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Analysis of Overall Effectiveness on Hall Separator Punching Machine at PT. DNIA

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Abstract. PT. DNIA is a company engaged in manufacture of automotive parts, one of which is condenser. Manufacture of condenser components requires small parts produced using a hole separator punching machine. However, it deals with high downtime of the machine, resulting in low production performance. This research aimed to identify the extent of hole separator punching machine performance using analysis of Overall Equipment Effectiveness (OEE) and to analyse six big loses which impact on machine downtime. Calculation results show that OEE value obtained, 48.54%, was still below the standard, and therefore continuous improvement attempt is essential to perform. The low OEE value was a result of low performance efficiency which was caused by idling and minor stoppages of 24.54%. In order to improve the performance and carry out idling and minor stoppages loss, it is important to perform improvement attempt in a number of aspects, such as man aspect by training operators to carry machine-related works, machine aspect by repairing abnormal ups and downs of dies, and material aspect by fixing inappropriate position of header tank (material).

Keywords: Overall Equipment Effectiveness (OEE), six big losses, down time, productivity

1. Introduction

PT. DNIA is engaged in manufacture of automotive parts, i.e. powertrain thermal, one of which is condenser. Manufacture of some components for condenser requires small parts produced with a hole separator punching machine. Historically, downtime frequency of machines used for condenser production is a major cause for high losses man hour. Based on observation in previous studies, it has been noticed that hole separator punching machine shows downtime frequency of 30 times per day. In addition, absence of production data record in previous period results in more difficulty during downtime identification of hole separator punching machine. High downtime frequency of hole separator punching machine leads to delays of condenser production which impacts on a decreased performance, eventually.

In the present study, performance measurement was conducted using an Overall Equipment Effectiveness (OEE) method. OEE is frequently employed to measure TMP performance as reported by [1] or is employed for determining critical machine as reported by [2]. [3] used OEE in performance measurement, while [4] claimed that OEE is the main performance measurement used in mass production environment. Similarly, [5] argued that system and equipment-related performance can be analysed using OEE. The above explanation on OEE becomes a consideration of OEE implementation for minimizing occurrence of machine downtime in order to improve performance, which contributes to an increased productivity, eventually. Once OEE value is measured, identification of six big losses is carried out in order to find out causes for machine downtime.

This research aimed to identify Overall Equipment Effectiveness (OEE) of hole punching separator machine in manufacture of small parts at condenser lines, identify major problems occurring using Six Big Losses in order to discover the most predominantly problem which impacts on a decreased effectiveness of hole separator punching machine during manufacture of small parts at condenser lines, as well as to propose improvement in issues related to effectivity of hole separator punching machine in the manufacture of small parts at condenser lines.

2. Methods

Methods used to solve the above mentioned problems consist of three stages, i.e. stage 1 in which calculation of Overall Equipment Effectiveness (OEE) was performed, stage 2 in which six big losses analysis was performed, and stage 3 in which analysis using a number of tools and seven tools in forms of pareto and fishbone diagram was performed.

Stage 1. OEE Calculation

[6] reported that Overall Equipment Effectiveness (OEE) is a tool for measuring an efficiency level. It is affected by several factors, i.e. Availability Rate, Performance Rate, and Quality Yield, of which equation is expressed as follows.

OEE = Availability x Performance x Quality

Availability in machine/equipment is a ratio of operation time to loading time of machine, of which equation is expressed as follows.

$$Availability = \frac{Availabprodcle\ Time\ - Downtime}{Loading\ Time}\ x\ 100$$

Performance is a ratio of product quality multiplied by ideal cycle time, to operation time, of which equation is expressed as follows

$$Performance = \frac{Output\ x\ Ideal\ Cycle\ Time}{Operating\ Time}\ x\ 100$$

Quality is a ratio that describes machine capability in manufacturing products complying with specified standard, of which equation is expressed as follows.

$$Quality = \frac{Output\ x\ Defect\ Amount}{Processed\ Amount}\ x\ 100$$

Measurement of OEE value should be carried out with considering standard value that has been specified, and according to [7] World Class OEE value is 85%.

Stage 2. Analysis of Six Big Losses

The objective of Six Big Losses is zero breakdown. They are a part of TPM, of which system assists in eliminating six big losses from equipment and processes of production. The whole process of TPM is focussed on eliminating wastes, which are categorized into 6 types of losses [8], namely:

a. Downtime Losses

- Setup and Adjustment Losses are losses due to setup and adjustment at the beginning and end of engine operation.

$$Set\ Up\ and\ Adjustment\ Losses\ = \frac{Setup\ and\ Adjusment}{Loading\ Time}\ x\ 100$$

- Equipment Failures Losses are losses due to engine failure which results in shut off.

$$Equipment\ Failures\ Loss = \frac{Breakdown}{Loading\ Time}\ x\ 100$$

b. Speed Losses

- Idling and Minor Stoppages Losses are losses due to an engine momentary stop, stuck engine, and engine idle time.

$$Idle\ and\ Minor\ stoppages\ Looses = \frac{(jumlah\ target - jumlah\ produksi) x ideal\ cycle\ time}{Loading\ Time}\ x\ 100$$

- Reduced Speed Losses are losses due to un-optimum run of engine (reduced speed of engine operation)

$$Reduced\ Speed\ Losses = \frac{(actual\ cycle\ time - ideal\ cycle\ time)\ x\ output}{Loading\ Time}\ x\ 100$$

c. Quality Losses

- Defect Losses are losses that occur due to defective or reworked products.

$$Defect\ Losses = \frac{output\ cacat\ x\ ideal\ cycle\ time}{Loading\ Time}\ x\ 100$$

- Reduced Yield is a material loss required by a machine to produce new products at expected quality.

Stage 3. Analysis using Tools Contained in 7 Tools

In this stage, there were only 2 tools employed, i.e. pareto and fishbone diagram. Pareto diagram constitutes a bar chart and a line chart that describe comparison between each type of data and overall data. This diagrams seems to be very simple, however it is very beneficial in control of factory quality [9].

The fundamental function of Fishbone/Cause-effect diagram is to identify and organize possible causes for specific effects, followed by separation of root causes. Identification was carried out using a structured approach that enabled incorporation of a detailed analysis. There were 5 major factors analysed using Fish bone, i.e. man, work method, machine/equipment, and environment [10].

3. Results and Discussion

Data used in this research was obtained based on direct observation at the company and company's data source related to production of hole separator punching. Data related to this research such as planned downtime, set up and adjustment, output, breakdown machine, etc. are presented in Table 1.

Table 1. Production Hole Separator Punching Machine

No	Date	*Operating Time (second)*	*Loading Time (second)*	*Ideal Cycle Time (second)*	*Output*	*Defect*
1	1	54212	72000	14.27	2860	4
2	2	52200	72000	12.62	3000	0
3	3	55834.4	72000	15.04	2878	4
4	4	27813	43200	7.98	2740	0
5	5	51170	72000	12.04	3020	0
6	6	55757	72000	14.06	3070	1
7	7	57097.5	72000	14.87	3045	22
8	8	51225	72000	13.96	2610	0
9	9	41600	72000	8.23	2920	0
10	10	40415	61199	10.57	2720	3
11	11	52116	72000	10.90	3460	0
12	12	53846	72000	11.64	3460	18

13	13	54894	72000	11.58	3615	1
14	14	37793	72000	8.11	2445	18
15	15	18132	43200	3.86	3060	16
16	16	52274	72000	12.09	3140	0
17	18	41043	72000	7.15	3270	0
18	19	51984	72000	11.17	3360	18
19	20	43725	72000	9.32	2850	6
20	21	52100	72000	11.09	3400	0
21	22	42324	72000	9.87	2520	0
22	23	49391	68399	11.43	3180	9
23	24	58590	72000	14.45	3300	6
24	25	45730	72000	12.63	2300	0
25	26	50451	72000	10.94	3230	5

Stage 1. Calculation of Overall Equipment Effectiveness (OEE)

OEE calculation was initiated with identifying three values of OEE factors, i.e. availability, performance, and quality, as shown in Table 2.

Tabel 2. OEE calculation at Hole Separator Punching Machine

Date	*Availability*	*Performance*	*Quality*	OEE
1	75.29%	75.29%	99.86%	56.61%
2	72.50%	72.50%	100.00%	52.56%
3	77.55%	77.55%	99.86%	60.05%
4	64.38%	78.63%	100.00%	50.62%
5	71.07%	71.07%	100.00%	50.51%
6	77.44%	77.44%	99.97%	59.95%
7	79.30%	79.30%	99.28%	62.43%
8	71.15%	71.15%	100.00%	50.62%
9	57.78%	57.78%	100.00%	33.38%
10	66.04%	71.13%	99.89%	46.92%
11	72.38%	72.38%	100.00%	52.39%
12	74.79%	74.79%	99.48%	55.64%
13	76.24%	76.24%	99.97%	58.11%
14	52.49%	52.49%	99.26%	27.35%
15	41.97%	65.18%	99.48%	27.22%
16	72.60%	72.60%	100.00%	52.71%
18	57.00%	57.00%	100.00%	32.49%
19	72.20%	72.20%	99.46%	51.85%
20	60.73%	60.73%	99.79%	36.80%
21	72.36%	72.36%	100.00%	52.36%
22	58.78%	58.78%	100.00%	34.55%
23	72.21%	73.60%	99.72%	53.00%
24	81.38%	81.38%	99.82%	66.10%
25	63.51%	63.51%	100.00%	40.34%
26	70.07%	70.07%	99.85%	49.02%

Averaged Overall Equipment Effectiveness (OEE) results obtained was 48.54%. According to Japan Institute of Plant Maintenance (JIPM), 40% ≤ OEE values < 59% are categorized low, and therefore company should improve the existing system performance to prevent it from economic loss and low competitiveness (Nakajima. 1998). Figure 1 shows a comparison graph of OEE at hole separator punching machine.

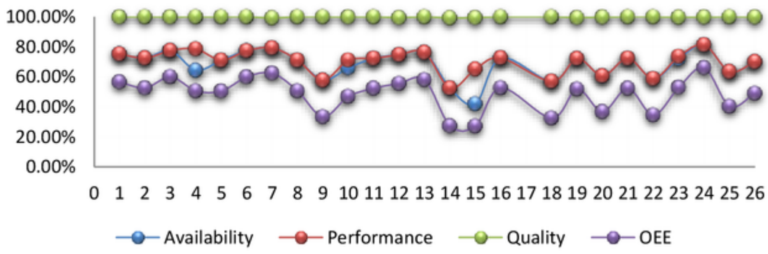


Figure 1. OEE calculation at hole separator punching machine

As seen in Figure 1, performance percentage was slightly lower as compared to availability percentage which was a major factor in performance scope. Calculation of losses in factors that result in low performance percentage was carried out using a six big losses approach.

Stage 2. Calculation of Six Big Losses

Calculation of six big losses is beneficial for the company to discover factors producing the largest losses and contributing to low Overall Equipment Effectiveness (OEE). Those causative factors will be considered as the main priority to address.

Table 2. *Six Big Losses* Calculation at Hole Separator Punching Machine

Date	*Set-up and Adjustment Losses*	*Breakdwon Losses*	*Idle and Minor Stoppages Loss*	*Reduced Speed Loss*	*Rework Losses*	*Reduced Yeild Losses*
1	7.63%	17.08%	31.99%	18.60%	0.11%	0.00%
2	8.75%	18.75%	25.98%	19.94%	0.00%	0.00%
3	7.66%	14.79%	32.25%	17.41%	0.11%	0.00%
4	11.35%	24.26%	31.37%	13.76%	0.00%	0.00%
5	8.80%	20.13%	24.83%	20.56%	0.00%	0.00%
6	9.34%	13.22%	25.35%	17.47%	0.03%	0.00%
7	9.28%	11.42%	26.82%	16.41%	0.57%	0.00%
8	7.47%	21.39%	39.93%	20.53%	0.00%	0.00%
9	9.78%	32.44%	22.85%	24.40%	0.00%	0.00%
10	9.52%	24.44%	32.90%	19.06%	0.07%	0.00%
11	9.36%	18.26%	12.87%	19.99%	0.00%	0.00%
12	10.80%	14.42%	13.29%	18.86%	0.39%	0.00%
13	10.70%	13.05%	9.70%	18.11%	0.02%	0.00%
14	7.44%	40.07%	34.99%	24.94%	0.39%	0.00%
15	15.53%	42.50%	13.92%	14.61%	0.22%	0.00%
16	7.34%	20.06%	21.62%	19.89%	0.00%	0.00%
18	7.57%	35.43%	14.03%	24.51%	0.00%	0.00%
19	9.13%	18.67%	15.36%	20.07%	0.39%	0.00%
20	8.40%	30.88%	26.10%	23.85%	0.13%	0.00%
21	9.22%	18.42%	14.37%	20.00%	0.00%	0.00%

22	7.27%	33.95%	36.27%	24.23%	0.00%	0.00%
23	6.87%	20.92%	20.32%	19.06%	0.20%	0.00%
24	8.08%	10.54%	19.11%	15.16%	0.15%	0.00%
25	6.46%	30.03%	49.02%	23.17%	0.00%	0.00%
26	6.15%	23.78%	18.33%	20.97%	0.11%	0.00%

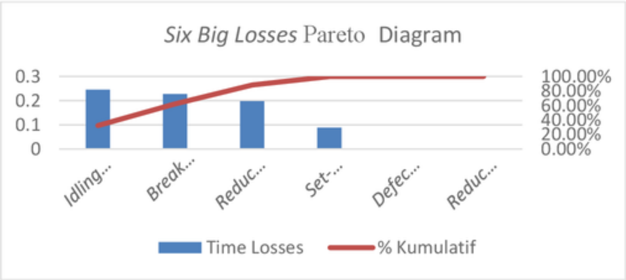
It is noticed from Table 3 that averaged values of setup and adjustment was 8.80%, equipment failure / breakdown losses was 22.76%, idle and minor stoppages was 24.54%, reduced speed loss was 19.82%, defect loss was 0.12%, and reduced yield loss was 0%.

Table 4 *Six Big Losses* at Hole Separator Punching machine

Six Big Losses	Time Losses (second)	Cumulative	Cumulative percentage (%)
Idling and Minor Stoppages	0.25	0.25	32.28%
Breakdwon Looses	0.23	0.47	62.21%
Reduced Speed Losses	0.20	0.67	88.28%
Set-up and Adjustment Looses	0.09	0.76	99.85%
Defect Losses	0.0012	0.76	100.00%
Reduced Yield Losses	0.00	0.76	100.00%

Stage 3. Analysis using Pareto and Fish Bone Diagram

Results obtained in Table 4 was further analysed using a pareto diagram in order to obtain actual root causes for problems occurring at hole separator punching machine, as given in Figure 2.



It is noticed from Figure 2 that idling and minor stoppages loss was at 32.28%, which allowed it to be a major cause for low OEE value, and therefore a further analysis was required. The next analysis was carried out using a cause-and-effect diagram (fishbone diagram) as presented in Figure 3.

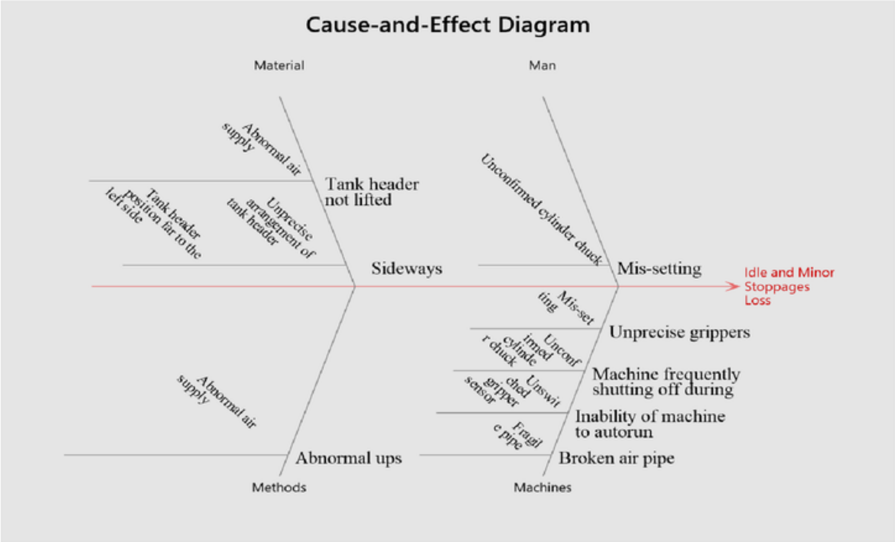


Figure 3. Diagram of Fishbone Idle and Minor Stoppages Loss

As seen in Figure 3, there were several aspects which affected high idle and minor stoppages of hole separator punching machine, which are further described as follows.

1. Man
   Man or operator assigned at the hole separator punching machine often carries double jobs, allowing to carelessness during machine setting and operation.
2. Method
   The obstacle encountered is abnormal ups and downs of dies which are caused by abnormal air supply.
3. Machine
   A number of obstacles encountered include inability of autorun due to unconfirmed cylinder chuck, unprecise or unaligned gripper due to mis-setting at the initial production process, broken air pipe due to fragility, as well as frequently shut-off machine during production process due to unswitched gripper sensor.
4. Material
   Obstacles encountered in the material factor are tank header (material) that is not lifted by gripper due to unprecise or unaligned arrangement as well as tank header position is far to the left side allowing it to crash the slider when being dropped by gripper and resulting in an unprecise position.

Based on the above fishbone idle and minor stoppages losses on man, method, and machine, some recommendations are proposed as follows.

1. Man
   Operators assigned at hole separator punching machine are not burdened by additional works which are not related to the machine.
2. Method
   Periodic calibration of the dies can be performed in the beginning and end of every week (once a week at the least).
3. Machine
   Improvement include periodically preventive maintenance (pm), re-setting in the beginning and end of production, as well as replacement of machine parts that do not working properly.
4. Material

Positioning of tank header arrangement is carried out using a device. In addition, slope and arrangement of tank header should be measured to prevent it from being dropped or lifted during arrangement.

4. Conclusion

According to results as well as data processing and analysis of the present study, it can be concluded that

1. Averaged OEE value of Hole Separator Punching machine of 48.54% was still below the specified standard, and therefore a continuous improvement attempt has to be conducted.
2. Low OEE value was a consequence of low efficiency performance largely contributed by idling and minor stoppages, 24.54%.
3. According to fishbone diagram analysis, factors which impact on idling and minor stoppages loss are as follows.
   a. Man : Operators carrying out works that are not related to machine
   b. Method : Abnormal ups and downs of dies
   c. Machine : Problematic gripper, machine unable to autorun
   d. Material : Inappropriate position of tank header (material)

Some recommendation proposed to improve performance of hole separator punching machine include requirement to implement scheduled and recorded autonomous maintenance in order to facilitate evaluation when problems raise. In addition, OEE calculation should be performed continuously using an information system recorded in database, followed by maintenance, replacement, and re-design of gripper parts.

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