TOTAL PRODUCTIVE MAINTENANCE ON THE AIRBUS PART MANUFACTURING

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ABSTRACT

An Indonesia manufacturing company producing Airbus wing parts experienced losses of more than \$100,000 in 2017. The production of A 380 wing parts contributed to 73% of the total losses, and 37% came from parts production of A 350 and A 320. The study focused on the most significant contribution losses of A 380 wing parts that is Drive Rib 1. This paper aims at examining the root cause of the loss in A 380-Program, solving the root cause by proposing the alternative solution, and improving the performance in A 380 Program. By conducting the interview and archival data, the data were analyzed employing Root Cause Analysis (RCA) to discover the root cause of problems. Low reliability of the production machine (DGAL Cincinnati Milacron) was identified as a root cause indicated by Overall Equipment Effectiveness (OEE) at 50.3% used since the 1980s. According to Total Productive Maintenance (TPM), this study proposes three alternative business solutions (autonomous maintenance, quality maintenance, and machine replacement). By considering the results of OEE and Analytical Hierarchy Process (AHP) with three criteria (cost, benefit, and implementation), the problem-solution proposes two approaches, namely conducting the autonomous maintenance with an improvement of OEE about 7% for the short term period and organizing the machine replacement with a significant OEE improvement about 17.1%.

Keywords: aircraft, manufacturing, maintenance

TOTAL PRODUCTIVE MAINTENANCE PADA MANUFAKTUR KOMPONEN PESAWAT AIRBUS

ABSTRAK

Perusahaan manufaktur Indonesia yang memproduksi komponen sayap Airbus mengalami kerugian lebih dari \$ 100.000 pada tahun 2017. Produksi komponen A 380 telah berkontribusi dalam 73% dari total kerugian, yang sisanya berasal dari produksi komponen A 350 dan A 320. Studi ini akan fokus pada kontribusi terbesar dari komponen sayap A 380 yaitu Drive Rib 1. Penelitian ini bertujuan untuk menemukan akar penyebab kerugian dalam Program A 380, mengusulkan solusi alternatif, dan peningkatan kinerja lebih lanjut dalam Program A 380. Dengan melakukan wawancara dan studi data arsip, data dianalisis dengan menggunakan Root Cause Analysis (RCA) untuk menemukan akar penyebab masalah. Masalah tersebut disebabkan oleh rendahnya keandalan mesin produksi (DGAL Cincinnati Milacron), hal ini ditunjukkan oleh Overall Equipment Effectiveness (OEE) sebesar 50,3%, yang digunakan sejak 1980-an. Berdasarkan Total Productive Maintenance (TPM), penelitian ini mengusulkan tiga alternatif solusi bisnis (pemeliharaan otonom, pemeliharaan kualitas, dan penggantian mesin). Dengan mempertimbangkan hasil OEE dan Analytical Hierarchy Process (AHP) dengan tiga kriteria (biaya, manfaat, dan implementasi), solusi bisnis dari masalah ini adalah melakukan pemeliharaan otonom dengan peningkatan OEE sekitar 7% untuk periode jangka pendek. Untuk jangka panjang, penggantian mesin memiliki peningkatan OEE yang signifikan sekitar 17,1% akan sangat cocok.

Kata-kata Kunci: manufaktur, perawatan, pesawat

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INTRODUCTION

The airbus company subcontracts its aircraft structure parts to the aircraft part manufacturer around the world, and one of the suppliers is a company in Indonesia that produces wing parts specifically for A 320, A 350, and A 380. The company must deliver the product to Airbus in compliance with the design requirements and on time. While the parts are being produced, the contracting authority inspects them and then delivers to the Airbus with free of charge delivery, no logistic expense from the company subcontractor. The defect parts lead to delayed shipment, and the company has to take the logistic expense itself. This condition has contributed significantly to non-conforming parts and operational costs.

The company currently faces the late deliveries to Airbus and has to pay the penalty for about thousands of USD. In 2017, the company had lost thousands of USD from the project, 15% from operational loss cost and 85% from the material loss cost. The losses due to Rejection Take (RT) and defect material resulted in operational loss and scrapped product loss. The A 380 has the most contribution losses about 73%, meanwhile A 350 (8%) and A 320 (19%). The research focuses on analyzing the business issue in A 380 because it possesses the most significant contribution losses covering 10% loss in operational cost and 90% loss in the defective product as the result of material loss. Based on the company data, the delivery processes were delayed for about 15 weeks. The

late deliveries and defective product impact on the higher material loss cost than operational cost.

In 2017, the other research in the same company presented that the rejection rate was at 6.74%, which is higher than 5% (Gracecia, Lubis, & Juliani, 2018). Every year, since 2014-2018, there were various types of components of A 280 rejected. The research limitation focuses on the most expensive parts in the issue of the defect, which is Drive Rib 1 as the significant losses' contribution. They are three research objectives, namely examining the root cause of the loss in A 380 Program, solving the root cause by proposing the alternative solution, and improving the machine performance of A 380 Program.

LITERATURE REVIEW

Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) is a total employee involvement by caring for the plant & equipment to maximize performance and output (Kennedy, 2006). TPM aims to achieve zero breakdowns, eliminate the defect, and reduce Six Big Losses (Breakdown, Setup and adjustment, idling & minor stoppage, reduce speed, start-up reject, and production reject) (Sulanjari & Firman, 2012). TPM has the basis of 5S (Sort, Systemize, Sweep, Standardize, and Self-Discipline) to support eight pillars (Haddad & Jaaron, 2012). The eight pillars of TPM consists of Autonomous Maintenance, Focused Improvement, Planned Maintenance, Quality Maintenance, Education & Training, Safety Health & Environment, Office

TPM, and Development Management (Venkatesh, 2007).

Current Reality Tree (CRT)

Current Reality Tree (CRT) is a tool to analyze the root cause problem by describing the cause-effect relationship between the symptoms at once. The CRT advantage is capable of identifying the dependencies between problems and their roots. This approach greatly assists in focused improvement of the system. Firstly, creating the list of Undesirable Effects (UDE) to be connected by creating cause-effect relationships toward the root cause. The structure of CRT systematically connects the symptoms which leads up to the core root cause of problems. It is assumed to be symptoms of the deeper common causal. Looking up to the cause-effect relationship among UDE, conducting analysis to understand the phenomenon explanation. In completing the analysis, link up everything together to identify the issues.

Overall Equipment Effectiveness (OEE)

The evaluation of Overall Equipment Effectiveness (OEE) can be employed to ensure equipment reliability. OEE is a multiply formulation of Availability Rate, Quality Rate, and Performance Rate (Vijayakumar & Gajendran, 2014). In the ideal condition, the machine possessing OEE at 100 means that the machine entirely operates with ideal speed and produces a perfect quality product without defect. Based on the benchmark, the accepted OEE in the manufacturing industry is about 85% (Elevli & Elevli, 2010). If the value is

lower than 85%, the evaluation for improvement must be conducted.

The availability means the hour of the available machine used in production. In collecting the availability value, the production time will be compared with calendar time that consists of the period of workdays. Several factors could reduce machine availability, such as planned downtime and unplanned downtime. The availability formula is shown in equation (i) (Ahuja & Khamba, 2008). The study classifies the planned breakdown hours as the planned maintenance and the unplanned breakdown hours as the corrective maintenance. It measures monthly the machine availability of OEE.

Availability =

$$\frac{\text{Calendar Hour} - (\text{Planned and Unplanned Downtime})}{\text{Calendar Hour}} \quad (\text{i})$$

Performance value is an estimation of how the machine productivity works. The real performance of the machine is the calculation of finished products and defects divided by operational time and divided on the ideal speed of machine that can be gained from the manual book of the machine or the standard machine process the formula is as shown in the equation (ii) (Ahuja & Khamba, 2008).

$$\text{Performance} = \frac{\text{Actual Average Production}(\frac{T}{H})}{\text{Standard Production}(\frac{T}{H})} \quad (\text{ii})$$

The quality values of OEE can be gained from the finished products subtracted by the defective products and then divided by the total production on the period. According to (Ahuja & Khamba, 2008), the equation of quality is described as follows (iii).

$$Quality = \frac{Production(T)=(7(T)+8(T))}{Production(T)} \times 100\% \text{ (iii)}$$

Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) as a measurement method in deriving the priority scales conducts pairwise comparisons according to the expert's judgment (Saaty, 2008). AHP assists in making decisions by considering the trade-offs intangible factors. AHP is suitable for a wide range of applications because AHP has three primary functions, namely structuring complexity, measurement on a ratio scale, and synthesis (Forman & Gass, 2001). AHP is initiated by defining the problem, structuring the decision hierarchy, constructing a set of pairwise comparison matrices, and comparing the weight priorities as the decision support (Saaty, 2008).

METHODS

The proposed business solutions for the conceptual framework consists of four stages. First, the research implemented the discovery stage for data collection and analysis conducted about four months from September until December 2018 in the manufacturing company. The data collection was derived from the interview and archival data.

The purposive sampling was implemented to choose participants with intentional choice based on their qualities. It does not have a fundamental theory to set the number of participants (Etikan, Musa, & Alkassim, 2016) and the choice of the most advantageous position to provide the necessary information (Sekaran & Bougie, 2016).

The interviews involved three key stakeholders, namely, program supervisor, quality assurance department, and the high-speed machine leader for the specified program until the end of the research stage. It was selected under the business issue and experienced employees in the company. In the interview, the researchers understand the business process and the current situation in the company comprehensively. The existing condition in the company has been using TPM.

Second, in the diagnostic stage, the data were employed to identify the problems. The analysis was supported by interview and company archival data (production and maintenance data) to identify Six Big Losses and to find the root cause of the problems by using the CRT tool. Systematically, it connects the symptoms of the problem scenario that lead up to the apparent root cause.

The production process is examined by using the business process model and notation, which can determine the problem sequentially. The material inspection as the initial step is verified, then it is continued to the machining process with DGAL Cincinnati. The part is delivered to several inspections before the drilling process and final inspection. Based on the part cost, Drive Rib 1 has the most significant contribution losses of defect parts about 4,000 USD per unit, which was confirmed by the program supervisor. The components of Drive rib 1 consist of 21 parts. The most expensive parts of drive rib 1 are Rib Inboard 1, Rib Outboard 1, and Drive Rib 1.

The study focuses on A 380 Program, with range data from 2014 until 2018. The results show that 50% of rejected production comes from workstations 331501. The other rejected product comes from another work center such as 88301 at 27%, 380119 at 13%, and the rest are less than 10%. Work Center 331501 has DGAL Cincinnati Millacron Machine as the production machining tool. The machine is an old machining technology produced in the 1980s that is the unreliable machine because the parts are not produced anymore and exceeding the productivity age. Based on the CRT results, evaluating the production performance will use the OEE to measure the symptom in TPM.

Third, in the designing stage, the company was given several alternative solutions to comply with TPM. Each solution is compared and evaluated by considering the OEE and AHP as the decision tool for justification. The delivery stage as the final stage, the business solution would give the optimum results when implemented. The solution's effectiveness was measured based on the performance. Several recommendations were delivered in the delivery stage for the company to improve business sustainability in the future.

RESULTS AND DISCUSSION

Root Cause Analysis (RCA)

According to the CRT, an error in machining is caused by the defects. Moreover, the company cannot fulfill target deliveries because of product loss and defective products. Figure 1 shows that the primary root cause is that problems in the DGAL

Cincinnati Milacron Machining. The similar relevant study in Small and Medium Enterprises (SMEs) in Indonesia showed that machine is one of the causes in the defective products (Ilyasa, Bernik, & Harsanto, 2016).

The finding was similar to previous researches in which the high frequency of breakdown caused more extended downtimes, defective products, operational trouble, and delayed deliveries. 60% of the maintenance caused by Axis and Spindle maintenance did not align properly (Kuswardani, Atmaji, & Athari, 2016; Rasindyo, Leksananto, & Helianty, 2015).

Figure 1. Current Reality Tree

In 2015, the peak downtime was 5,956 hours, with downtime cost more than 1 million USD. The DGAL Cincinnati Milacron had a total of processing time at 25.3%, which is significantly higher than other machines in 2017 (Gracecia et al., 2018). It concluded that the high frequency of defective products is in the station of 33501.

Six Big Losses of DGAL Cincinnati Milacron

Through secondary data from Astuti (2016) and archival data, Six Big Losses were classified into six parts, such as breakdown, setup and adjustment, idling and minor stoppage, reduced speed, start-up reject, and process reject. The breakdown was the major downtime in the production line, such as parts breakdown, leaking parts, preventive maintenance, Overheating Electric Panel, and axis synchronization. It made machine downtime for more than one hour, and the worst was 112 hours caused by the bearing problem. The setup and adjustment were small stops in the production due to these losses. The common problems were equipment jammed, inactive servo, equipment adjustment, program error, and unstable voltage. The average downtime was about 1-2 hours.

Idling and Minor Stoppage caused speed reduction on the operating machine. In this case, the minor stoppage consisted of lamp off, machine off, monitor/display off, lack of coolant, and trouble connector spindle pipe. Overall, the downtime was less than an hour. Reduced speed made the machine must reduce the speed due to the wear of components, and the parts should be replaced, for instance, a broken hydraulic unit,

bearing replacement, rubber coupling, and a mechanical seal. Start-up rejects or reduced yield was the losses due to machine initiation and improper equipment set up. There were a few start-up rejects, such as lack of hydraulic and coolant oil. The processing of a steady-state process caused the rejected process. The defective products such as undersized, marking, bending, undercut, damaged, and thinned were in the lists of defective and rejected products in the next manufacturing process.

Overall Equipment Effectiveness (OEE)

The OEE of the machine was calculated with data in 2017. The study assumed that the company has eight working hours in a day with 22 workdays. The unavailability occurred in February due to the planned maintenance that has a total of 138 Hours. The machine availability had a high unplanned breakdown in November 2017 at 114 hours that had an impact on the availability of 35%. The average result was above the industry average. There were few considerations to improve the availability of the machine. The average availability of machines was 76%, within the industry average.

The performance data of lead time for 53 hours was based on the internal data of 2017 of the DGAL Cincinnati Milacron, while the standard machine time of 45 hours was based on internal data. They stated that the production of 1 Drive Rib Inboard/Outboard was 45,789 hours with one quantity per production. The performance OEE was 85%, within industry standard.

The calculation of OEE was based on the production of Drive Rib 1 Outboard and Inboard. The DGAL Cincinnati Milacron did not only produce Drive Rib 1 Outboard and Inboard, but it also produced other products such as Drive Rib 2 Outboard/Inboard, Drive Rib 3 Outboard/Inboard, Hinge Rib 1, Front Spar and Sub Spar. Based on the data, OEE was calculated monthly according to the defects and productions. The OEE showed that the average machine quality producing Drive Rib 1 Inboard and Outboard was 78%, which was above 65% in the industry standard.

By calculating Availability, Performance, and Quality, the result of OEE was 50.3 %. It showed that the DGAL Cincinnati Milacron is ineffective compared to the global industry standard at 65%. Research finding discovered that OEE was slightly going down from 2014 at 85% to 75% (Astuti, 2016), while another finding figured out that the OEE in 2016 was at 60% (Andriyadi, Atmaji, & Athari, 2016). It represents that each year the machine is currently deteriorating due to the outdated technology and the unreliable machine.

Business Solution Alternatives

Based on the results of root cause analysis, the study proposes three alternative business solutions. TPM maintains and improves the robustness of production and quality through the improvement of process, machine, equipment, and employees in order to add value to the organization: (1) Autonomous Maintenance, (2) Quality Maintenance, and (3) Machine Replacement.

Autonomous Maintenance (AM)

Autonomous Maintenance is the maintenance activity before the lack of machine identification does not work correctly as the causal of the defective products. The employees are expected to be able to detect the symptoms of abnormalities to prevent downtime of the machine. It consequently improves availability and quality. The primary role of autonomous maintenance is the collaboration of production line operator and maintenance operator in the daily operation. This method prevents machine breakdowns, predicts failures, and extends equipment life (W. H. W. Mahmood & Ab Rahman Mahmood, 2008).

Rasindyo et al. (2015) argued that the company conducted autonomous maintenance by applying run to failure mode regulation to let the machine operate until it broke down. The machine got maintenance twice a year or after the period in which the machine had already reached 2,000 work hours and the second period where the machine already hits 4,000 work hours. In the period of production, the machine has no maintenance. With implementing autonomous maintenance, abnormalities/defects should be able to be detected more frequently and earlier.

For autonomous maintenance, Fuguai Mapping is one of the tools that could be used in the production line in which the tagging is directly placed on the part of the machine that seems to have a problem. The physical box defines the abnormalities in the machine that can be seen directly by eyes. In contrast, the function box

defines the abnormalities on the machines that lead to the not working machine. The Safety box shows machine abnormalities that could lead to the danger for the operator.

In Japanese, the literal definition of Fuguai means abnormality defined as an unneeded thing that is located in the wrong places or situation (W. H. Mahmood & Abdullah, 2008). These abnormalities usually affect the functional, safety, and physical problems of the machines. Firstly, implementing F-Tagging as a card to “tag” where the abnormalities exist in the machine. The tags are defined into three categories which are Red, Yellow, and Blue. The red tags indicate the technical requirement for machine maintenance. The yellow tags indicate that abnormalities could be solved through mechanic or operator for safety and environment purposes. The blue tags for the operator (non-maintenance) to fix the abnormality of the machine. The tagging description shows the date of abnormalities and wherein the abnormalities founded.

The implementation of Fuguai Mapping, the operators should get training of machine function to comprehend the basics of the machine indicators and its basic function. A machine components sheet explained in training is helpful for the operators to know the basic functions of the machine and identify the root cause. Rasindyo et al. (2015) and Kuswardani et al. (2016) described the components of the DGAL Cincinnati Millacron. Failure mode equipment analysis is capable of determining the specific equipment that has a function for each component and knowing how the

components would fail. Axis and spindle subsystems are prioritized machines of risk components in which most components are directly related to those subsystems. The essential components are related to the defective parts that have five-axis coordinates used for roughing, finishing drilling, and milling on the DGAL Cincinnati Millacron. They are usually misaligned when they are machining the material. Autonomous maintenance should be implemented in the critical area of the machine, which is the five-axis system.

General cleaning and inspection to implement the autonomous maintenance, operators must begin cleaning and inspecting for faults in the machine. By cleaning thoroughly, the operators inspect the machine to find abnormalities on the machine. Moreover, it ensures the machines restored to its peak performance by identifying and eliminating signs of abnormalities in machine functions. Cleaning in inaccessible areas is important to find hidden abnormalities of the machine function. After using Fuguai Tagging, the operator can use the tags on the parts that looked abnormal. The general cleaning and inspection must be accompanied by the maintenance department.

AM boards should be filled for indicating which abnormalities have been solved and which has not. The board aims to figure out which component has the most breakdown for the machine. It consists of machine components sheets and pin-point graphs of the problem. The sheets describe machine function and probable cause of

failure. The pin-point graph explains the graph mapping in time series which examines the components that have the most abnormalities from the machine (W. H. W. Mahmood & Ab Rahman Mahmood, 2008). Problem listing provides a list of the existing and past problems. Then, the countermeasure should be conducted to address those problems. Before and after putting photos in the autonomous maintenance, the board provides information about the machine components that have been fixed.

A general check sheet is created to know all the problem listing and countermeasures using the board. It is known as a standardized cleaning and inspection procedure that is made for the operator to operate the DGAL Cincinnati Milacron. It should be SOP before operating the machine. The general check sheet is created based on the Six Big Losses (Rasindyo et al., 2015). The priority of the first inspection is the axis system by examining whether it is properly calibrated with the datum settings or not. The general check sheet, the problem listing and the countermeasure in the machine must be combined in a standardized procedure check sheet that is used before the workers operate the machine. The general check sheet is created to ensure the machine functions are working correctly.

The early detection in defective parts can improve the availability of the machine and the product quality significantly. That circumstance makes the machine performance stable and increases the availability and quality rate. Without reducing the regulation of preventive maintenance

at 2,000 hours and 4,000 hours, the study argued that corrective maintenance is reduced by half because the problems can be solved earlier, and defects can be reduced significantly. OEE calculation can be done using simulation data in 2017.

The quality rate has improved from 78% to 82% by significantly reducing the number of defects. Availability can be calculated by employing the available data of 2017 and reducing monthly corrective maintenance by half. The availability also improved significantly from 76% to 83%. The improvements make OEE increase by 7% by using autonomous maintenance and improving the quality rate as well as the availability rate. However, the results are still under the industry standard which is 65% value of OEE. It is caused by the engine life that leads to the production inefficiency. However, the company's preference for keeping the machine by autonomous maintenance is one of the solutions to improve OEE and ensure the machine's reliability and effectiveness.

Quality Maintenance

Quality Maintenance is an approach to improve product quality through defect-free production. It aims to improve production efficiency by reducing the probability of equipment breakdown, defects, and losses (Vardhan, Gupta, & Gangwar, 2015). This method focuses on eliminating non-conforming products and maintaining equipment to make high-quality products. The previous study (Vardhan et al., 2015) conducted quality

inspections on not only the products but also the machine in order to improve equipment efficiency.

It suggested changing the work order process of the operator in the DGAL machine. The process of DGAL Cincinnati Milacron consists of four processes, starting with raw material are roughing, milling, drilling, and finishing. In the production line, the operators play a role as a quality inspector and act as quality self-check to detect previous defects.

Figure 2. Self-Quality Inspection Procedure

The algorithm shown in

describes the addition of quality checkpoints key points in the process before the job is stopped to ensure the quality assessment and continuing to the finishing process. According to the Six Big Losses, the axis adjustment is needed as one of the losses for setup and adjustment. Quality inspection of equipment is placed on the finishing process because spindle problems occur while finishing the material. If the equipment problems have been found, a report should be made to the maintenance division to replace the parts of

the spindle. Quality control includes a visual check and a measurement with several tools to measure and match the required specifications.

The other standard process in quality inspections is reporting the defective products to the engineering officer and Airbus to confirm the tolerance. If the product is approved, the production is continued, and if it is not approved, the production is scrapped. The report is delivered to the maintenance division to conduct effective maintenance in order to find the problem in the machine. By assuming the performance and availability is constant, based on the data 2017, the average quality rate increases from 78% to 82%. The result of OEE is 53%, the increment is only 3%. The current condition of the machine causes insignificant improvement.

Machine Replacement

Considering the engine life, insignificant maintenance, and low productivity, this study proposes other solutions to replace the machine. Based on the results of the interview with the stakeholders, Cincinnati XP Profilers is proposed to comply with the production for the Airbus component. By considering the type is specifically for aerospace industries and aluminum material. According to the manufacturer of Cincinnati XP Profilers, the performance would increase up to 80% faster, which means 80% less cutting time. With the standardization of production time, the performance of the new machine would be about 90%, more than a world-class standard.

The assumptions used are there are no defects and no downtime because there is no corrective maintenance. With data from 2017, the quality rate has improved on averagely for a year 82%. The availability of the machine is increased by up to 91%. The OEE calculation is improved up to 67.1%, more than the industry standard at 65%. The OEE is not at full capacity due to the utilization of production from the machine, and the machine is not utilized to produce parts for Airbus in May and June.

The highest OEE is machine replacement, significantly improved by 17% because it assumed that no defective product and no downtime consequently affect the quality and availability. Where the OEE is at 67.1% while the second one is using autonomous maintenance at 57.3%, and the last one is using Quality Maintenance with 53% of OEE. Although the machine replacement would be the best option to ensure continuous production with reducing the defects significantly, the company thought this would be a long-term solution for machine investments because of how much the investment would be made for investing in a new machine.

Analytical Hierarchy Process (AHP)

The three proposed solutions were discussed with the stakeholders (program supervisor, quality assurance department, and the high-speed machine leader) to ensure the suitability of solutions in the implementation by using AHP with three parameters (cost, benefit, and implementation). Cost is the total spent for goods or services

including money, time, and labor. The benefit is the quality of having an advantage for the company. Implementation is the act of executing the order.

The comparison result is shown in Table 1. The AHP results show that an autonomous maintenance solution is the most suitable for the current condition in the company. Machine replacement is more suitable for the long term and requires a feasibility study. Based on the discussion with the stakeholders in the Aerostructure Department, maintaining the current equipment is preferable than investing in a new machine. The machine investment was chosen as a long-term solution due to the price of each machine, which is about \$792,700. By replacing 2 DGAL Cincinnati Milacron, the company should invest in a total of \$1,590,716. This projection of investment requires further discussion with the board of directors, whether to invest in a new machine or not.

Table 1. Comparison of Business Solution

	OEE	AHP
New Machine	67.10%	9.47%
Autonomous Maintenance	57.30%	87.15%
Quality Maintenance	53%	22.90%

CONCLUSION

Through this study, the root cause of project losses emerges from the late shipments due to the defective product that is the most significant loss contribution in wing parts of A 380, Drive Rib 1. The parts were delivered to work centers that handle machining by using the DGAL Cincinnati Milacron. The machine performance possesses low reliability due to the age and improperly working

were proved by OEE (formulated by availability, quality, and performance) on 50.3%, which is below the standard industry (65%) in 2017. The study proposes three alternative business solutions according to the TPM: (1) autonomous maintenance, (2) quality maintenance, and (3) machine replacement. The OEE value shows that machine replacement is the best choice for a short period. By using AHP, the stakeholders prefer autonomous maintenance to others.

The autonomous maintenance creates a self-sufficient operator who can maintain and well acquainted with the machine, so if there is a problem with the machine, the operator has the capability to check and solve it. With the assumption that corrective maintenance in the machine would be reduced significantly by half each month, and the defect is zero. Through using Autonomous Maintenance, it was shown that there was an increase of 7% in OEE to be 57%.

The alternative solution chosen by the department is the autonomous maintenance which solves the problem of losses due to the defect and machine. This study recommends conducting machine replacement through several financial alternative solutions such as leasing and lending. The implementation of other TPM Pillar can maximize the performance and output.

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