Machine Maintenance Planning in Manufacturing Company using RCM II Methods

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Abstract. Production machine is a crucial thing to be taken care of in order to keep the production flow stays in the right time, therefore maintenance management is needed. PT. XYZ is a manufacturing company that produces cables. One of the machines that are used and often experiences downtime is the drawing machine. Preventive Maintenance handling interval schedule could be designed by using Reliability Centered Maintenance II method. There are several ways for the data processing, which are FMEA calculation, RCM II Diagram Decision Worksheet, TTF and TTR parameter calculation, determining the correct distribution using Least Square Curve Fitting and Goodness of Fit, MTTF and MTTR calculation, reliability comparison between the conditions before and after the Preventive Maintenance is implemented, cost savings comparison between the condition before and after the maintenance is done. This research proves that interval 3 formulation with the Pay Off for 361 hours, Dancer for 327 hours, and Double Spooler for 174 hours would enhance the reliability of Pay Off to 52%, so could it to Dancer (to 57%) and Double Spooler (75%). It also proves that by implementing Preventive Maintenance with the formulated interval and the result of RCM II Decision Worksheet indicators would produce in cost savings for the Pay Off part to 25,96%, the Dancer to 35,1%, and Double Spooler to 53,52%.

Keywords: Downtime, Maintenance, Manufacturing Company, Preventive Maintenance, Reliability Centered Maintenance II.

1. Preliminary
According to Harrison and Samson (1997) technology is a source of strength in the industrial sector in increasing productivity and supporting performance growth. Technological developments in industrial machinery have increased and encouraged industrial companies to adopt these technologies to produce quality products regardless of the investment costs that must be incurred by the company. Production machines are crucial and no less important to pay attention to so that the production process remains in the right rhythm (Komarasakti, 2008).

Carrying out engine maintenance aims to make the production operation to its full potential. Maintenance aims as an activity to maintain or maintain facilities and supporting equipment and make repairs or changes made for the purposes of the machine so that there is a state of production operations
in accordance with the plan. High engine downtime is an average problem encountered company. This condition will certainly result in an inefficient production process in the company (Bangun, 2014).

To overcome these problems, the authors conducted research using the Reliability Centered Maintenance II (RCM II) method. With this method, it can help develop scheduled preventive maintenance activities. That way, the Reliability Centered Maintenance II method is applied so that it is used to obtain an ideal maintenance time interval in the hope of a planned repair time.

2. Research Methodology
The first step taken in this study was field observation of the object, which the total lost time at each Work Station in PT. XYZ. Next step is identification of the problem. The purpose of this study was to determine the priority of critical components of the RPN value of FMEA analysis results that will be carried out further analysis using pareto diagrams and provide proposed actions and appropriate maintenance intervals on critical components based on RCM II Decision Worksheet.

2.1 Problem Identification
The problems raised in this study are the work stations with the highest lost time in January 2019 until the month of July 2019, namely the Trimming Work Station. The reason for the high lost time at the Trimming Work Station is the high lost time caused by the Hoist. So far, preventive maintenance has been carried out every 3, 6 and 12 months, but unexpected damage still often occurs. This research will propose appropriate maintenance measures and maintenance intervals on critical components of the Hoist in order to reduce obstruction of production activities due to sudden Hoist damage.

2.2. Data Collection Procedure
Data collection techniques used in this study are the study of literature, observation, and interviews. Observation is carried out by observing the workings of the Hoist at the Trimming Work Station, observing the Hoist specifications, and observing the components that cause damage to the Hoist, with guidance by employees in the Maintenance Department. Interviews were conducted with related parties in the Maintenance Department (Maintenance Engineer, Trimming Foreman, and Trimming Maintenance Technician) regarding how the Hoist works, the function of components in the Hoist and the failure modes on the components in the Hoist.

3. Data Analysis

3.1 Failure Modes and Effect Analysis (FMEA)
Below is a recapitulation of the FMEA Worksheet from 3 respondent Draw Engine technicians.

| Part Off | FF | FM | FE | RPN |
|----------|----|----|----|-----|
| Plummer Block is stuck | Screw occurs friction and noises | Twisted screw | The machine is difficult to pull the cable | 126 |
| Plummer Block is stuck | The burden is more than it should be | Cable does not come out | 128 |
| Main Gear Box | Dirty Shaft | The cable is stuck to enter the machine | Shaft changes color | 72 |

Table 1. Recapitulation of FMEA
| Part                   | FF          | FM                      | FE                                      | RPN |
|------------------------|-------------|-------------------------|-----------------------------------------|-----|
| Crooked seals          | Seals always rub against the surface of the machine | Vibrating engine                       | 24  |
| Gear Box Capstan       | Bearing stuck | The bearings make the winding faller due to lack of oil | Do not wind the cable                   | 53  |
| Capstan Roll Annealing | Traverse Shafts is broken | The path was blocked due to damaged traverse shaft affecting roll annealing parts | Reduced speed and bent cable output    | 9   |
| Capstan Finish         | Capstan ring position that is not correct because it shifts when merolling wire | Irregular tripping line path            | 102 |
| Capstan Finish         | Engine speed is not sprayed, the output has a different diameter | Engine speed is not sprayed, the output has a different diameter | 100 |
| Roll Annealing         | The Roll Dancer Upper changes shape, warps and affects the sensor on pay off | Proximity Pay Off Sensor error          | 210 |
| Roll Annealing         | The cooling system pipe leaked | The cooling pipe leaked spreads to touch other engine parts | Influenced by the process of heating the cable, elongation is not perfect | 20  |
| Dancer                 | The exit cable is stuck smoothly not smoothly and also makes vibrations in the middle of the engine | The engine must stop because the bearing must be repaired | 150 |
| Double Spooler         | Solenoid Valve changes color | Color changes occur due to air content and also age | Double spoolers are exposed to heat with high temperature | 100 |
| Part                   | FF          | FM                      | FE                                      | RPN |
| TOTAL                  |             |                         |                                         |     |
| TOTAL                  | 33          | 96                     |                                         |     |

| Part                   | FF          | FM                      | FE                                      | RPN |
|------------------------|-------------|-------------------------|-----------------------------------------|-----|
| Traverse Roll Annealing | Camp traverses experience abrasion | Having abrasion, insulators are not running normally, excess carrier current | Influences with error traverse isolators | 20  |
| Bearing 6202 is broken | The traverse camp section is not attached and allows for bearing age that is old | The traverse camp section is not attached and allows for bearing age that is old | Friction camp traverse with the surface of the engine makes sound that can be detected quickly | 60  |
| TOTAL                  |             |                         |                                         | 89  |
| TOTAL                  |             |                         |                                         |     |

| Part                   | FF          | FM                      | FE                                      | RPN |
|------------------------|-------------|-------------------------|-----------------------------------------|-----|
| Roll Annealing         | Plat belt TC-55ER-50-1825 is stuck | Loose or loose bolts on the upper bearing so that the plate stuck | Affects the double spooler which does not absorb heat | 45  |
| TOTAL                  |             |                         |                                         | 65  |
| TOTAL                  |             |                         |                                         |     |

TOTAL: 460
From the FMEA calculation, the 3 highest RPN components are taken, namely the Pay Off component with RPN 422, Dancer with RPN 460, and Double Spooler with RPN 628. From this FMEA calculation, it is continued by filling in RCM II Worksheet.

### 3.2. RCM II Decision Worksheet

RCM II Decision Worksheet for Pay Off part is as follows.

**Table 2. Recapitulation of RCM II Decision Worksheet**

| Part          | FF        | FM       | FE       | RPN |
|---------------|-----------|----------|----------|-----|
| Hose is leaking | The rubbing of the hose with the safety socket makes a fine hole leak | Cooler leaked about the coiler |         | 96  |
| Hocking wire is tilted | The burden is too heavy | Vibration occurred |         | 180 |
| T. Belt 1890-14-M L55 putus | There is continuous friction to rotate the ring causing the T Belt to erode and break | The ring stops rolling cables |         | 252 |
| Coiler        | Open carrier cover | The carrier cover has the potential to open when vibrations are high and temperatures are high | The double spooler must be checked and the carrier cover reconnected | 70  |
| Coiler        |            |          |          | 628 |
| TOTAL         |           |          |          |     |

**Table 2. Recapitulation of RCM II Decision Worksheet**

| Part          | FF        | FM       | FE       | RPN |
|---------------|-----------|----------|----------|-----|
| Angled Disc Brake |            |          |          | 16  |
| Wire faltered to be rolled, bearing that has changed color | | | |
| Coiler doesn't move | | | |
| WATER PUMP | Annealing water pump error | Occurrence of water tightness (error) | Check or replacement of water pump | 48  |
| Heat Exchanger | Temperature straightener is too high | High temperature makes heat exchangers not optimal | Overheat causes the drawing process to be stopped and affects the pipe installation | 48  |
| TOTAL         |           |          |          |     |

From the FMEA calculation, the 3 highest RPN components are taken, namely the Pay Off component with RPN 422, Dancer with RPN 460, and Double Spooler with RPN 628. From this FMEA calculation, it is continued by filling in RCM II Worksheet.
3.3. **Data Distribution**

The result of Time To Repair (TTR) for Least Square Curve Fitting are seen from the Largest Index of Fit

| Part                | Component                          | Proposed Task         |
|---------------------|------------------------------------|-----------------------|
|                     | Hocking Wire                       | Scheduled Restoration Task |
|                     | T. Belt 1890-14-ML55               | Scheduled Restoration Task |

**Table 3. Recapitulation of Index of Fit TTR**

| Part    | Weib  | Lognorm | Norm  | Ekspo | Info     |
|---------|-------|---------|-------|-------|----------|
| Pay Off | -0.104| 0.144   | 0.206 | -0.043| Normal   |
| Dancer  | 0.171 | 0.165   | 0.161 | -0.101| Weibull  |
| Double  | -0.175| 0.107   | 0.181 | -0.108| Normal   |
| Spooler |       |         |       |       |          |

The result of the Time To Repair (TTR) data for Goodness of Fit use Minitab 19 software, seen from the largest P-Value and the smallest AD Value. Following is the recapitulation of Goodness of Fit.

**Table 4. Recapitulation of Goodness of Fit TTR**

| Part        | Distribution | AD | P-Value |
|-------------|--------------|----|---------|
| Pay Off     | Normal       | 0.555 | 0.123   |
| Dancer      | Weibull      | 0.452 | 0.25    |
| Double Spooler | Normal     | 0.2  | 0.872   |

The results of the Time To Failure (TTF) data for Least Square Curve Fitting are seen from the largest Index of Fit

**Table 5. Recapitulation of Index of Fit TTF**

| Part               | Weib | Lognor | Norm   | Ekspo | Info     |
|--------------------|------|--------|--------|-------|----------|
| Pay Off            | -0.436| 0.388  | 0.44   | 0.499 | Ekspo    |
| Dancer             | -0.949| 0.910  | -0.022 | -0.903| Lognorm  |
| Double Spooler     | -0.467| 0.004  | -0.021 | -0.286| Lognorm  |

The results of the Time To Failure (TTF) data for Goodness Of Fit use Minitab 19 software, seen from the largest P-Value and the smallest AD Value. Following is the recapitulation of Goodness Of Fit.

**Table 6. Recapitulation of Goodness of Fit TTF**

| Part          | Distribution | AD   | P-Value |
|---------------|--------------|------|---------|
| Pay Off       | Ekspo        | 0.323| 0.682   |
| Dancer        | Lognorm      | 0.347| 0.429   |
| Double Spooler| Lognorm      | 1.6  | 0.005   |

3.4. **Mean Time To Repair (MTTR) and Mean Time To Failure (MTTF)**

Before calculating MTTR and MTTF, parameter calculation is performed with the following results:

**Table 7. Recapitulation of Parameter**

| Part    | TTR          | TTF          |
|---------|--------------|--------------|
| Pay Off | $\mu = 1.529$ | $\lambda = 0.001579$ |
| Dancer  | $\beta = 3.3$ | $t_{med} = 366.419$ |
Double Spooler $\mu = 2.778$ $t_{\text{med}} = 393.21$

Next calculate MTTR and MTTF according to the existing distribution. Following is the recapitulation of MTTR and MTTF results.

**Table 8. Recapitulation of MTRR and MTTF**

| Part        | MTTR      | MTTF     |
|-------------|-----------|----------|
| Pay Off     | 1.529 hours | 633.312 hours |
| Dancer      | 1.623 hours | 681.485 hours |
| Double Spooler | 2.778 hours | 831.66 hours |

### 3.5. Maintenance Interval

Maintenance intervals and parts availability obtained from the calculation are as follows.

**Table 9. Recapitulation of Maintenance and Availability Intervals**

| Maintenance Intervals | Availability |
|-----------------------|--------------|
| Pay Off               | 361 hours    | 0.997     |
| Dancer                | 327 hours    | 0.996     |
| Double Spooler        | 174 hours    | 0.994     |

**Table 10. Maintenance Intervals (a)**

| Component | 2019 |
|-----------|------|
|           | Jan 2019 | Feb 2019 | Mar 2019 |
| Pay Off   | 2 10 21 22 28 7 11 13 18 27 1 6 11 20 22 28 29 |
| Dancer    |          |          |          |
| Double S. |          |          |          |

(b)

| Component | 2019 |
|-----------|------|
|           | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 |
| Pay Off   | 10 13 25 | 2 6 13 34 27 24 10 12 18 20 28 13 | 10 9 10 |
| Dancer    |          |          |          |          |
| Double S. |          |          |          |          |

(c)

| Component | 2019 |
|-----------|------|
|           | Jul 2019 | Aug 2019 | Sep 2019 | Oct 2019 |
| Pay Off   | 18 24 20 | 10 7 11 16 19 27 4 5 6 16 25 29 4 15 |
| Dancer    |          |          |          |          |
| Double S. |          |          |          |          |

(d)

| Component | 2019 |
|-----------|------|
|           | Oct 19 | Nov 2019 | Dec 2019 | Jan 2020 |
| Pay Off   | 16 24 4 5 6 13 22 25 27 3 12 13 14 23 3 4 110 |
| Dancer    |          |          |          |          |
| Double S. |          |          |          |          |

(e)

| Component | 2020 |
|-----------|------|
|           | Jan 2020 | Feb 2020 | Mar 2020 | Apr 2020 |
| Pay Off   | 14 23 24 31 3 12 13 24 4 5 13 16 24 26 3 7 15 |
| Dancer    |          |          |          |          |
| Double S. |          |          |          |          |

(f)
3.6. Reliability
Comparison of reliability before preventive maintenance and after preventive maintenance is as follows.

Table 11. Recapitulation of Reliability

| Part       | R Before PM | R After PM |
|------------|-------------|------------|
| Pay Off    | 37%         | 52%        |
| Dancer     | 33%         | 54%        |
| Double Spooler | 27%     | 75%        |

An increase in the reliability of parts from before doing Preventive maintenance with intervals that have been calculated by the RCM II method from before the calculation.

3.7. Comparison of the level of cost savings
The level of cost savings is needed to determine whether preventive maintenance can reduce the maintenance costs incurred by the factory before implementing preventive maintenance. The following is a comparison of costs before and after preventive maintenance.

Table 12. Recapitulation of Cost

| Part          | Cost Before PM (Rp/Month) | Cost After PM (Rp/Month) | Savings   |
|---------------|---------------------------|--------------------------|-----------|
| Pay Off       | 22,072,723,7             | 16,302,367.12            | 25.96%    |
| Dancer        | 23,453,945,9             | 15,183,295.02            | 35.1%     |
| Double Spooler| 40,941,843,4             | 18,964,709.86            | 53.52%    |

From the results that have been processed, the level of cost savings if PT. XYZ implements preventive maintenance using RCM 2 method so it can reduce costs.

4. Conclusion
Based on research and data processing that has been done, the conclusions can be drawn, namely:

- From the interval that has been obtained, namely Pay Off per 361 hours, Dancer per 327 hours, Double Spooler per 174 hours, the design of the engine maintenance schedule was made in 2 years, namely 2019 and 2020.
In the RCM II Decision worksheet, maintenance indicators are obtained so that the engine maintenance design can be carried out in accordance with the indicators on the RCM II Decision Worksheet.

There was a decrease in costs generated before preventive maintenance and after preventive maintenance on the Pay Off part was 25.96%, the Dancer part was 35.1% and the Double Spooler part was 53.52%.

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