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Research Paper

Quality Control Circles Technique for Reducing Fine Bored Parts Rejects After Tool Change

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Abstract

This study aims to assess reduction of rejects after tool change in a crankshaft manufacturing industry using Quality Control Circles (QCC) technique. Four months production data of crankshaft was collected and analyzed in 2022 in one of the largest automotive industries in Indonesia. Fine boring process was identified as the largest contributor of rejects. QCC activities were conducted to streamline the type of rejects in fine boring. QCC introduced a new intermediate action in calibrating machine setting after tool change. The results show a significant reduction in the level of rejection from 35% to just 5% of total rejects in the fine boring process after this QCC method was implemented. This result shows that this QCC method, by brainstorming among employees, can continuously improve and solve the problem in the workplace. This QCC method not just reduce the reject rate but also increasing morale, safety maintenance for employee, smoothness in supplying the next process, and reducing the cost (QCDSM). The limitation of this method is high dependency to the knowledge, experience and skill of the QCC team. Development of QCC team in term of new knowledge may lead to future improvement opportunity through development of quality control techniques with incorporation of internet of things or smart devices.

Keywords: *Quality Control Circle, Continuous Improvement, QCDSM*

INTRODUCTION

Nowadays, the industry worldwide has faced a very fierce level of competition, especially in the manufacturing industry. Increasing productivity is essential to survive and excel in the market for the success of a company. Therefore, the engineering process plays an important role to control and minimize wastage in the lean manufacturing environment, especially in handling quality related problems. Reduction of rejects is a way to increase productivity. One way to control quality in manufacturing is to perform quality improvement via quality control circle.

Quality Control Circle (QCC), or better known with the name of quality control group (GKM) in Indonesia, is an effort or management tool that should be applied by the organization for quality improvement. It was originated from Japan in 1962 and was introduced to Chinese medical institutions in 2001 to improve and solve medical quality and problems. Based on the plan – do – check – action cycle theory, this fully mobilizes participants' enthusiasm, initiative, and creativity to explore and fix problems together (Zhong et al., 2020) A QCC is a small group of staff, who work together, to contribute to the improvement of the plant by solving quality control related problems. In the research that has been carried out by Shenzhen Hospital, University of the Chinese Academy of Sciences in China, the incidence of Catheter-associated Urinary Tract Infection (CAUTI) increased by 0.299% per month from 0.65% of the period in January 2016, then gradually increased to 5.72 % in the period of April 2017. Due to its increasing trends, QCC activities were implemented in the first period in May 2017. The QCC implementation was found to have the CAUTI incidences decreased by 1.317% immediately, then gradually decreased by 0.510% per month. This should be approached with a logical and efficient problem-solving methodology in ensuring the quality of the plant. Seven basic quality control (QC) tools are widely used in industry for the systematic and logical problem-solving activities.

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An automotive parts manufacturing industry faces challenges to reduce rejects. In order to reduce rejection rates as well as provide suggestions for product improvement, this paper intends to implement quality control tools in the stage of the production process of an automative part. Systematic QCC activities has been implemented to identify the major contributors to the rejection of a crank, which was related to the diameter of the holes produced in the fine boring process. The diameter of the sorting hole is significantly larger than the diameter of the finished product, thereby re-working was not possible and producing a large amount of material waste. This waste increases production costs and negatively affects process efficiency. Finally, this paper outlines the process to reduce rejection due to the diameter of the bored hole. The number of rejects before and after QCC activities has been compared.

LITERATURE REVIEW

According to Attaqwa, the causes of rejects in the production process include porous, broken, cracked, and incomplete sand. From the 4M and 1E analysis, the human factor is the dominant one in contributing to its rejection (Attaqwa et al., 2021).

Based on the research conducted by Isaac using the QCC method combined with Six Sigma, the rate of rejects was reduced, but it required qualified human resources to implement Six Sigma. Additionally, real commitment within the organization was needed for successful implementation (Ishak et al., 2019).

According to Riadi's research, to reduce rejects in the production process of car chairs, management applied the QCC method and implemented 3M (accept good stuff, make good item, send good stuff) along with SCW action (stop, call, wait) if deviation occurred in the production process (Riadi & Haryadi, 2020).

Supriyadi's research indicated that with the application of the QCC method in the production process of tires, there was a decrease in blown scrap reject rate from 0.54% to 0.16%, as well as a decline in the average total rejects from 3.29% to 1.7%. New standard operating procedures were created to prevent reject scrap blown and continuous improvements were made to achieve the target reject rate of 1% (Supriyadi et al., 2021).

In Syahrullah's research, the QCC method combined with FMEA (failure mode effects analysis) was used to lower the reject rate on product sarongs. The FMEA calculation found that reject edges were damaged on machine Rapier weaving and focused on repair (Syahrullah & Izza, 2021).

According to Zhong's research, the application of the QCC method reduced incidents in vacation sharing in three stages: before, during, and after. There was a significant decline in cases by 1,317% in total, decreasing slowly or in increments of 0.510% per month. However, after the QCC application, there was a slight increase in cases by 0.266%, which was not statistically significant (Zhong et al., 2020).

From these literatures, QCC has shown successful improvement to various fields. However, the actual implementation to different productions using QCC may yield to different unknown challenges and results. Hence, this study was motivated to evaluate the usefulness of QCC in improving production efficiency in a systematic manner.

RESEARCH METHOD

Research subject

The crankshaft is part of the main engine component, which is made from a combination of ferrous material with other chemical elements with a composition of magnesium carbon and steel elements obtained from the results of a high-density furnace that is processed in a combustion or electric furnace at a temperature of 1,500 °C (Ramnath et al., 2018). The crankshaft functions to change the back-and-forth movement of the piston, into rotary motion for the flywheel and stator which will then produce rotating energy on the motorcycle wheel as the basic component of a series of combustion motors (engine) then the crankshaft quality must be properly maintained because the size or dimensions of this crankshaft are very precise (*See Figure 1*).

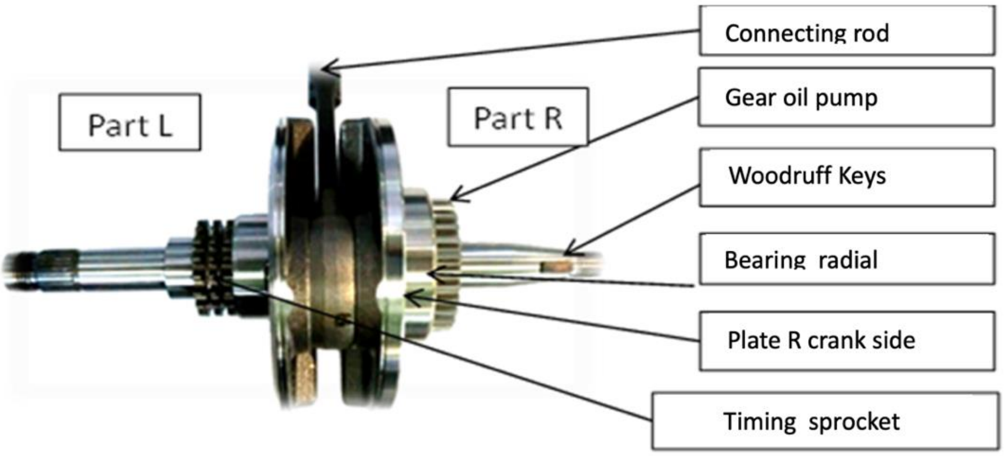

Figure 1. Components of a crankshaft

As part of continuous quality improvement, QCC method is possible to be developed and combined with lean techniques or methods in order to get a more optimal result. The problem of rejects due to the fine-bored diameter of crank side was found to be the highest for the period January - April 2022. Based on the results of research and past experience, there are several factors that cause the occurrence of this over-bored diameter, including Man, Material, Machine and Method.

However, in research or causal factors, only machines and methods were considered, because for these factors are more likely to be tackled immediately in an effective and efficient manner without affecting the morale of staff and control of supply. Therefore, this paper employed a quantitative research methodology to analyse the production data of a crankshaft production in one of the largest automotive industries in Indonesia. The systematic approach based on PDCA cycle and 8 steps of QCC were applied to streamline the major contributor to the rejects of the crankshaft production.

Data Collection

Data collection was carried out directly into the production floor. Since each component of a crankshaft must pass the quality test, only rejects were recorded in the production floor. About 202,800 pieces of crankshaft was produced during 4 months of production, with an average of 1,690 pieces per day. The analysis on the rejects were conducted via field observations and interview study based on PDCA cycle and 8 steps of QCC. PDCA cycle involved activities described below and illustrated in Fig. 2 to serve as continuous improvement principle of the QCC:

1. Plan (identifying and specifying problems and collecting data)
2. Do (Carrying out, including data analysis making tentative conclusions)
3. Check (comparing actual results with plans)
4. Action (take the next action)

As for conducting data processing, the following QCC steps in Figure 2 were taken, as part of PDCA, as follows:

1. Determining a theme (PLAN)
2. Set targets (PLAN)
3. Analysis of existing problems (anaconda) (PLAN)
4. Plan for improvement (PLAN)
5. Implement an improvement plan (DO)
6. Evaluate results (CHECK)
7. Standardization (ACTION)
8. Settle the next step (ACTION)

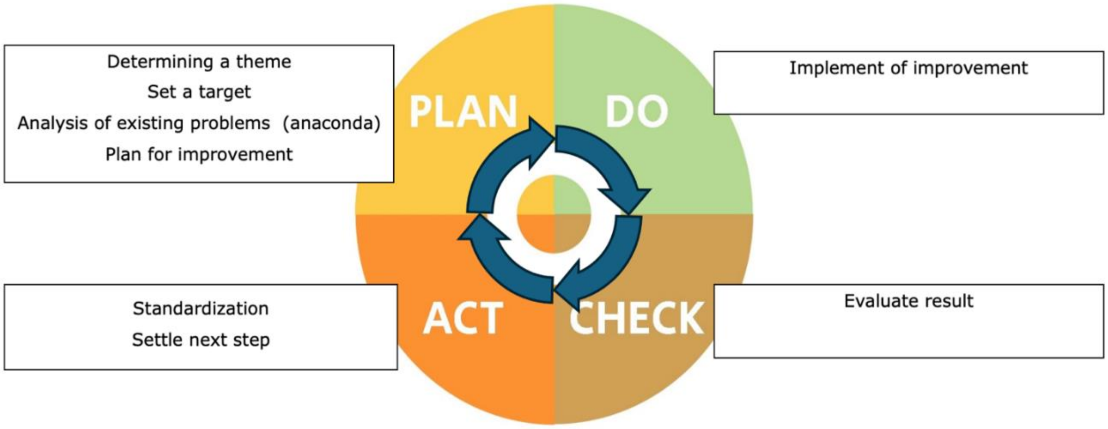

Figure 2. PDCA cycle

FINDINGS AND DISCUSSION

Identification of Theme

Based on the results of data collection, the following results in Figure 3 were obtained. Three major processes that contributed to the rejection of crankshaft for the January to April 2022 period were fine boring, grinding and turning. The fine boring process resulted to the largest rejection, amounting 44.11% during the period of January – April 2022. The number of rejects occurred in the fine boring process with a total of 412 pieces, or 44.11% of all rejects from three major processes. This shows that the fine-boring process was the largest contributor to rejects in the crankshaft manufacturing process during that period. For this reason, corrective action was needed through improvement in order to reduce the level of rejects that occur through a method, namely the quality control circle, where corrective action is through suggestions from operators in the field themselves so that the quality level is maintained within standardized control limits. Therefore, QCC agreed to set the theme, namely decreasing the reject in the fine boring process, by taking corrective action.

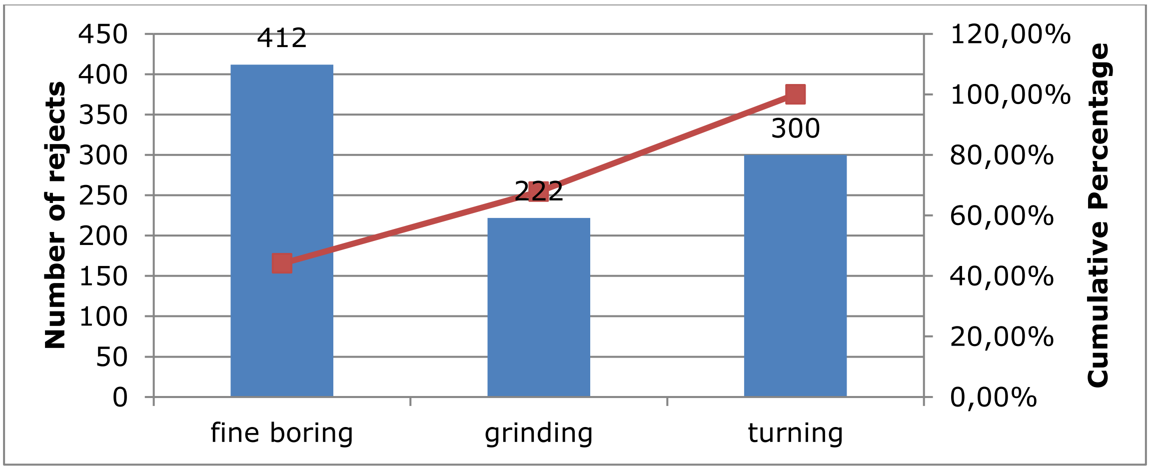

Figure 3. Rejects during production of crankshaft based on three major processes for January – April 2022

The detail of rejects due to fine boring process was further analyzed, as shown in Figure 4. The rejects in the fine boring process were due to several problems such as diameter plus, outsetting, oval diameter, misalignment of bore center, inaccurate distance of center, and cracks. It revealed that the rejects due to diameter plus was the highest. During the period January – April 2022, as many as 35 % of the total rejects that occurred in the fine boring process from the total of 247 pieces. Based on the data from Pareto in Figure 4, rejects due to diameter plus (+) occupies the highest position, therefore the specific theme was set to reduce reject diameter plus in the Quality Control Circle team.

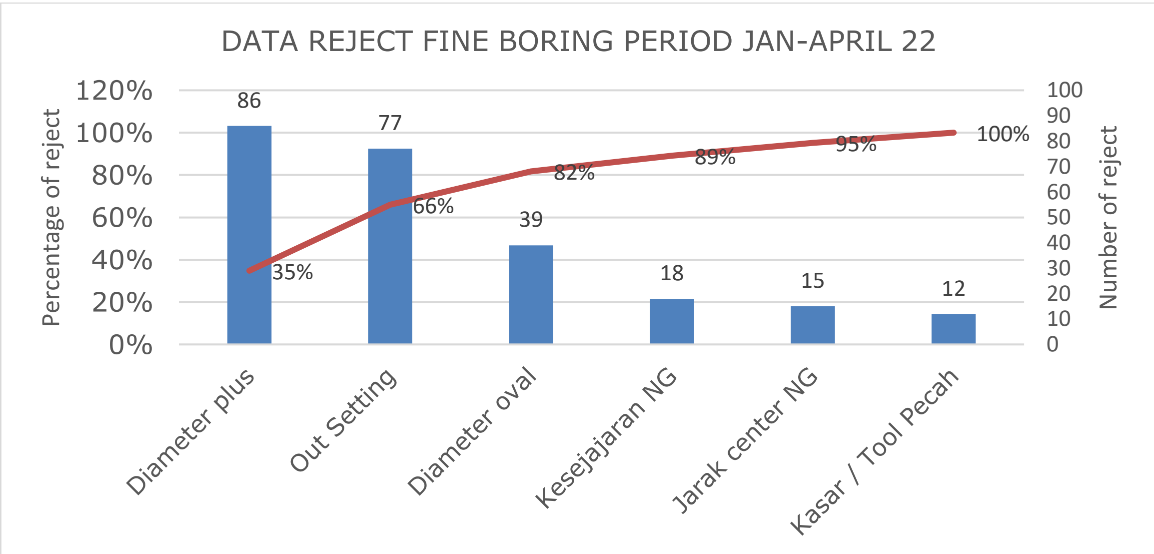

Figure 4. Pareto of rejects during fine boring process pre-QCC

Target Setting Based on QCDSM Rules

The QCC team held discussions and agreed to reduce rejects or set the target **to 0%** using the QCC method using the QCDSM (Quality,Cost,Delivery,Safety and Morale) rule, as shown in Fig. 5

QUALITY : reducing reject diameter plus from 89 pieces to 0 piece

COST : reducing costs due to rejects Rp.48,812/pcs x 89 =Rp.4.344.268

DELIVERY : there is a delay in supplying the next process due to rejects

SAFETY : safety is not maintained

MORALE : Work morale decreases due to rejection

Based on the description of the QCDSM chart in Fig. 5, several conditions in the fine boring process that will be repaired with set targets. The quality was identified as the main issue that lead to incurred cost, delay, safety, and morale. Brainstorming process among employees and implementers in the field was conducted to obtain the root cause and solution for the specific theme. The delivery, safety and moral matters were expected to be rectify after corrective action or improvement on the quality of the product can be made properly.

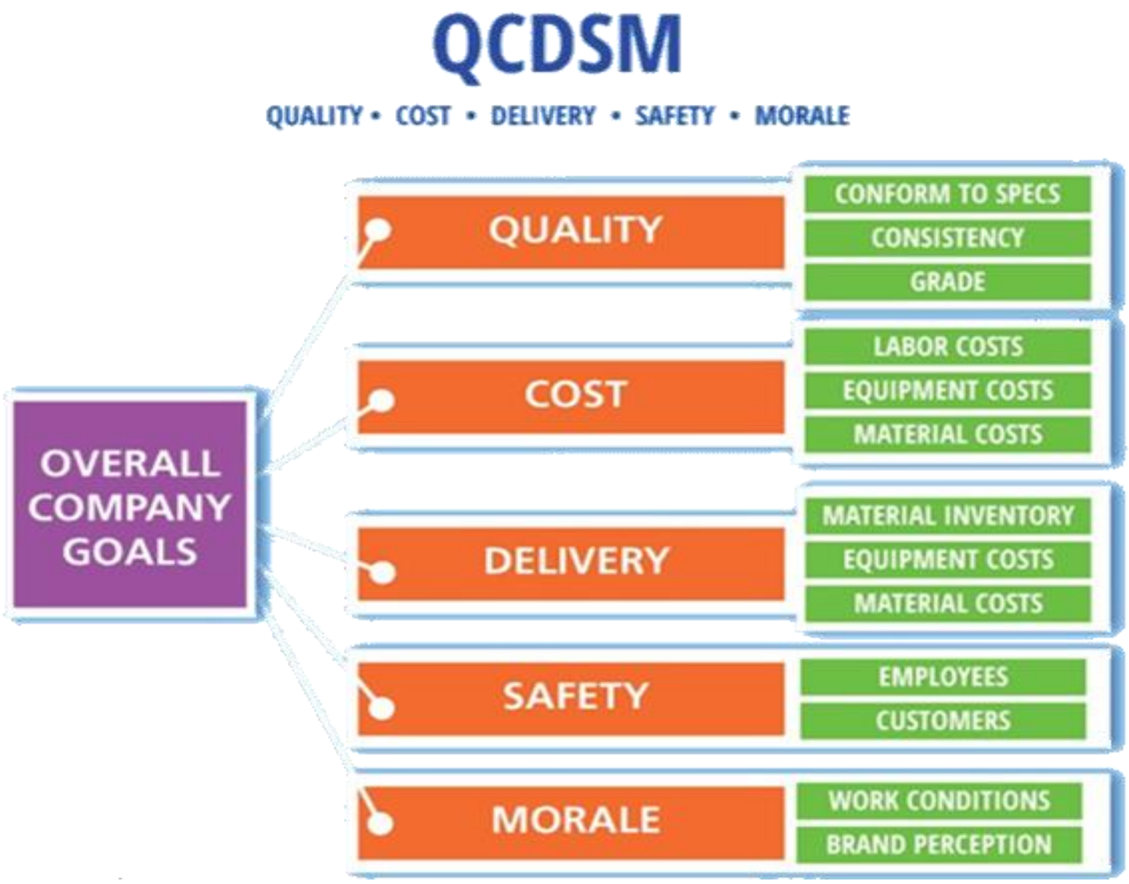

Figure 5. QCDSM Chart

Based on the results of observations and brainstorming on factors in the existing processes and working conditions, as shown in Figure 6, it was found that the contributing factors to the occurrence of plus diameter rejects were method and machine factors. There is no specific method for changing tools. The additional offset was made to the machine by worker based on past experience after tool change. These factors results in the unnecessary reject of diameter plus (+)

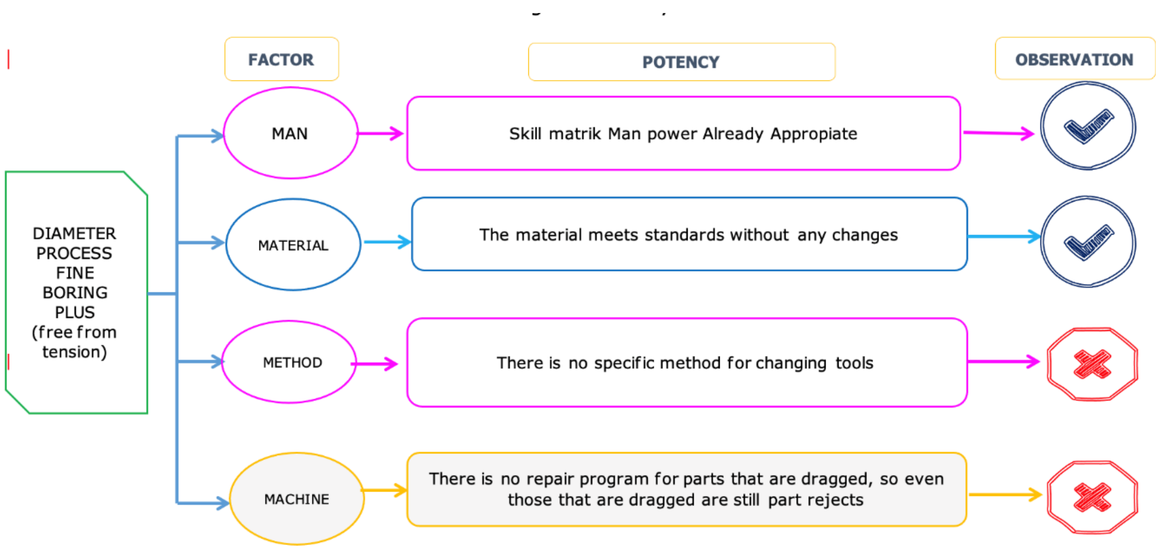

Figure 6. Analysis of Factors

The QCC team discussed on the solution to make a tool change program to the machine. A program has been created for tool replacement so that it makes it easier for operators when changing tools, be it tool life time or changing models (model change), as shown in Figure 7. Before the program was modified, it will run the fine boring until finished at once, even after tool change. The modified program will halt in the middle in fine boring process to allow the operator to measure the diameter of the temporary process using the bore gauge. The result of the diameter process could be plus (+) or minus (-). The operator could then modify the boring setting accordingly before the whole boring process was completed. This allowed the immediate rectification being made to the workpiece, thus reducing the reject or re-work of workpiece.

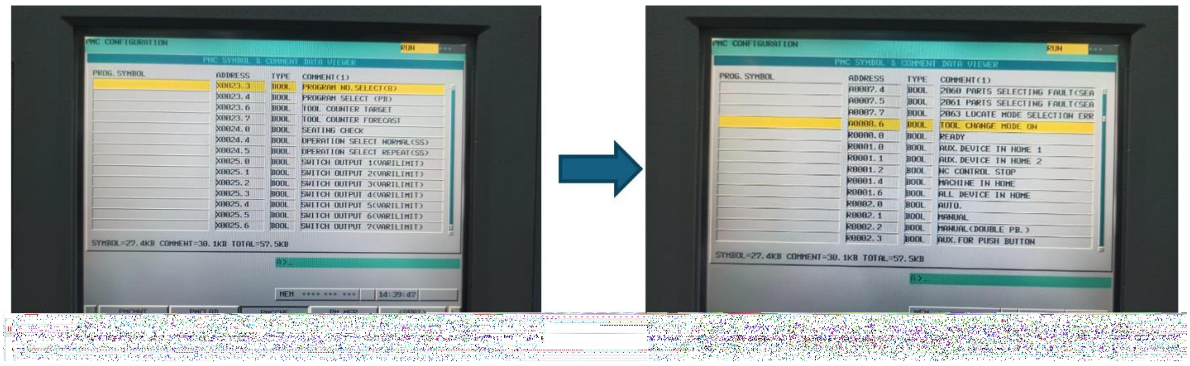

Figure 7. Modified program on the machine

After the program was added, a knob or switch was installed on the dashboard or control panel on the machine to activate or deactivate the modified program, as shown in Fig. 8. The knob made the selection of program becomes easier, since the tool change was as frequent as three to four times per day. The knob selector allowed such that when changing tools, the lever is directed to the "tool change" position so that the machine operation will not process until it is finished (stopping in the middle of the process) but the part cannot be taken from the machine jig.

Then the operator measures the diameter of the part using an arbor measuring tool, after measuring and getting results in accordance with standards, the process continues. If the measurement results do not match (plus or minus) then the offset is added or subtracted. If the diameter meets the range of acceptable diameter, then the process can be continued again and the mode selector is directed to the normal position for the machine to return to normal boring operation.

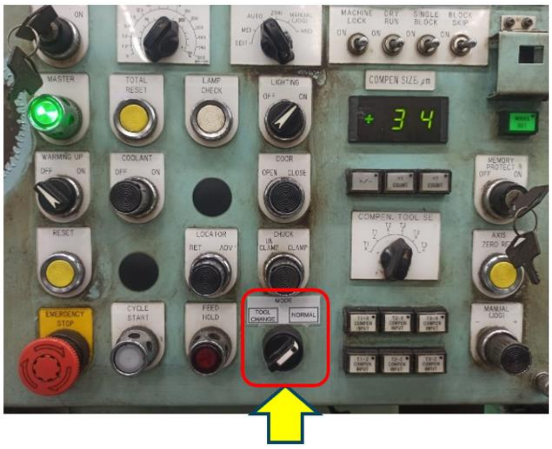

Figure 8. Addition of mode selector for tool change

Evaluation of Improvements

After the improvement was made, then measurement of improvement was performed. Figure 9 shows the rejects data during the period May – June 2022 for fine boring process. Apparently, the initial highest reject rate due to the plus diameter has been improved to the lowest reject in the fine boring process. This signifies that the improvement process was effective or successful, although the results has yet to meet the target of zero.

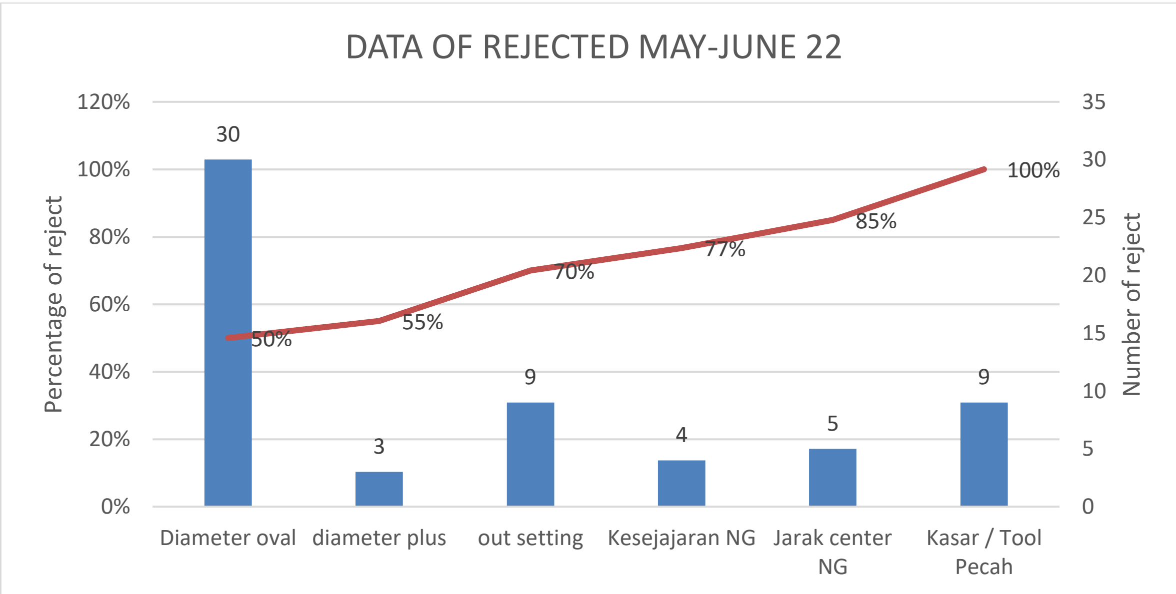

Figure 9. Pareto of rejects during fine boring process post-QCC

Based on the data above, there has been a decrease in plus diameter rejects from 89 pcs to 3 pcs, even though it has not yet meet the desired target, namely 0 (zero defects) and this is still our focus to improve in the future so that we will find a way to reduce rejects to zero level. The following is the QCDSM after making improvements:

QUALITY : reject diameter plus from 89 pieces to 3 pieces (May-June)
COST : cost due to rejection becomes Rp. 48,812 x 3pcs = Rp.146.436
DELIVERY : there is smoothness in supplying the next process

SAFETY : safety is maintained
MORAL : Work morale increases due to reduced rejects

After doing action repair, then found that the target was appropriate to our _ expectations. where the reject rate declines There is also a reduction in costs due to rejection and delivery, safety awareness during the production process, and finally rising the employee morale.Consequently, a work instruction was created and approved by each work leader. Socialization and monitoring are carried out in its implementation. The next step is to improve with a target of zero defects or reduce the reject target in other processes**.**

CONCLUSIONS

In summary, the reject has been significantly reduced. Through the improvement, the efficiency of the fine boring process has been improved, thus reduced costs in the automotive parts manufacturing industry automotive. However, there are still rejects that occur and this is a challenge for the QCC team to develop improvements in the future. Besides, the number of rejects due to oval diameter could be tackled using the same QCC methods following the philosophy of the quality control circle, where action repair that was done in a way consistent. At last, the process modifications that we carry out through the QCC method can reduce rejects that occur even though it may still need improvements in its application and this method can be a reference for other industries in making improvements to their production processes in the future. It can be a method that can be developed for various other fields in implementing its improvements. This finding proved that QCC technique was effective in reducing rejects of fine-boring process, resulted from incorrect setting of machine after tool change.

LIMITATION & FURTHER RESEARCH

This research was limited to a sample of Indonesian manufacturing in the Greater Jakarta area. Thus, this method is high dependency to the knowledge, experience and skill of the QCC team. The proposed solution was unique and specific to the type of machine of fine boring. However, the method to identify the problem that led to the same conclusion of cause of major rejection using QCC, could be the same. Development of QCC team in term of new knowledge may lead to future improvement opportunity through development of quality control techniques with incorporation of internet of things or smart devices.

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