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Root Causes of Brake Caliper Problems as A Corrective Action in Front of LH: A Case Study in Manufacturing Industry

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A B S T R A C T

The industrial sector is the backbone of the country in building the defense sector and economic stability that needs to maintain productivity and be competitive. One of the companies that manufacture automotive components, Mitsubishi, manufactures automotive components and must have zero defect requirements. However, in practice, it was found that 1 (one) unit of CJM had a brake caliper malfunction in the condition that the unit was ready to be sent to the carpool consumer of a company that produces automotive components. The damage is a discrepancy in the diameter of the piston seal, which closes the gap between the piston and the piston housing, allowing for brake fluid leakage, which affects the "zero defect" commitment. Through the application of the Root Cause Corrective Action (RCCA) method with the formation of a Root Cause Investigation (RCI) team, an investigation was carried out to find the root cause of the failure. However, the data processing results of the diameter of the seal thickness obtained have a Cp value of 0.98 and a Cpk of 0.81, which means the process has not been able to work optimally. Therefore, we decided to make some improvements, adding Standard Operating Procedures (SOP), Work Instructions (WI), and making Poka-Yokes as corrective actions in dealing with this problem. After almost 3 months since the investigation began, the data processing results on the piston seal were Cp = 1.86 and Cpk = 1.80.

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1. INTRODUCTION

The industry is required to be competitive by continuously improving company systems internally and externally (Arnina, 2016). In addition, the automotive industry requires a level of accuracy, speed, and accuracy in the implementation of the production process by implementing quality improvements (Isniah et al., 2020; Pinto & Mendes, 2017; Taufik, 2020; Ferdousi, 2009; S. Wijaya et al., 2019). For

example, one of the companies that manufacture automotive components, Mitsubishi Corporation, part of the Krama Yudha Group, operates in the automotive assembly sector, which has a problem with brake fluid leakage in the front CJM brake caliper unit body when the vehicle brakes are in normal condition. The affects the productivity of the company, so improvements are needed.
The company created an investigative team to conduct improvement investigations by applying brainstorming. The team applied Root Cause Investigation (RCI) and Root Cause Corrective Action (RCCA) methods. RCCA can identify the cause and can successfully fix problems that are tested for success so that they can find the root of the problem (Tomić & Brkić, 2011; Kuswardana, 2017; Keyser, 2021; Bhattacharya et al., 2014). RCI is used to determine whether or not a root cause investigation is necessary. There are several techniques for implementing RCCA, including 5W+1H, Control Chart, Check Sheet, Cause Mapping, Cause-and- Effect diagram, 5-Whys, Failure Mode and Effects Analysis (FMEA), and Fault Tree Analysis (FTA), etc. (Bluvband & Grabov, 2009; Tanner, 2020; Schulz, 2014).

2. LITERATURE REVIEW

The word quality has many different definitions, ranging from conventional to more strategic. The conventional definition of quality usually describes the immediate characteristics of a product such as performance, reliability, ease of use, esthetics, and so on. However, managers of companies competing in global markets should pay serious attention to strategic definition of quality: quality is everything that is capable of meeting the needs of customers (Humiras Hardi Purba et al., 2017).

As a concept of sustainable development involving labor, techniques are needed that can help systematically overcome problems. There are various quality improvement techniques in analyzing the types of dominant damage and causes of damage among others (Humiras Hardi Purba et al., 2018). The tools commonly used in quality improvement are as follows:

1. Check sheet

A *check sheet* is a sheet containing notes about events over a period, usually daily. The purpose of making a check sheet is to facilitate recording events, save recording time, and standardize recording. The benefits of having a check sheet are that it facilitates checking, recapitulations, and analysis (Ariani, 2004).
Before being poured into a datasheet, the data we obtain needs to be examined first with the following considerations (Ariani, 2004):

a) Can reveal facts ultimately.
b) By the facts

Several things that need to be considered in data collection are:

- The target of data collection must be clear.
- Classify data according to needs to facilitate data collection.
- Ensuring data validity (data can be relied on/by existing facts/reality).
- Determining data collection methods and equipment.
- Trying to obtain data from as many possible sources as possible.

2. Control Chart

The first control chart was introduced by Dr. Walter Andrew Shewhart of Bell Telephone Laboratories, USA, in 1924 with the intention of eliminating abnormal variations through the separation of variation caused by special causes (variations caused by common causes variation) (Cheng & Thaga, 2006), (Dahlgaard et al., 2008), (Gasperz, 2005).

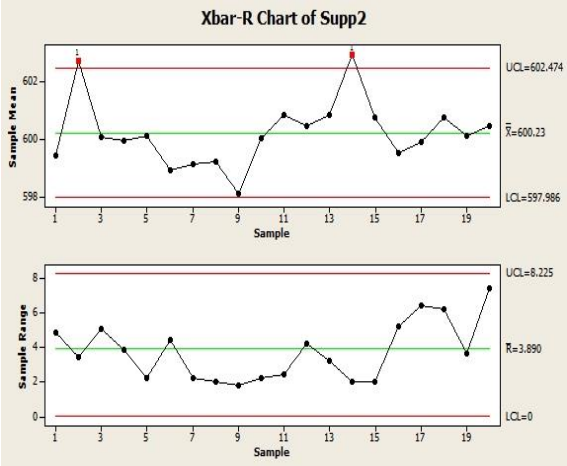


Figure 1. Sample map control Xbar and R
Source: (Oprime et al., 2019)

This common cause is always attached to the system, to eliminate it must trace the elements in the system and only the industrial management can fix it, because the industrial management that controls the system (Gasperz, 2005).

3. Process Capability (Cp) and Performance Index (Cpk)

Process capability to produce or deliver output in accordance with customer expectations and requirements. Process capability is a critical performance measure that shows the process is able to produce in accordance with product specifications applied by management based on customer needs and expectations.

4. Fishbone Diagram

Another basic instrument of quality improvement is the Ishikawa Diagram. Named Ishikawa according to the inventor's name derived from the Japanese country named Kaoru Ishikawa in 1943. Ishikawa diagram is also known as a Diagram of Cause or Fishbone Diagram. Application Fishbone diagram is very appropriate to use if you want the following things, namely (Yamit, 2001): (a) Identify the cause of the problem, (b) Identify actions to create desired results, (c) Discuss the existing matter in a complete and neat, and (d) Produce new thinking.

5. 5W-1H Method

Once the sources and root causes of the quality problem are identified, it is necessary to establish an action plan to improve the quality. Basically, action plans will describe the allocation of resources and priorities and / or alternatives made in the implementation of the plan. It must decide what to achieve (with regard to the targets to be set), the reason for the (why) plan of action should be done, where the plan is set or done, who will be in charge of the action plan (Gasperz, 2002).

6. Root Cause Corrective Action (RCCA)

Root Cause Corrective Action (RCCA) methodology for finding and correcting the most important reasons for performance problems, where RCCA is a combination of root cause analysis (RCA) and corrective action. Basically RCCA aims to identify the origin of problems that have occurred, and generally also a tool used to identify problems that have not happened that is failure mode effect analysis (FMEA), (Okes, 2009). In solving the problem using RCCA method, then the steps that must be done is as follows (Okes, 2009): (1) Preliminary Investigation. There are various "best practices" to consider and things that need to be adopted during the initial investigation process (Okes, 2009), (2) Preserve Scene and Data Collection. At this stage, all the data and evidence gathered are broken down into several key points to facilitate further investigation in the search for the root cause of the problem, (3) Communication and Documentation. The results of the investigative summary are generally communicated to the relevant sections, to disseminate the issue to the lowest responsible person, (4) Team Composition. The settlement of cases using the RCCA, should be complemented by the establishment of a team committed to detailed and targeted investigations and ongoing improvements to the point of perfection, (5) Collect and Classify Data. In establishing plans for data collection at the beginning of an incident or problem, it is necessary to understand specific questions to ensure that data collection remains focused on the target and does not waste effort or direction (Okes, 2009), (6) Problem Definition. Before the root cause is established, it is important to develop a definition of a problem or statement that

directly addresses the issues that need to be addressed, (7) Root Cause Analysis Method. In order to improve efficiency or prevent the recurrence of failure/anomaly of the product or process, the root causes must be understood in order to adequately identify and apply appropriate corrective actions (Okes, 2009): (a) Basic Implementation of RCA on Significant Cases, (b) Brainstorming About Potensis Related Causes/Factors. This step is often referred to as "brainstorming" and the goal is to not only identify the most obvious root causes but also to identify the underlying problems (Okes, 2009), Figure 2, (c) Fishbone Style. However, if during this assignment the root cause occurs repeatedly, it may be eligible to be re-evaluated and identified with a new category.

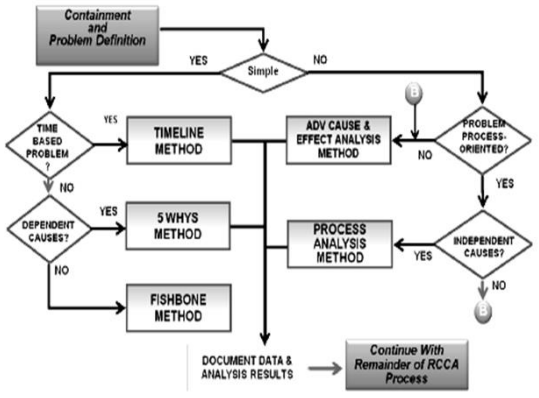


Figure 2. Flow chart cause analysis
Source: (Okes, 2009)

Table 1. RCA Impact Level Matrix

RCA Level	*Impact*	Data Yang Umumnya Digunakan	Jangka Waktu Analisis	Hasil Analisis (disesuaikan dengan permintaan)
5	High – High	• KNOT *chart* • Event Timeline • Process Mapping • Cause Mapping • Fishbone Diagram • Advanced Cause & Effect Analysis • Fault Tree Analysis	2 – 5 Minggu (bahkan lebih)	• Temuan dan kesimpulan RCA • Validasi dan strategi pengukuran • Ilustrasi RCA • Dikomunikasikan ke seluruh internal perusahaan
4	High – Medium Medium – High	• KNOT *chart* • Event Timeline • Process Mapping • Cause Mapping • Fishbone Diagram • Advanced Cause & Effect Analysis	4 Hari – 2 Minggu	• Temuan dan kesimpulan RCA • Validasi dan strategi pengukuran • Ilustrasi RCA • Dikomunikasikan pada user
3	High – Low Medium – Medium Low - High	• Brainstorming • Event Timeline • Process Mapping • Cause Mapping • Fishbone Diagram	1 – 3 Hari	• Temuan dan kesimpulan RCA • Validasi dan strategi pengukuran • Ilustrasi RCA • Dikomunikasikan pada orang yang terlibat
2	Low – Medium Medium – Low	• 5-Why's • Brainstorming • Fishbone Diagram	0,5 – 1 Hari	• Temuan dan kesimpulan RCA • Dikomunikasikan pada orang yang terlibat
1	Low - Low	• 5-Why's • Brainstorming	1 – 4 Jam	• Temuan dan kesimpulan RCA • Dikomunikasikan pada orang yang terlibat

Source: (Okes, 2009)

(8) Corrective Action Plan. The main evidence of root cause analysis is the validation of the corrective action performed as a result of the analysis. While detailed discussion of this step of the RCCA process is beyond the scope of the guidance, problems with production may be limited by incomplete evidence of its validity, prevention of ineffective recurring problems, and so on (Okes, 2009) (Table 1 and Figure 3).

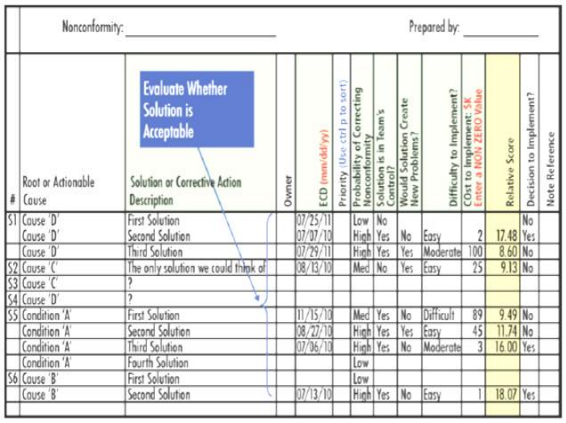


Figure 3. Example composition evaluation repair solution
(Source: Okes, 2009)

5) Poka Yoke

Workers are helped to prevent errors by using poka yoke methods or tools. This term is commonly translated into English as "mistake proofing" or "error proofing". This error correction is not a "tool" lean because it is a way of thinking and evaluating problems. Poka Yoke is based on the philosophy that people do not deliberately make mistakes or do work incorrectly, but mistakes can occur for various reasons (Prabowo & Aisyah, 2020), (Bachhav, 2016). (9). Standard Operating Procedures (SOP). Company is a system designed to achieve the things that cannot be achieved individually. In the face of increasingly competitive business competition, companies need skilled and competent strategies and personnel to facilitate the achievement of these goals (Arnina, 2016).

3. RESEARCH METHOD

RCA involves several stages, including:

1. **Data collection.**
   The data needed by the team includes the LH front caliper inspection data at PT Krama Carpool Yudha Three Berlian Motors for the CJM unit and check sheet data for the piston seal diameter.
2. **Diagram of causal factors**
   The preparation of the causal factor chart should start immediately with the fishbone chart.
3. **Identify the root cause.**
   After all the causative factors are identified, the team begins to identify the root cause.
4. **Create and implement recommendations.**
   After identifying the root cause, recommendations can be reached to prevent the recurrence of these factors.

Based on the literature of the Performance Review Institute (2006), conducting a thorough root cause analysis andproducing a root cause corrective action process (Figure 4).

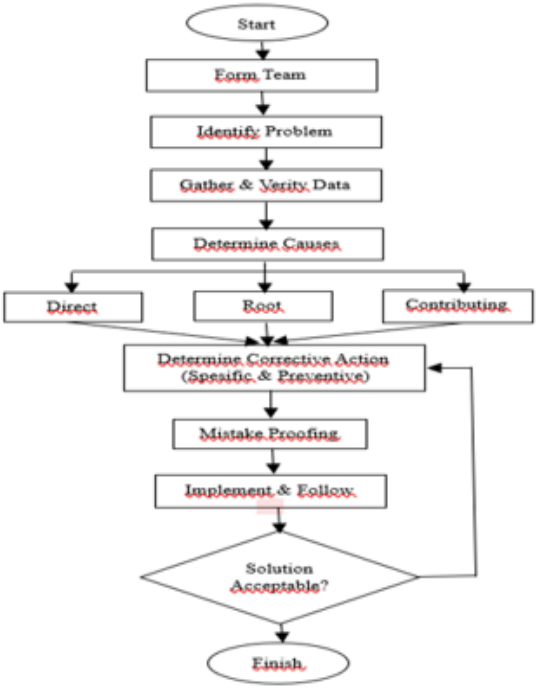


Figure 4. Flow chart of the RCA and corrective action process

4. RESULT AND DISCUSSION

The QC department has one duty to ensure the products meet the quality standards agreed during the contract with the relevant supplier. Products that pass the external inspection process (supplier investigation) are sent to the Trimming PC section at PT Krama Yudha Ratu Motors (assembly factory) to be ready for assembly in the related unit. Therefore, Quality Assurance (QA) publishes a Problem Information Sheet (PIS). In this study, the investigation began by creating a team that was attended by 8 (eight) people, including QC employees as consumers, QA and QC employees from representatives of the front LH brake caliper supplier CJM unit, and researchers who were responsible for this research, so that the investigation process was carried out. as in Figure 5.

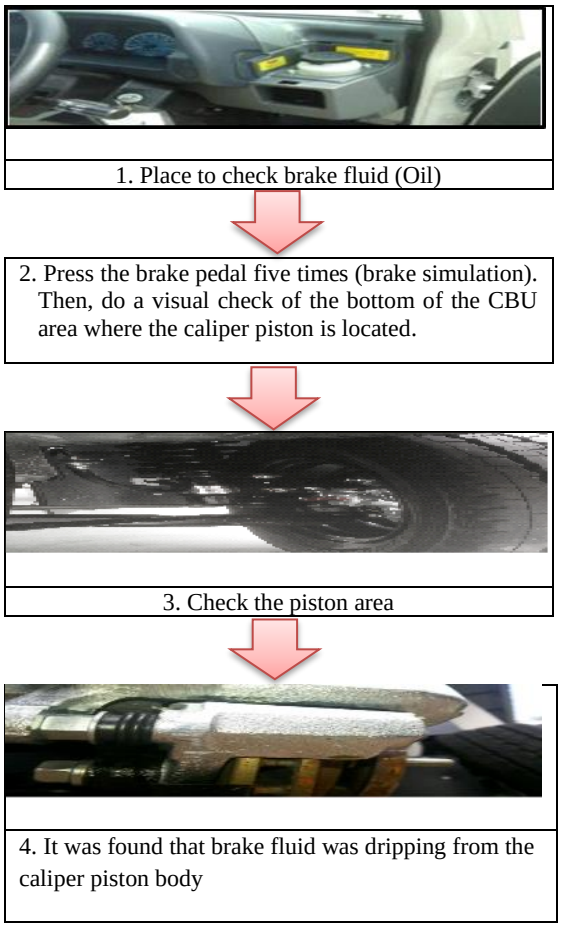


Figure 5. Investigation of the CJM unit braking system (Source: PT IUO Tbk)

The result of this visual investigation is the discovery of a brake fluid leak on the body

brake caliper front when the vehicle brake is in normal condition.

The investigation team decided to conduct further investigation of the section to ascertain the cause of the brake fluid leak which resulted in the CJM unit having blong brakes (Figure 6).

Body Caliper	Piston	Dust Cover	Seal
			
The piston chamber area is not scratched or deformed. Judge ok	No cuts or scratches. Judge ok	Not damaged or torn. Judge ok	The Piston seal looks abnormal (it forms a thin seal). Judge ok

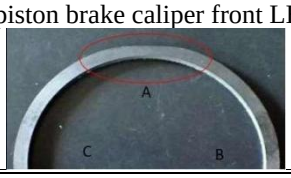
Figure 6. Investigation of piston seal and dust cover brake caliper front
(Source: PT IUO Tbk)

From the results of this investigation, it is known that the cause of the leak in the LH front brake caliper with the production code 6S12 is due to a discrepancy in the outer diameter of the piston seal. In the study of the scene preservation stage, there was a discrepancy in the front brake caliper of the CJM LH unit that was leaking and was found during the preliminary investigation stage. The following is leaked documentation of the front brake caliper of the LH CJM unit as a visual result of the inside (piston seal) shown in Figure. 7, which PT IUO Tbk produces as a supplier of PT ITD.

Figure 7. Visual check results of inner brake caliper front LH unit CJM
(Source: PT IUO Tbk)

The problem, in this case, is a leak in the front brake caliper of the CJM unit because the piston seal inside has an incompatible shape. In the existing technical drawings, it can be seen that the difference lies in the outer diameter of the piston seal, which should be 61.62 mm with a specification limit (0 - 0.2 mm). The measurements were averaged with the X-axis pattern and found to be 61,221 mm and a length of discrepancy of 16,961 mm. The measurement results can be seen in Table 2

Table 2. Seal piston brake caliper front LH results



Section	A	B	C	D	X	Y	L (A) (mm)
Specification	3,30 (+0, -0,25) (mm)				61,62 (+0,2, -0) (mm)		
Test Result	2,470	2,965	2,964	2,980	61,221	61,766	16,961

Sections A, B, C and D show the measurement of each thickness section in the outer diameter of the seal. Tolerance to piston seal diameter is 3.05 mm - 3.30 mm. In the case of the front brake caliper of the LH CJM unit, sample data was taken so than through the control chart Xbar and R map, it was abtained

$\bar{\bar{x}} = 3{,}15\ mm$

$\bar{R} = 0{,}09\ mm$

So that the result is :

1. Control Chart (Xbar)
   Based on the mean values, the calculations of CL, UCL and LCL control charts R are as follows:
   $$CL\ (\mathrm{X}) = \bar{\bar{\mathrm{X}}} = \frac{189{,}25}{60} = 3{,}15$$
2. Control Chart (R)
   Count Center Line (CL), Upper Control Limit (UCL), and Lower Control Limit (LCL). Based on the value of R, then the calculation of CL, UCL and LCL control chart R is as follows:
   $$CL\ (\mathrm{R}) = \bar{R} = \frac{5{,}24}{60} = 0{,}09$$

To know the control limits of the data, we need the control chart and the R control chart; the

following data is presented for the piston seal thickness using Minitab software, as shown in Figure 8-9. Based on the defect sample, the value of process capability index (Cpk) of 0.90 was obtained on the mismatch in diameter of piston seal thickness.

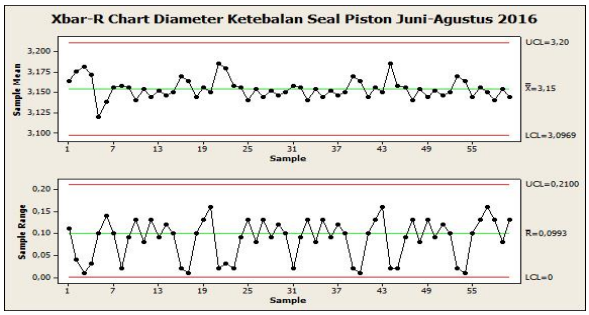


Figure 8. Map control and R seal piston with Minitab
(Source : Data Processing Result)

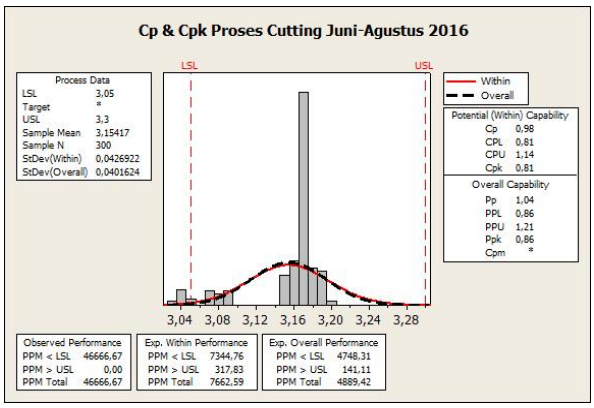


Figure 9. Calculation result Cp & Cpk Minitab cutting process
(Source: Data Processing Result)

The RCI team used fishbone diagrams. In this study, the fishbone diagram was made twice. The first diagram is made to identify problems at PT IUO (Figure 10), and the second is to identify problems at PT ITD (Figure 11). Here isa Fishbone Diagram of the front brake caliper leak of the LH CJM unit.

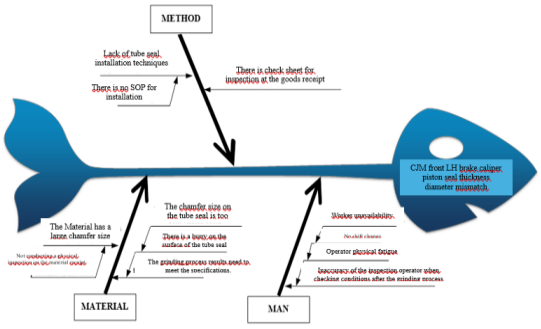


Figure 10. Fishbone diagram for problem analysis at PT IUO Tbk
(Source: Brainstroming)

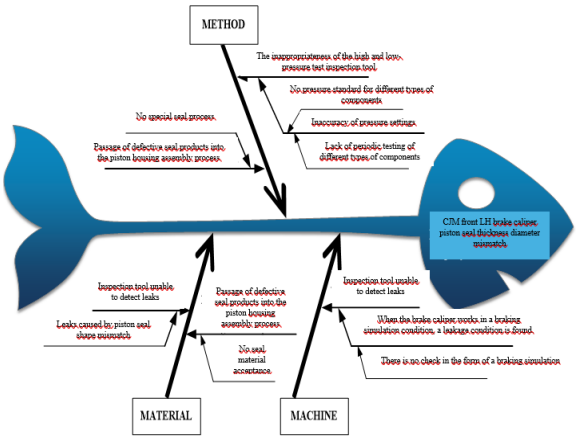


Figure 11. Fishbone diagram for problem analysis at PT ITD
(Source: Brainstroming)

Based on the analysis of the cause of the non-conformity problem, the diameter of the piston brake caliper in frontof the CJM LH unit occurs on each factor, given the proposals on how to work and how the processes that should be done to reduce the disability occur again. The correction tool (Poka-Yoke) was created to help humans correct the actions of the work being done. The human limitations of doing repetitive and lengthy work make this tool one of the best choices for improving the effectiveness of the work (Figure 12).

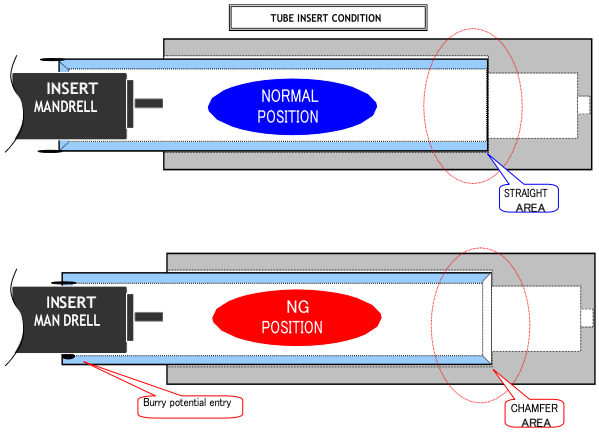


Figure 12. Position of tube seal installation into Poka-Yoke tool
(Source: Development result)

Based on the submission of the concept of Poka-Yoke to the company precisely at PT IUO to reduce the potential for incorrect installation of tube seals before the grinding process, the company receives and implements as needed. From several action plans of implementation of the improvement that has been prepared, 4

(four) plans have been realized following the target time is determined: (1) SOP addition of 100% visual check item at PT IUO Tbk., (2) SOP simulation of installation of tube seal to jig, (3) SOP of cleaning of raw material of tube seal at the reception section of PT IUO Tbk., (4) SOP addition of brake fluid to test inspection process sampled in PT ITD.

5. CONCLUSION

Quality Assurance (QA) reports indicate an LH unit CJM unit suffered brake caused by a brake oil leak on the brake caliper precisely at the piston home position. The cause of leakage on the brake caliper front of LH unit CJM is found through the preliminary investigation stage, caused by piston seal discrepancy, which is the responsibility of the seal supplier PT IUO and PT ITD asthe supplier of brake caliper front LH unit CJM. Further research on problem reports in handling mismatch diameter of piston brake caliper front LH unit CJM is continued with the application of the RCCA method. Recommendation of proposed improvement based on analysis result using RCCA method to assist the settlement of this case, among others the making of Poka-Yoke in pairing tube seal to jig before grinding process, making SOP of adding visual check item 100% In PT IUO, making SOP simulation of tube seal to jig installation, SOP cleaning of tube seal raw material at a reception at PT IUO, making SOP addition of brake fluid to test inspection process sampled in PT ITD. The evidence of quality improvement can be seen in the process capability calculation (Cp) results after the improvement of the previous increase of 1.12 to 1.86 and the process capability index (Cpk), which rose from 0.90 to 1.80.

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