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Analysis of Damage and Repairs to the Transmission Part of the Komatsu Type GD825-2 Grader Unit

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Abstract. The Plant Rebuild Center, owned by PT. X, must raise quality to meet customer expectations and fulfill field needs. According to customer warranty claims in 2022, oil leaks in the transmission control valves of GD825-2 type units—11 in total—are the most common cause. This research's operational goal is to identify the source of the most damage to transmission components, particularly in Komatsu GD 825-2 units that corrective action may be taken and the effects can be monitored. At PT X's Plant Rebuild Center, corrective measures were implemented and standard operating procedures were created to serve as a guide for rebuilding Komatsu GD 825-2 unit transmission components. The analytical approach applies five why analyses. The findings show that oil leaks in the transmission control valve are the most common cause of damage. The engineering techniques used to achieve this improvement included duplicating the sleeve using the manufacturer's standard reference and altering the o-ring seat height during the semi-finishing stage before measuring and cutting during the finishing process. This resulted in the surfaces of the sleeve and transmission housing being identical. Work Instructions (INK) for installing the GD825-2 unit transmission control valve and a Checksheet for the GD825-2 type Grader unit transmission assembly have been developed as Standard Operating Procedures (SOPs).

Keywords - Plant Rebuild Center*;* engineering techniques*;* transmission control valve

PENDAHULUAN

PT. X is one of the leading coal tanning services companies in Indonesia. To streamline its operational activities, PT. X implemented a comprehensive maintenance program that included both more detailed and comprehensive maintenance facilities. To sum up, in 2009, the Plant Rebuild Center was established as a center for rebuilding all of the major mine equipment [1].

Plant Rebuild Center produces a few components, such as engines and powertrains, to meet the needs of the field. Plant Rebuild Center is dedicated to improving customer quality by minimizing or eliminating any problems that arise with the engine and power train components [2], [1].

A power train is a mechanism consisting of several components working together to transfer energy from the engine to the final drive to operate a device [3]. The first diagram illustrates several components that make up the power train system: the differential, the final drive, the torque converter, and the power transmission [4].

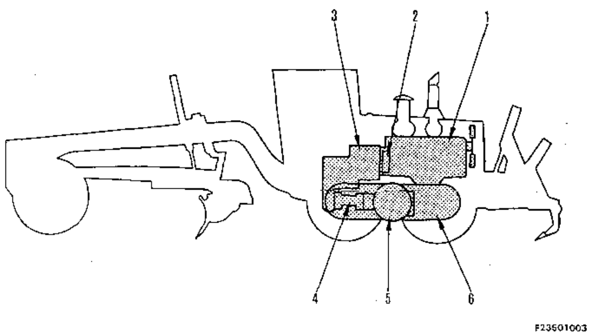

Figure 1. Komatsu GD825-2 power train unit parts

Deterioration in Figure 1.
1. Engine
2. Joint
3. Transmission
4. Driveshaft

5. Final drive
6. Tandem drives

Every component needs to function properly. This is so that the power train mechanism functions properly and the device can break [5]. To monitor the quality of the overhaul component and the results from the Plant Rebuild Center, data must be collected and used as a foundation for any improvement [6] [7]. Last but not least is the customer guarantee claim data. The purpose of this data is to identify any overhaul component failures of Plant Rebuild Center that occur throughout warranty periods. Based on existing claim data, it is possible to identify the components that require improvement. Figure 2 presents the claim statistics for the year 2022 [8] [9]. Figure 2 indicates that the highest claim threshold is on the transmission component. Total claim exceeds eighteen thousand. This makes it important to pay close attention to the transmission product to make more specific corrections and ensure that there are no problems with the user's component.

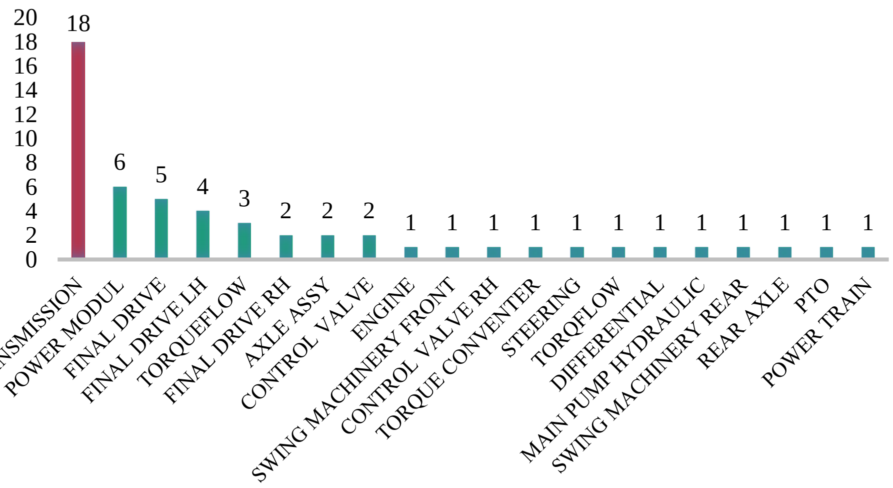

Figure 2. Warranty claim for model year 2022 users [10]

Plant Rebuild Center produces transmission components using a few models of components from various types. To that end, a closer look at the available data is necessary. Every type of claim data needs to be grouped according to the type of unit specifications that are being overhauled at the plant rebuild center (Figure 3).

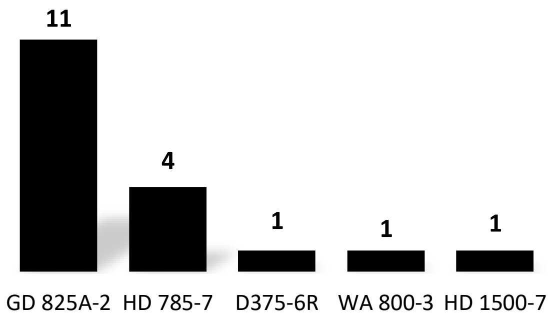

Figure 3. Graphic stating the transmission component's guarantee till 2022 [10]

Figure 3 indicates that the most frequently used transmission unit grader Komatsu with type GD825-2 is 11 cases. Due to this, a thorough analysis is required to specifically identify the type of failure that frequently occurs in the transmission component of the GD825-2 unit [11].

A critical analysis of the transmission component on the GD825-2 unit is necessary. If this is not done quickly, it could lead to a decline in customer satisfaction. In the long run, this will be detrimental to the company. This operational research goal is, To understand the reasons behind the severe transmission component failure, namely in unit GD 825-2 Komatsu at Plant Rebuild Center (PRC) PT. X. To create a correction and assess the results of the correction that is made. Create an operational procedure standard (SOP) for the work to be followed when overhauling the transmission unit (GD 825-2 Komatsu) at the Plant Rebuild Center (PT X)

METHOD

This study is being conducted at the Plant Rebuild Center PT. X, located on Jl. Narogong, Bekasi. One of the tools that are used is a Pareto diagram of the often occurring anomalies and ways to improve them [7],[12]. Therefore, it might be considered an investment to raise the quality of that particular component. This study is based on factual data obtained through open access from the customer data claims (claim warranty proposal) data for the years 2021–2022, and additional data is obtained through open access analysis of the transmission component. This study also includes customer data from Shopmanual data and new manufacturer information. The analysis method used is the Pareto technique. The research is explained in **Figure 4**. Oil leaks in the transmission control valve. For this reason, it is necessary to conduct a technical analysis that aims to determine the factors that cause frequent problems with the transmission components of the Komatsu GD825-2 unit, namely oil leaks in the transmission control valve section.

Figure 4. Oil leak at the GD825-2 transmission control valve

Figure 5 process of dismantling the transmission control valve from the transmission housing, to identify leakage problems that occur.

Figure 5. Removal of transmission control valve from transmission housing

Figure 6 identifies the next focus on the sleeve, this is because the o ring that is damaged is only the part that sits on the sleeve.

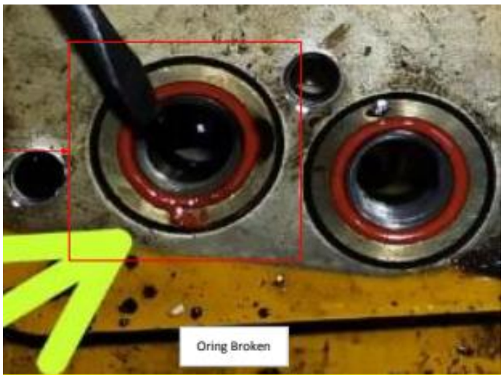

Figure 6. O-ring's findings on the damaged sleeve

RESULT AND DISCUSSION

The analysis that was completed during the study produced results similar to those shown in Table 1. To limit the amount of noise in the transmission component, use the parabolic method as shown in Figure 4. Where the x-axis is the number of component failures on the Komatsu GD825-2 unit and the y-axis is component damage. From Figure 7, oil leak failure occurred 7 times during 1 year, abnormal noise indication occurred 1 time, and ECMV error 1 time in 1 year. Where the x-axis is the number of component failures on the Komatsu GD825-2 unit and the y-axis is component damage. From Figure 7, oil leak failure occurred 7 times during 1 year, abnormal noise indication 1 time, and ECMV error 1 time during 1 year. Of the 4 indicators of damage, the highest damage occurs due to oil leaks.

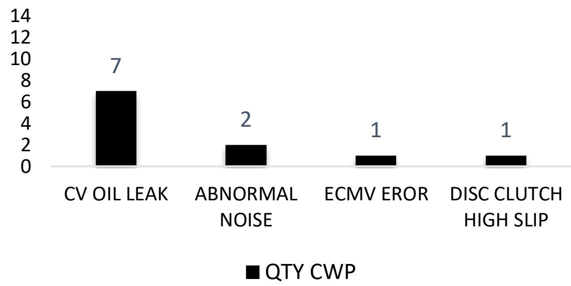

Figure 7. Partial schematic of the transmission component for the year 2022

Figure 7 indicates that the most common type of error that occurs in the transmission component of the GD825-2 is the mismatch in the valve transmission [13],[14],[15].

One of the problems with the transmission unit GD825-2 Komatsu is the oil skeleton in the transmission's upper control section. Various challenges were faced by the company throughout this crisis. The first step is to provide rusted parts due to the repair process. Notarial consisted of work-related expenses and losses resulting from a malfunctioning unit [16],[17],[18].

Discussion

To clearly understand the cause of the oil leak in the transmission control loop, a failure component demolition is performed. This transmission uses a system where the oil is moved using a transmission control valve through the oil's track in the transmission housing, with the oil's pressure measuring either 1.47 Mpa or 15 kg/cm^2 [19]. As a result, appropriate feedback needs to be given to the aforementioned gaps. The first step involves the transmission control loop assembly from the housing unit [20]. Following the breakdown of the transmission control unit, a failure was observed on the o-ring that had rusted through the sleeve. This resulted in the o-ring being unable to be properly seated and caused an oil transmission to break free from the individual transmission unit and housing.

Focus identification on the sleeve, as this is caused by an o-ring that experiences failure only on the sleeve's upper surface. The analysis process on the sleeve itself involves identifying the difference in sleeve surface area and transmission housing surface area.

Based on those results, it can be concluded that sleeve permeability is not as high as housing permeability. To ensure more accuracy in the process of cleaning the sleeve's exterior use a depth micrometer (Measuring micrometer). Before undergoing measurement, the sleeves must be labeled to ensure that the sleeves and seat stay together and are always separable. The results of the sleeve's measurement are shown in Table 1.

Table 1. Consequences of sleeve flatness following unloading

Sleeve	Measuring results (mm)
1	0,75
2	0,75
3	0,70
4	0,73
5	0,65
6	0,60

It is observed that the maximum thickness of the sleeve is 0.75 mm. To understand which part of the body is affected by the wear method of sleeve insertion. Table 2 displays the results of the sleeve seat experiment.

Table 2. Results of the sleeve udder inspection

Sleeve	Measuring results (mm)
1	4,80
2	4,78
3	4,70
4	4,75
5	4,67
6	4,65

It takes multiple analyses to determine why o-rings on sleeve garments break so regularly. O-ring resistance in oil sealing and o-ring perfection at temperature and pressure in the GD825-2 unit transmission are calculated. A few things to take into account include the O-ring's size and position on the sleeve, its material, and its stiffness (Shore)[21].

Squeeze calculations can be used to determine a balanced and appropriate sealing force for o-rings in their application. After an o-ring is released from its compressed state, the equilibrium compression set can be estimated using an additional empirical method [13]. As a result, to determine the effectiveness of the o-ring seal, it is important to compare the compression and Squeeze Set values with the actual dimensions of the transmission control valve that has been disassembled.

The o-ring installed on the sleeve was found to have non-standard results from the Compression Set and Squeeze measurements. This led to the o-ring being less effective in the pressurized oil sealing process, causing the installed o-ring to be damaged quickly and pressurized oil to escape through the gaps. o-ring distance.

Subsequently, the 5 Why analysis approach (5 whys) is employed to analyze the underlying reasons for the oil leakage issue in the transmission control valve, as illustrated in Table 3. The process by which an issue's underlying cause-and-effect relationship is looked into [22]. This is to enable the identification of the underlying issue causing the oil leak in the transmission control valve. Improvements are then made, and standardization follows

Table 3. *5 Ways Analysis*

PROBLEM	Transmission control valve connections are frequently the source of transmission oil leaks.
WHY 1	**Why does the Transmission Control Valve system frequently contain transmission oil?** - Harmed Because of the O-ring**.**
WHY 2	**Why do O-rings fracture?** - Since the O-ring is unable to completely seal the oil**.**
WHY 3	**Why can't O-rings seal oil perfectly?** - Since the squeeze O-ring and the compression set are non-standard**.**
WHY 4	**Why are Squeeze O-rings and compression sets not standard?** - Due to the very high O-ring mounting gap
WHY 5	**Why is there too much space between the O-rings?** - The gearbox housing's sleeve mount has worn out**.**

The analysis of the disassembly process revealed that wear on the contact area between the transmission housing and the sleeve was the reason for oil leakage from the transmission control valve. This led to an abnormally large gap between the sleeve and the transmission control valve's surface, which reduced the O-ring's process insulation effectiveness. To prevent oil leaks in the transmission control valve, it is necessary to make efficient repairs to the sleeve and seat.

Improvement Planning

A repair plan is made once the problem's core cause has been identified. Engineering must be corrected to get the sleeve's surface back to being flush with the transmission housing's surface. Here's a more practical and efficient method:

a. Producing duplicate sleeves based on standard sleeve sizes and altering the O-ring holder's height, or what is commonly referred to as a semi-finished product (semi-finishing).
b. Create a standard protective sleeve by making a standard protrusion on the transmission housing's surface.

Figure 8. Sleeve before repairs

Figure 9. Sleeve after repairs

Figure 8 results of material hardness measurements on the original sleeve 32.2 Hrc, with a height of 4 mm. Figure 9, the second sleeve's dimensions are raised by 7 mm. This puts the sleeve in a vulnerable position that will be machined using a lathe. Following the halfway completion of the duplicate sleeve, the depth measurement results indicate the next step in the repair process, the hardness test 32.5 HRC

Implementation of Improvements

The final step in repairing the duplicate sleeves is to mark the quantities and numbers of the values that will be machine-cut on six sleeves in total. The label needs to be altered to fit the labeled transmission housing's sleeve mount. The surface values for the duplicate sleeve in Table 4 that need to be cut are as follows.

Table 4. Distinctive sleeves that are worn

Sleeve	Measuring results (mm)
1	7 - 4,80 = 2,2
2	7 - 4,78 = 2,22
3	7 - 4,70 = 2,3
4	7 - 4,75 = 2,25
5	7 - 4,67 = 2,33
6	7 - 4,65 = 2,35

The half-finished sleeve is labeled with the quantity to be cut with a lathe and a description of the value to be cut. Table 5 displays the findings of the sleeve protrusion measurement following the machining procedure.

Table 5. Completed duplicate sleeve protrusion measurement results

Sleeve	Standard (mm)	Measuring results (mm)	OK / Not OK
1	0 – 0,10	0,04	OK
2	0 – 0,10	0,05	OK
3	0 – 0,10	0,04	OK
4	0 – 0,10	0,06	OK
5	0 – 0,10	0,07	OK
6	0 – 0,10	0,03	OK

The compression and squeeze set values for the O-ring with the modified sleeve condition must be calculated to ensure that the durability of the O-ring in the sleeve is more durable to ensure the effectiveness of the O-ring seal with sleeve modification.

Test Repair Results

Two steps comprise the repair test procedure: a hydraulic test bench leak check and a review of warranty claim data from January to September 2023. The Gradertype GD825-2 unit's transmission components are put through a performance test on the hydraulic test bench, one of which involves looking for leaks coming from the sides. joining of the transmission parts.

No oil leaks were discovered in the transmission control valve, according to the findings of an oil leak inspection utilizing a color-type fracture spot-detecting tool on the GD825-2 transmission. Additionally, the Lifetime data of the GD825-2 overhaul unit from PRC Narogong from January to September 2023 shows the caliber of the repair test results. beginning with the initial transmission component, which was implemented in January 2023. The device that was installed in February and was still in use (Running) until September is the Grader device with unit code GD 016-0068. Based on data monitoring customer warranty claims in 2023, it appears that consumers did not report any damage to the Komatsu Grader unit type GD825-2's transmission, particularly oil leaks at the transmission control valve, as shown in Figure 10.

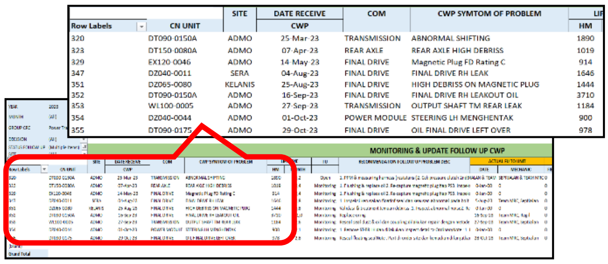

Figure 10. 2023 statistics on customer warranty claims [23]

Subsequently, transmission damage data for the Komatsu GD825-2 unit type was compared with customer warranty claim data both before and during repairs. The outcomes are displayed in Figure 11.

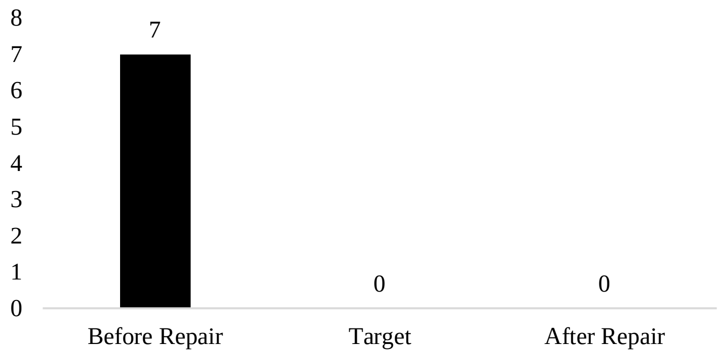

Figure 11. Graph following restoration

Based on the conducted research, it can be stated that the Komatsu type GD825-2 grader unit's transmission section damage analysis and repairs were successful. Leaks of oil in the gearbox control valve are a common source of damage. The improvement was made by applying engineering techniques to ensure that the transmission housing and sleeve surfaces were identical. Specifically, the sleeve was duplicated using the manufacturer's standard reference, and the o-ring seat height was modified during the semi-finishing stage before being measured and cut during the finishing process. The procedure of measuring the protrusion of the sleeve surface on the surface of the transmission housing has been standard work at PRC PT. X and is incorporated into the standard operating procedure (SOP) in the form of a checksheet assembly transmission unit grader type GD825-2 and Work Instructions (INK) to ensure that oil leakage damage to the transmission valve of the GD825-2 unit does not occur again. Install the GD825-2 unit's transmission valve transmission.

CONCLUSION

The Komatsu type GD825-2 grader unit's transmission part has undergone successful analysis and repairs. Leaks of oil in the gearbox control valve are a common source of damage. The improvement was achieved by applying engineering procedures to create an identical replica of the sleeve based on the manufacturer's standard reference, making the surfaces of the sleeve and transmission housing even. The o-ring seat is in the semi-finishing stage by changing the height by 7 mm, and the measuring and cutting procedure is then completed in the finishing stage. The protrusion of the sleeve surface is measured to prevent future damage to the transmission valve of the GD825-2 unit due to an oil leak. A result of 28% was obtained by testing the compression set and squeezing the O-ring on the sleeve following repairs, using the typical compression set of 20–30%. In contrast, the test results were 21.4%, when the typical squeeze is between 20 and 22%. The examination of the compression and squeeze set calculations on the Oring that rests on the modified sleeve has reached satisfactory criteria based on the results of the sleeve modification. It is a routine work procedure at PRC PT. X and is poured into Standard Operating Procedures (SOP) on the exterior of the transmission housing. The Work Instructions (INK) for installing the transmission control valve on the Grader unit type GD825-2, as well as the Checksheet form for the transmission assembly.

REFERENCE

[1] KOMATSU, "Shop Manual GD825-2 Series," *KOMATSU JAPAN*, 2003.

[2] M. D. Section, *TRAINING GENERAL UNIT GD825-2 KOMATSU*. BONTANG: PT. PAMA PERSADA NUSANTARA, 2005.

[3] Khoerul Anam Vuko A T manurung, "MENURUNKAN KERUSAKAN YANG TIDAK TERJADWAL (UNSCHEDULE BREAKDOWN) SISTEM TRANSMISI MOTOR GRADER KOMATSU TIPE GD 825A-2 DI PT. PAMAPERSADA DISTRIC ADARO," *Technol. polman astra*, vol. 9, 2018.

[4] Plant People Development PT SIS JAKARTA, "Transmision unit GD825-2 Overhaule," *Plant People Dev. PT SIS*, 2004.

[5] Y. Zamrodah, *POWERTRAIN DAN HIDRAULIC ALAT BERAT*, vol. 15, no. 2. 2016.

[6] H. Bloch, "The theory of economic development," *Schumpeter's Price Theory*, vol. 108, no. 3, pp. 13–23, 2020, doi: 10.4324/9781315724744-2.

[7] ERIK, "ERIKS - Sealing Elements - Technical Handbook O-rings - Designing With Rubber".

[8] Komatsu, "Unit Instruktion Manual Powertrain Basic Power Transmision Component unit GD825-2," *KOMATSU JAPAN*, 2003.

[9] M. D. Section, *Prefentive Maintenance Komatsu Motor Grader GD825-2*. jakarta: PT. PAMA PERSADA NUSANTARA, 2001.

[10] planning & control P. D. Production, "CLAIM WARANTY PROPOSAL PRC NARO PT.SAPTAINDRA SEJATI," BEKASI, 2022.

[11] Plant People Development PT SIS JAKARTA, *MATERIALS & PARTS*. JAKARTA: plant people development pt saptaindra sejati, 2009.

[12] Arikunto suharsimi, "Pendekatan penelitian," *rineka cipta*, 1998.

[13] S. Subagiyo, A. Asrori, and L. Agustriyana, "Analisis Kekerasan Baja S45C Hasil Hardening Dengan Variasi Media Pendingin," *Info-Teknik*, vol. 19, no. 1, p. 43, 2018, doi: 10.20527/infotek.v19i1.5141.

[14] I. Kurniawan, U. Budiarto, and I. P. Mulyatno, "Analisa Kekuatan Puntir, Kekuatan Tarik, Kekerasan dan Uji Metalografi Baja S45C Sebagai Bahan Poros Baling-Baling Kapal (Propeller Shaft) Setelah Proses Tempering," *J. Tek. Perkapalan*, vol. 6, no. 1, pp. 313–322, 2018.

[15] IRFAN FERIANTO WIBISONO, "PENGEMBANGAN MEDIA PEMBELAJARAN INTERAKTIF TEORI DASAR MESIN BUBUT KONVENSIONAL BERBASIS SOFTWARE MACROMEDIA FLASH PROFESIONAL 8," pp. 1–94, 2012.

[16] G. D. Flourentzou, N., Agelidis, V. G., & Demetriades, "VSC-based HVDC power transmission systems," *IEEE Trans. power Electron.*, vol. 24, no. 3, pp. 592–602, 2009.

[17] K. T. Gillen, R. Bernstein, and M. H. Wilson, "Predicting and confirming the lifetime of o-rings," *Polym. Degrad. Stab.*, vol. 87, no. 2, pp. 257–270, 2005, doi: 10.1016/j.polymdegradstab.2004.07.019.

[18] T. SHOYAMA and K. FUJIMOTO, "Calculation of high-frequency dynamic properties of squeezed O-ring for bearing support," *Mech. Eng. J.*, vol. 5, no. 2, pp. 17-00444-17–00444, 2018, doi: 10.1299/mej.17-00444.

[19] W. Punakawan, "Gambar, Pengertian dan Informasi Tentang 'Mesin Bubut.'"

[20] X. Chen and S. M. Zhao, "Evaluation of fatigue damage at welded tube joint under cyclic pressure using surface hardness measurement," *Eng. Fail. Anal.*, vol. 12, no. 4, pp. 616–622, 2005, doi: 10.1016/j.engfailanal.2004.08.001.

[21] A. Rodríguez-Prieto, E. Primera, M. Frigione, and A. M. Camacho, "Reliability prediction of acrylonitrile o-ring for nuclear power applications based on shore hardness measurements," *Polymers (Basel).*, vol. 13, no. 6, pp. 1–18, 2021, doi: 10.3390/polym13060943.

[22] J. Heritage, "5 Conversation Analysis and Institutional Talk," *Handb. Lang. Soc. Interact.*, pp. 103–147, 2004.

[23] planning & control P. D. Production, "CLAIM WARANTY PROPOSAL PRC NARO PT.SAPTAINDRA SEJATI," BEKASI, 2023.