per week, MTBF = 72 hrs
For one problems per week, MTBF = 144 hrs

2) Total time of 2.5 man-hours per shift is available for preventive checks on splicing machines.

The time required for preventive checks are

- Step problem - 15 min
- Jaw problem -10 min
- Overhang problem - 10 min
- Entry open problem -2 min
- Blade carriage problem -10 min
- Electrical problem -10 min

3) a. Each machine should have a comprehensive preventive check per week. Some of the minor problems which occur every rarely (once on 6 weeks, once in 8 weeks etc) are considered here. Also maintenance functions like machine cleaning, machine lubrication etc are carried out during comprehensive checks (schedule 1).

(Or)

b. Each machine should have at least one comprehensive electrical and one comprehensive mechanical maintenance personnel could do their work separately (schedule 2). Here the step problem, open problem, overhang problem and electrical problem are electrical problems. Preventive checks for these problems are carried out by electrical maintenance personnel.

Considering splicing machine, the comprehensive check for machine 2 has been incorporated in the third shift of Tuesday.

For the step problem, occurring five times a week the MTBF is 28.8 hrs. The first check is in the first shift on Friday. So to ensure that the MTBF constraint is not violated, the second check is incorporated in the first shift of the next day i.e., Saturday.

This is followed for all problems on machine 2.

The entire procedure is repeated for each machine.

Thursdays which is the maintenance day at PRP ltd, has been left free to cater to the maintenance needs of the remaining machines in the plant

Schedule 1

DAY	FRIDAY			SATURDAY			SUNDAY			MONDAY			TUESDAY			WEDNESDAY		
SHIFT	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	A2 A4 B4 C4 D4 E4 F4 F11	A3 B3 C3 D3 E3 F3 A5 B5	A1 A6 B6 C6 D6 E6 F6 A7 A8 B8 A11	A2 A4 A9 B9 C9 D9 E9 F9 A10 B10 F10	B1 E1 A3 A5 A12 B12 C12 D12 E12 F12	A1 B2 E2 F2 F4 A6 A7 A8 A13	A2 A4 B4 D4 A9 A11 B11 C11 E11 F11	A5 B5 C5 D5 E5 F5 B7 F5 A11 E14	A3 A6 E6 A8 B8 C8 D8 E8 F8 A10	A1 A4 C4 E4 F4 A7 F9 B13 C13 E13 F13	A2 B3 C3 E3 F3 A5 A9 A12 F12	A3 B4 D4 A6 B6 C6 F6 A8 A11 F11 A13	A4 A7 B9 C9 E9 A10 B10 C11 D10 E10 F10	A1 B1 C1 D1 E1 F1 A5 B5 B8 A9	A2 B2 C2 D2 E2 F2 F4 A6 E6 A8	A3 A4 F9 A11 B11 C11 A14 B14 C14 E14 F14	A1 A5 E5 F5 A7 B7 C7 D7 E7 F7 A12 F12	A6 A8 C8 F8 A9 A10 A13 B13 C13 D13 E13 F13

NUMBER 1 TO 8 SEMPRIT M/C'S A = step B= jaw c= over hang,

NUMBER 9 10 11 L&T M/C'S D= entry open, E= blade carriage

NUMBER 12 13 & 14 MIDLAND M/C'S F= electrical

Schedule 2

DAY	FRIDAY			SATURDAY			SUNDAY			MONDAY			TUESDAY			WEDNESDAY		
SHIFT	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	A# d4 c6 f6 a7 a8 a10 b10 e10 a13	C2 d2 f2 a5 e5 a9 b9 a11 b11 e11 f12	A1 a4 b4 a6 b6 f9 c10 d10 f10 c10 c13 d13 f13	A2 c4 f4 f7 a8 b8 e8 c11 d11 f11	B1 e1 a3 a5 b5 a7 c8 d8 f8 a9 a10	A1 b2 e2 a4 a6 e6 a11 a12 b12 a14 e14	A2b3 e3 d4 b7 a8 a13 b13 e13	A3 c3 d3 f3 f4 a5 a7 c12 d12 f12	A4 b4 e4 c5 d5 f5 a6 a9 c9 d9 f9	A1 c1 d1 f1 c6 f6 a8 b8 a10 b10 f11	A2 f2 a5 b5 e5 b9 e9 a11 b11 c14 f14	A3 a4 a6 b6 e6 a7 a9 f10 a12 c13 f13	C4 d4 f4 c7 d7 f7 a8 c11 a13	A1 b1 e1 a5 c8 f8 a10 f12	A2 b2 e2 a4 b4 a6 f9 a11 a14 b14 a14	A3 b3 e3 a7 b7 e7 a8 b8 a9 f11 b13 e13	A1 c3 f3 f4 a5 b5	A2 a4 e4 f5 a6 e6 c9 a12

NUMBER 1 TO 8 SEMPRIT M/C'S A = step B= jaw c= over hang,

NUMBER 9 10 11 L&T M/C'S D= entry open, E= blade carriage

NUMBER 12 13 & 14 MIDLAND M/C'S F= electrical

VIII. COST BENEFIT ANALYSIS

For semprit splicing machines total downtime Over 43 weeks due to different problems = 7887900sec
For semprit splicing machines total downtime per week =7887900/43 sec
=183439
=183440
Total time required for preventive checks
On semprit splicing machine per week = 81600 sec
Production time saved per week on semprit splicing machines = 183440-81600
=101840 sec

At present the curing presses are been utilized at 80-82% capacity. 6-8% loss in utilization occurs due to breakdowns in the curing presses and unto 10% due to unavailability of the curing presses, it is necessary to increase the output of splicing machine by at least 10%.
Time saved per week (if preventive maintenance is effective by 30%) = (101839*30)/100 = 30552 sec
Time saved per week (if preventive maintenance is effective by20%) = (101839*20)/100
=20368 sec
Time saved per week (if preventive maintenance is effective by10%) = (101839*100)/100
=10184 sec
Average time that a tube spends on semprit splicing machines = 56.25 sec
Extra tubes that can be manufactured if
Preventive maintenance is effective by 30% = 30552/56.25
=543 tubes / week
Preventive maintenance is effective by 20% = 20368/56.25
=362tubes / week
Preventive maintenance is effective by 10% = 10184/56.25
=181tubes / week
Average cost of tube manufactured on semprit splicing machine = Rs 74/-
Additional income per week
if Preventive maintenance is effective by 30% = 543/56.25
= 40182/-
Preventive maintenance is effective by 20% = 362/56.25 =26788/-
Preventive maintenance is effective by 10% = 181/56.25 =13394/-Even if the preventive maintenance is effective by 10 % it results an additional income of Rs.(13,394+2,8282+254+3062.5+1025.1) = Rs 20536.6/week or Rs 82,256/ - per month

Cost Benefit Analysis

	Semprit	L&t 1	L&t2	L&t3	Midland
Total down time for 43 wks (sec)	7887900	809100	377400	576000	339000
Total time for preventive checks/wk (sec)	81600	10620	7920	9120	5280
Time saved/wk(sec)	101839	8200	860	4280	2610
Time saved/wk if preventive maintenance is effective by */(sec) 30 20 10	30552 20368 10184	2459 1640 820	257 172 86	1282.6 855 428	782 520 261
Time one tube spends on a splicing m/c (sec)	56.25	28.72	48.21	56.25	27.0
Extra tubes that can be manufactured in saved time at */ (per wk) 30 20 10	543 362 181	85 57 28	5 3 1	23 15 7	28 19 9
Average cost of a tube manufactured (rs)	74	101	254	437.5	113.9
Additional income per week at */ effectiveness of preventive checks 30 20 10	40182 26788 13394	8585 5757 2828	1270 762 254	10062.5 6562.5 3062.5	3189.2 2164.1 1025.1

Additional income per month = Rs 82,256/- at 10% effectiveness

The scheduling model proposed is theoretical model. The formulation is based on statistics obtained from previous breakdowns. Practical shop floor conditions may vary. This may affect the efficiency of the preventive maintenance schedule. The times considered for preventive checks are taken on an average. Actual times for preventive checks may vary depending on maintenance personnel capability and complexity of problems. Break down data can be created and the data analysis can be computerized, which eliminates lot of clerical work. This procedure can be generalized and can be extended to any number of machines to get the preventive maintenance schedule for the entire plant.

Acknowledgment

This is the best part of the paper; I thank my Parents, & Mr Mohammed Ismail and Dr M.S sham Prasad, Associate Professor, of Industrial & Production Engineering Department, NIE, and Mysore for their guidance in bringing out this journal. I thank Mr. Lingaraju, work Manager, polymers and rubber products ltd, manufacturer butyl automotive tubes for two wheelers, passenger vehicles and heavy transport vehicles, for their valuable time spent with me to know about company environment.

REFERENCES

[1] statistical methods for engineers-Richard h mccuen statistical quality control-grant and ireon
[2] applied statistics for engineers-William volk
[3] maintenance hand book-L.R Higgins
[4] maintainability and maintenance management-Joseph d.patton
[5] M.C. ETI, S.O.T. OGAJI and S.D. PROBERT, “Reducing the cost of preventive maintenance (PM) through adopting a proactive reliability-focused culture” Mechanical Engineering Department, Rivers

State University Of Science And Technology, volume 83 issue 11 November 2006

[6] duyquang nguyen and Miguel bagajewicz, " optimization of preventive maintenance scheduling in processing plants" the university of Oklahoma, 18th European Symposium on Computer Aided Process Engineering 2008.

[7] Mehdi Vasili, Tang Sai Hong, Napsiah Ismail, Mohammadreza vasili, "Maintenance optimization models: a review and analysis" Department of Mechanical & Manufacturing Engineering, University Putra, Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management Kuala Lumpur, Malaysia, January 22 – 24, 2011.

[8] B.denkenaa, S. kröningaa, k. doretha "operational planning of maintenance measures by means of event-driven simulation" a institute of production engineering and machine toots an der universität 2, Germany 2012

[9] K. Efthymioua, N. Papakostasa, D. Mourtzisa, G. Chryssolourisa "On a Predictive Maintenance Platform for Production Systems" Department of Mechanical Engineering & Aeronautics, University of Patras 2012

[10] Amit Kumar Jain, "an Optimal Preventive Maintenance Strategy for Efficient Operation of Boilers" in Industry Department of Mechanical Engineering M.A.N.I.T. Bhopal India, Vol 2, No.4, 2012

[11] Praveen Kumar R, Rudramurthy, "Analysis of Breakdowns and Improvement of Preventive Maintenance on 1000 Ton Hydraulic Press" M.Tech scholar, Assistant Professor, Department of Mechanical Engineering, Sri Jayachamarajendra college of Engineering, Mysore, Karnataka, India Volume 3, Issue 8, August 2013

[12] Richa Chouhan, Dr.Manoj Kumar Gauryand Rohit Tripathiz "Implementing a Preventive Maintenance Planning Model on an Ageing and Deteriorating" Production System M.Tech. Student, Dept.of Mechanical Engineering at MITS-Gwalior, India Volume 4, July 2013

[13] Magnus Holma, Aimar Cordero Garcia, Göran Adamsona and Lihui Wangb "Adaptive decision support for shop-floor operators in automotive industry" a University of Skövde, Sweden 2014

[14] Ulrich Thombansena, Torsten Hermannsb, Stoyan Stoyanovc "Setup and Maintenance of Manufacturing Quality in CO2 Laser Cutting" a RWTH Aachen University, Chair for Laser technology LLT, Steinbachstrasse 15, 52074 Aachen, Germany 2014

[15] Mourtzis Da*, Doukas Ma, Vlachou Aa, Xanthopoulos Na "Machine Availability Monitoring for adaptive holistic scheduling: A conceptual framework for mass customization a Laboratory for Manufacturing Systems and Automation" University of Patras, Procedia Cirp 25 2014