

# Predictive and Preventive Maintenance of Two and Three Wheelers Tube Defects in Splicing Process

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**Abstract** - bjective of any industry is to reduce the production and maintenance cost to enhance the quality of product for consumer needs. The production loss due to machine breakdown has made a critical factor in modern industries. Today, with the developments of special purpose and sophisticated machines and equipments will cost more and there downtime is more expensive. Therefore there is a necessity to reduce the cost of production without affecting the quality of the product.

Maintenance of machines helps to run round the clock without fail .Maintenance ensures the plant and equipments available for production at minimum cost for the scheduled hours and operating at specified standards with minimum wastage.

Predictive maintenance is a more condition-based maintenance approach which is based on measuring of the equipment condition in order to assess the equipment failure during production. Preventive maintenance is a planned maintenance schedule aimed to prevent breakdowns and failures. The primary goal of preventive maintenance is to prevent the failure of equipment before actually it occurs.

Splicing is an important process in tube production. It is the process of joining the tube open ends to form a closed loop. Splicing must be performed as efficiently as possible, since splice open faults contributes major rejections of tube. Hence it required to prevent such tube defects to increase the production of quality tubes.

The main objective of this project is to study breakdown details of splicing processes, equipment reliability, availability, failure rate and maintainability rate were calculated based on root causes for the breakdowns using brainstorming technique. Action plans were suggested to correct them by implementing predictive and preventive maintenance checklists.

## OBJECTIVE OF THE STUDY

In order to minimize the tube defect and maximize the profit, the machine breakdown should be reduced. A good preventive maintenance and predictive maintenance schedule is required to minimize the breakdowns.

The main objectives of the project are:

- To Increase availability and reliability of the machine.
- To reduce down time of the machine.
- To develop preventive and predictive maintenance checks.
- To carry out failure data analysis using brainstorming technique.
- To optimize MTBF, MTTR, scrap due to splice open and maintainability of the machine.

## METHODOLOGY

Before implementing PM and PDM checklist, few machines were showing major breakdowns.

The method adopted for project work given below

- Collection of data regarding breakdown and machine details
- Study of different sizes tube defects
- Identify possible causes and effect diagram
- Failure rate analysis and reliability are carried to determine performance of machine
- Develop preventive maintenance and predictive maintenance

Table: Tubes manufactured at falcon

| Tube size                 | Weight +/- 0.020 (kg) |
|---------------------------|-----------------------|
| 2.25/2.50-16              | 0.373                 |
| 2.50/2.75-18(White line)  | 0.463                 |
| 2.50/2.75-18(Blue line)   | 0.463                 |
| 2.75/3.00-10              | 0.333                 |
| 2.75/3.00-17              | 0.428                 |
| 3.00-18(Blue line)        | 0.501                 |
| 3.00-18(White line)       | 0.501                 |
| 3.00-17(Double line-blue) | 0.501                 |
| 3.50-10                   | 0.370                 |
| 3.00/3.25-19              | 0.613                 |
| 100/90-17                 | 0.626                 |
| 100/90-18                 | 0.691                 |

### TUBE PROCESS IN FALCON TYRES

At master batch compound obtained from rubber mixing unit is stored with utmost care. Master batch compound is called 'Stock compound' at falcon. Stock compound is not directly used to manufacture tubes. It is first cleaned and then curatives are mixed with it. The final compound thus obtained is used to manufacture tubes.

### QUALITY POLICY

Falcon tyres ltd. Are committed to supply quality tyres, tubes ,and flaps on time to achieve fullest customer satisfaction. It will achieve this by providing training to all levels, continually improving the system and processes

- ❖ Mission statement
- ✓ To focus on 2 & 3 wheelers business along with capacity expansion of existing capacity per tyre
- ✓ To make falcon tyres available all across India
- ✓ Improvement in customer relations and production quality

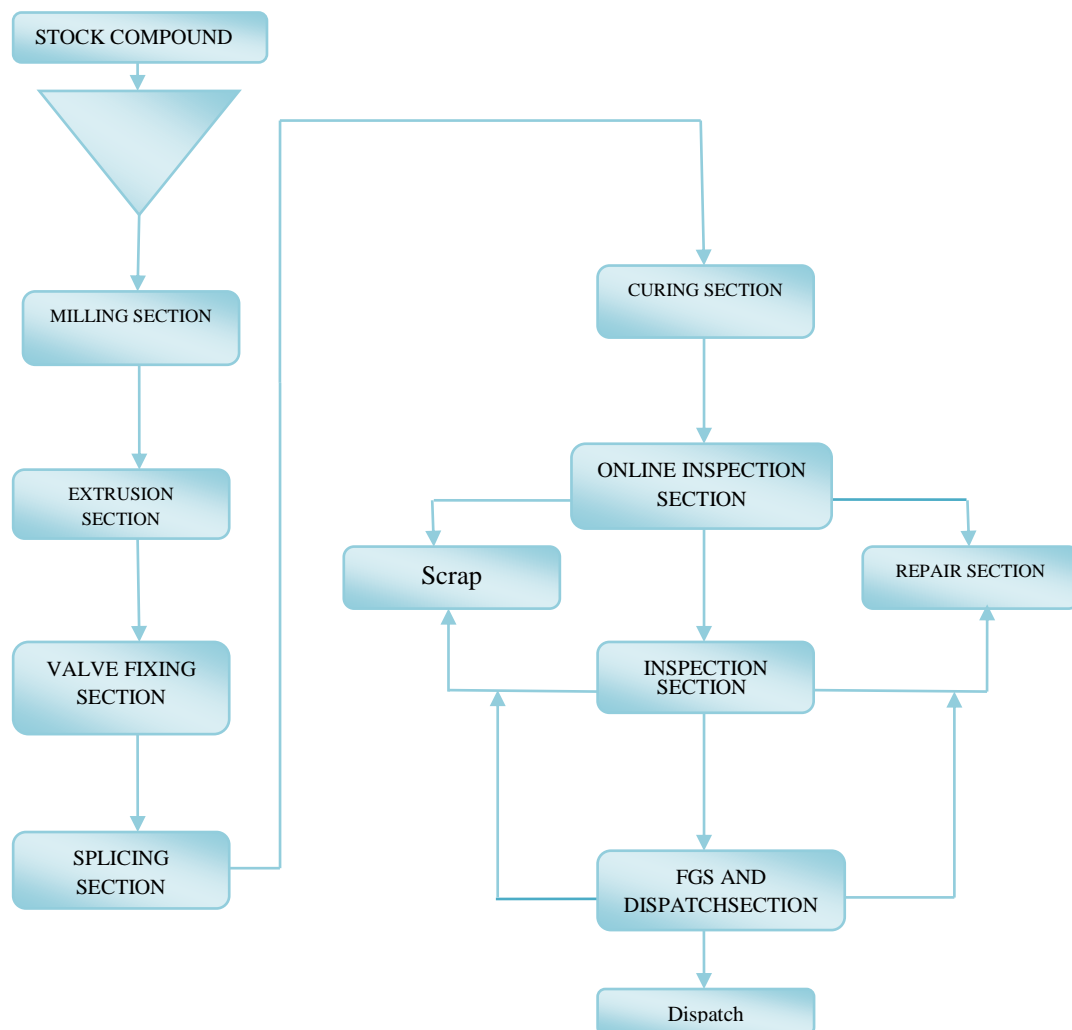


Fig: Process flow chart in section wise

### DATA COLLECTION

#### A STUDY OF SPLICING PROCESS

Splicing is the operation of joining the tube open ends to form a closed loop. The type of joint is butt joint. Splicing is fundamentally an important step in tube production and must be performed as efficiently as possible, since splice faults often form large proportion of total rejects.

Butyl tubes are spliced by automated butt splicing machines, the ends of the inner tubes to be joined are cut to length by a hot knife and the fresh tacky surfaces are butted together and consolidated. Butt splicing machines may be of hydraulic or pneumatic type. Optimum butt splice quality to be obtained with a horizontal cut and rubber-faced clamps.



Fig: Splicing Machine

### SEQUENCE OF OPERATIONS IN A SPLICING MACHINE

#### MACHINE SPECIFICATION

|                                 |  |
|---------------------------------|--|
| MACHINE NAME                    | : INNER TUBE SPLICER                           |
| MAX. BUTTING FORCE              | : 15.000LBS                                    |
| WITH CYLINDER SIZE              | : 4 <sup>11</sup> DIA X 5 <sup>11</sup> STROKE |
| AT HYDRAULIC PRESSURE           | : 1200 PSI                                     |
| MAX.FLATE TUBE WIDTH            | : 8 <sup>11</sup>                              |
| MIN.FLATE TUBE WIDTH            | : 1 <sup>11</sup>                              |
| MAX.DOUBLE WALL THICKNESS       | : 1/2 <sup>11</sup>                            |
| MAX.CLAMPING FORCE              | : 1500LBS                                      |
| HYDRAULIC PRESSURE              | : 475PSI                                       |
| MIN.FLATE LENTH OF TUBE         | : 27.5 <sup>11</sup>                           |
| HYD.POWER UNIT PUMP DRIVE MOTOR | : 10HP -1500RPM                                |
| APPROXIMATE WEIGHT              | : 63000LBS                                     |

APPROXIMATE WEIGHT : 63000LBS

Table: Machine starting procedure

| 1.PRIMARY OPERATIONS                                       | INDICATIONS                                 |
|--|---|
| 1. Turn power 'ON'   | "Reset machine" indicating lamp ON          |
| 2. Push "START PUMP" push button                           | pump pressure develops                      |
| 3. Operate "knife down" selector switch                    | To ensure knife full down position          |
| 4. Kick the safety plate                                   | To ensure clamp arm and table Home position |
| 5. Push "Reset" push button LH&RH at the same time         | "ready" lamp glows                          |
| 6. For tube trials keep the heat selector in 'ON' position | "HEAT ON" indicating lamp flashes           |
| 2. MANUAL OPERATIONS                                       |   |

|   |   |
|---|---|
| 1. "Clamp arms DOWN" selector switch is on  | Arms safety lever lifts and arms come down  |
| 2. "Clamp arms UP" SS in on   | Clamp arms goes up  |
| 3. Knife up/down  | Corresponding knife selector is operated  |
| 4. Knife forward/ reverse   | Knife travel in the medium speed in cutting direction                                     |
| 5. Table forward/ reverse   | Table comes forward and goes back when corresponding selector switch position is selected |
| <ul style="list-style-type: none"><li>• Ensure that the machine is 'reset' before any manual operation</li></ul>                                    |   |
| <ul style="list-style-type: none"><li>• All the manual operations will place as long as relevant selector switch is actuated</li></ul>              |   |
| <ul style="list-style-type: none"><li>• Ensure that the clamp arms are down before butting the table to avoid bending force in clamp arms</li></ul> |   |
| <ul style="list-style-type: none"><li>• Do not kick the safety plate or raise the clamp arms when the knife is within the rubber jaws</li></ul>     |   |

#### WORK INSTRUCTIONS BEFORE COMMISSIONING THE MACHINE

1. Before starting the drive motor it must be made certain that oil reservoir, pumps, valves, hydraulic cylinder, hydraulic motor and all other loose supply components pipes and fittings are properly cleaned and inter connected correctly with suitable and correct size of pipe lines
2. Filter and fill the hydraulic oil in the reservoir up to the maximum level indicated.
3. Check the level of unit in respective planes. Also check the alignment of pump and electric motor.
4. Loosen the bleeding screws whenever provided.
5. Unscrew and adjust relief valve at lowest pressure setting. Also adjust various pressure control valves/flow control valves.
6. Check the direction of rotation; correct the direction of rotation if necessary.
7. Ensure the water flow is available to the cooler in case a water cooled cooler is incorporated in the circuit.
8. Record the oil temperature at suitable intervals and ensure that is within the recommended range.

#### ANALYSIS AND CALCULATION

##### FAILURE ANALYSIS

Failure analysis consists of investigation to find out how and why something failed. Understanding the actual reason for failures for is absolutely required to avoid recurrence and prevent failure in similar equipment the analysis helps in understanding and improvement of design, material selection, fabrication techniques, and inspection methods. The history of a failed part is very important to the analyst. All information concerning the record of a part illuminates the cause of a failure considered by the designer..

##### TYPES OF FAILURE ANALYSIS

There are two types of failure analysis

- Technical failure analysis.
  - Statistical failure analysis.
- availability of the machine and long life.

##### FAILURE DATA COLLECTION

The following information is available in maintenance data log books or log sheets and if computerized, data is available in equipment history 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. These data, after analysis, will be helpful in the redesigning during the availability improvement attempt.

The maintenance phase requires these data to be updated and used in the corrective maintenance planning.

#### STEPS INVOLVED IN FAILURE ANALYSIS

Failure data analysis involves the following steps:

- a) Brainstorming
- b) Bar charts and Histogram
- c) Cause and effect diagram

#### PREVENTIVE MAINTENANCE OF SPLICING PROCESS

Preventive maintenance of machine components is a basic & simple procedure & if followed properly, can eliminate most of the component failures. PM must be followed in order to obtain good results. We must view a PM program as a performance oriented rather than activity oriented. Many organizations have good PM procedures, but do not have maintenance personnel to follow them. In order to develop an effective preventive maintenance program for a system following steps are considered:

- a) First identify the operating condition:
- b) Does the system operate 24 hours a day, 7 days a week? Does the system operate at maximum flow & pressure? Is system located in a dirty or hot environment?
- c) What requirements does the equipment manufacturer state for preventive maintenance of the equipment?
- d) What requirements & operating parameters does the component manufacturer state concerning the particulate?
- e) Past experience on the machine history to follow the procedure. What equipment history is available to verify the above procedures for the equipment?

As in PM programs, we must write procedures required for each PM task. These steps or procedures must be accurate & understandable by all maintenance personnel from entry level to master. PM procedures must be a part of the PM Job plan that includes tools or special equipment required to perform the task.

#### SAFETY OPERATION PROCEDURE

1. Switch off the machine at the end of the shift.
2. Use emergency stop switch in case of emergency.
  - a. Clean the light source before starting the shift.
3. Always switch off machine while cleaning.
4. Apply pause speed push button for let-off to avoid any slackness in ply.
5. Maintain grease level as per marking.
6. Always use plastic wire for binding electrical cables.
7. Use ear plugs for sound control.
8. Wear safety shoes and hand gloves.
9. Ensure chilled water line hand valve is closed at shift end, after completion of work.
10. Ensure power cable is always connected using cable tray.
11. Ensure all gauges are cleaned for perfect visibility.
12. Ensure working of safety devices before start up.
13. Ensure measuring instruments are calibrated.
14. Clean the panels & motors by vacuum cleaner regularly.
15. Ensure proper electrical insulation at wire joints.
16. Do not allow squeeze to accumulate on floor.
17. Check condition of brakes & adjustments.
18. Bearing block, drive chain greasing to be done as per defined frequency.
19. Check for proper earthing, cable terminations at junction boxes & panels.
20. Observe for any abnormal noise while operating the machine.
21. Ensure lubrication points are free from blockages.
22. Do not use mobile phones while working.
23. Always ensure that control panel is locked.
24. Ensure that all the screws are threaded uniformly.
25. Do not wear loose clothing while working on the machine (rotating parts).

26. Check the condition of let-off & wind-up locks at the start up.
27. Do not stand in the way of moving part.
28. Use ladder to clean the machine top. Do not climb on the machine and disturb the settings.
29. Do not allow dirt to deposit on electrical pipe connected to power pack.
30. Ensure electrical On/Off switch is tight.

## RESULT AND DISCUSSION

### IMPLEMENTATION OF PREDICTIVE AND PREVENTIVE MAINTENANCE OF SPLICING PROCESS

Before implementation of predictive and preventive maintenance of splicing process the mean time between failure, equipment availability, and reliability was not meeting the requirements. And also downtime hours was quite high.

After implementation of predictive and preventive maintenance of splicing process the calculated values for mean time between failure, downtime, failure rate, equipment availability, reliability, maintainability rate is as follows.

Table: Break Down Details of Splicing Machine in Year March-17 to May-17

| Months   | Available time | No. of B/Ds | Total B/D time<br>hrs: min | Repair time<br>hrs: min |
|----------|----------------|-------------|----------------------------|-------------------------|
| March-13 | 648            | 12          | 12:20                      | 06:45                   |
| Apr-13   | 660            | 8           | 16:45                      | 10:25                   |
| May-13   | 645            | 7           | 06:45                      | 04:40                   |
| Total    | 1953           | 27          | 35:50                      | 21:50                   |

## RELIABILITY ASSESSMENT

Reliability assessment of splicing machine

Total available time = 1953 hours

Total number of breakdown = 27

Total machine downtime = 35 hours50 mins or 35.83 hours

Total repair time = 21hrs 50 mins or 21.83 hours

Total number of maintenance actions = 27

Table: Preventive maintenance checklist

|  |   |                                  |                           |                           |            |
|--|---|----------------------------------|---------------------------|---------------------------|------------|
| Falcon Tyres ltd                           |   | Maintenance Department           |                           | Date                      |            |
| KRS road, Metagalli,                       |   | Preventive Maintenance Checklist |                           |                           |            |
| Mysore-570 016                             |   | M/C Name: Splicing Machine       |                           | M/c Code: 15000-8”-M4L8   |            |
| Preventive Maintenance on Splicing machine |   |                                  |                           |                           |            |
| Sl. No.                                    | Inspection Points                                   | Specification                    | Actual                    | Work Done                 | Remarks    |
| 1  | Drive motor base bolts                              | No damage                        | No damage                 |                           |            |
| 2  | coupling  | No damage, worn-out, play        | No damage, worn-out, play |                           |            |
| 3  | Power pack oil level                                | No struck or damage              | Checked ok                |                           |            |
| 4  | Knife carriage unit                                 | No damage, play                  | Checked ok                |                           |            |
| 5  | Table butting unit                                  | No excessive play                | Checked ok                |                           |            |
| 6  | Knife sinking unit                                  | No step formation                | Checked ok                |                           |            |
| 7  | Clamping arm unit                                   | 0.01 to 0.02mm                   | Found 0.1mm               | Alignment done            | Checked ok |
| 8  | Knife change(jaws& knife change details on machine) | Damage                           |                           | replace                   | Checked ok |
| 9  | Machine bed bolts                                   | No blockage                      | Checked ok                |                           |            |
| Points added after Analysis                |   |                                  |                           |                           |            |
| 1  | Feed gear cleanliness                               | Should be clean                  | Checked ok                |                           |            |
| 2  | Clamping jaws                                       | damage                           |                           | Replace the clamping jaws | Checked ok |

| 2                           | Worm box oil level         | Drain, Clean& level to maintain     | Checked ok |  | Checked ok |
|-----------------------------|----------------------------|-------------------------------------|------------|--|------------|
| 3                           | Clutch working             | Proper engage & disengage           | Checked ok |  | Checked ok |
| 4                           | Spindle run out            | 0.15mm                              | 0.015      |  | Checked ok |
| 5                           | Knife speed                | slow                                |            | Replace the switch                         | Checked ok |
| ELECTRICAL                  |                            |                                     |            |  |            |
| Sl. No.                     | Inspection Points          | Specification                       | Actual     | Work Done                                  | Remarks    |
| 1                           | Ac motor                   | Good condition                      | Checked ok |  | Checked ok |
| 2                           | Knife heating              | At specified temperature            | Checked ok |  | Checked ok |
| 3                           | Instrumentation            | Good condition                      |            |  | Checked ok |
| 4                           | solenoid valve             | damage                              |            | Replace the valve                          | Checked ok |
| 5                           | flow control valve         | No damage                           | Checked ok |  |            |
| 6                           | Relief valve               | Good condition                      | Checked ok |  | Checked ok |
| Points added after Analysis |                            |                                     |            |  |            |
| 1                           | Voltage supply             | Low voltage                         |            | Correct the voltage                        | Checked ok |
| 2                           | Main motor                 | Tripping again and again            |            | The correct voltage supply to the machine  | Checked ok |
| 3                           | Knife current              | Frequent variation in the current   |            | Install suitable stabilizer                | Checked ok |
| 4                           | Clamp arms not coming down | No electrical supply to valve       |            | Check the system as per electrical diagram | Checked ok |
| 5                           | Limit switch               | Checked ok                          | No damage  |  | checked    |
| 6                           | Clamp arms                 | Wrong setting of heat safety switch |            | Set the gap between jaws to 2to 2.5mm      | Checked ok |

### CONCLUSION

This project work is intended to develop predictive and preventive maintenance program for tube splicing process, failure analysis and reliability assessment were carried out towards the minimization of the tube defects.

Breakdown data of splicing machine has been analyzed and the repetitive problems are identified and the causes for these failures are determined by brainstorming technique. Root cause and action plan analysis charts were displayed at a prominent place near the splicing machine so that operator can operate the machine without any fault.

Maintenance actions rates were determined effectively in a proper manner. The reliability assessment of the machine was found to be 3.17% after 250 hours, and maintainability rate was around 99.27% after 4 hours, which means that maintenance was carried out more effectively. Also the MTBF was increased to 72.46 hrs, MTTR was reduced to 49 mins and downtime of a machine was found to be 1.83% further enhancing the machine availability, which is around 98.90%.

Before implementation the scrap due to splice open was around 0.33%, after implementation of predictive and preventive maintenance of splicing process scrap due to splice open is reduced to 0.26%. It indicates that rejection of tube defects were minimized.

Study of failure data analysis and reliability assessment were made by calculating cost of repair, cost of inspection etc., and an optimal inspection frequency analysis was developed for the critical parts of machine to carry out predictive maintenance inspection to reduce the breakdown below the target level.