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# The Influence of Seal Kit Performance on the Pressure of Hydraulic Press Part Roll Cylinder in the Paper Industry

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**ABSTRACT**

The hydraulic system is an energy transmission system utilizing liquid fluids. Liquids possess a characteristic different from solids in their inability to withstand shear stress. The employed methodology is qualitative research, also referred to as naturalistic qualitative research, which entails a natural implementation without manipulating circumstances. This study aims to identify the causes of damage to the hydraulic system in the press section machine, along with implementing appropriate corrective measures, while examining the hydraulic functioning of the press section machine. The research problem specifically focuses on analyzing the damage to the hydraulic cylinder and addressing cylinder seal failure. The damage results from seal wrinkling caused by aging, heat and wear. It is important to ensure that the hydrostatic test pressure is carried out at pressures up to 20 MPa with a holding time of at least 30 seconds. This examination ensures that the hydraulic roll press problem has been fully resolved and will not reoccur. Hydraulic systems offer numerous advantages as an energy source in various applications. These advantages include their lightweight nature, ease of installation, and low maintenance requirements. Inadequate performance in the hydraulic roller pressure section is attributed to a hydraulic cylinder seal that does not meet the specified standards, necessitating replacement with a suitable seal.
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***Keywords:*** *Hydrostatic test pressure, Hydraulic press part roll cylinder, Paper Industry, Reynolds number, Seal Kit,*

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## 1. INTRODUCTIONS

Paper production involves pressing dry-treated fibers with additional materials to bind and intertwine them, typically using natural fibers rich in cellulose and hemicellulose. The paper is divided into two main groups: cultural paper (e.g., printing and writing paper) and industrial paper (e.g., oil paper, fruit paper, electrical insulation paper, and cardboard). Raw materials for paper production come from plants with dietary fiber, including various plants like rice straw, bamboo, sugar cane, and more. Wood, both hardwood and softwood, is also used as paper raw material due to its high cellulose content. Recycling paper is another method to produce paper, where raw materials are processed and transformed into new paper. Almost all types of wood, including hardwood and softwood, can serve as paper raw materials due to their high cellulose content (approximately 40-45%). Paper can also be produced from recycled paper, where raw wood materials are processed and transformed into new paper [1]. A hydraulic actuator is a component that converts working fluid energy into mechanical energy linked to reciprocating motion. The actuator's piston and cylinder assembly are subjected to fluid pressure, which generates a force that propels the piston. The

piston rod can exert pressure on the fluid in the same direction as the piston, converting fluid energy into mechanical force [2-3]. The hydraulic actuator serves as the executive component within the hydraulic system. This arrangement possesses several advantages, such as generating a substantial force output while operating at a relatively low speed [4]. In order to preserve production efficiency during the paper-making process, the press part machine must function properly, and any damage to its parts can cause manufacturing to be interrupted.

Hydraulic actuators are components that convert fluid energy into mechanical energy, generating reciprocating motion [5]. The piston and cylinder assembly of the actuator are subjected to fluid pressure, which propels the piston and, in turn, converts fluid energy into mechanical force. Hydraulic actuators find application in various industries, especially in machinery, due to their ability to generate substantial force output at relatively low speeds.The utilization of hydraulic systems has experienced significant growth to the extent that they are now employed across various industries. Generally, hydraulic systems find application in the machinery industry. Numerous automated industrial tools operate within the industrial realm utilizing mechanical, electronic, hydraulic cylinder, pneumatic, or other systems. Hydraulic cylinders have effectively secured a significant position in the industrial domain due to their ability to control machine operations economically.

Research on modeling an electro-hydraulic actuator was done by [6]. Experiments on a test bed with an EHA under sensor failure circumstances were used to examine the proposed FTC architecture's effectiveness thoroughly. The study demonstrated the capability to manage sensor faults and maintain stable and accurate tracking control in EHAs even in difficult circumstances by utilizing the EKBUIO-based fault detection and the BELBIC intelligent controller. The setup of the system is depicted in Figure. 1. A hydraulic cylinder powered by a three-phase servo motor and a hydraulic pump with a single direction and fixed displacement were both included in the EHA system, as shown in Figure 1. Four high-speed ON/OFF solenoid-controlled valves and one safety pressure regulating valve made up this valve circuit, which was used to control all cylinder operations.

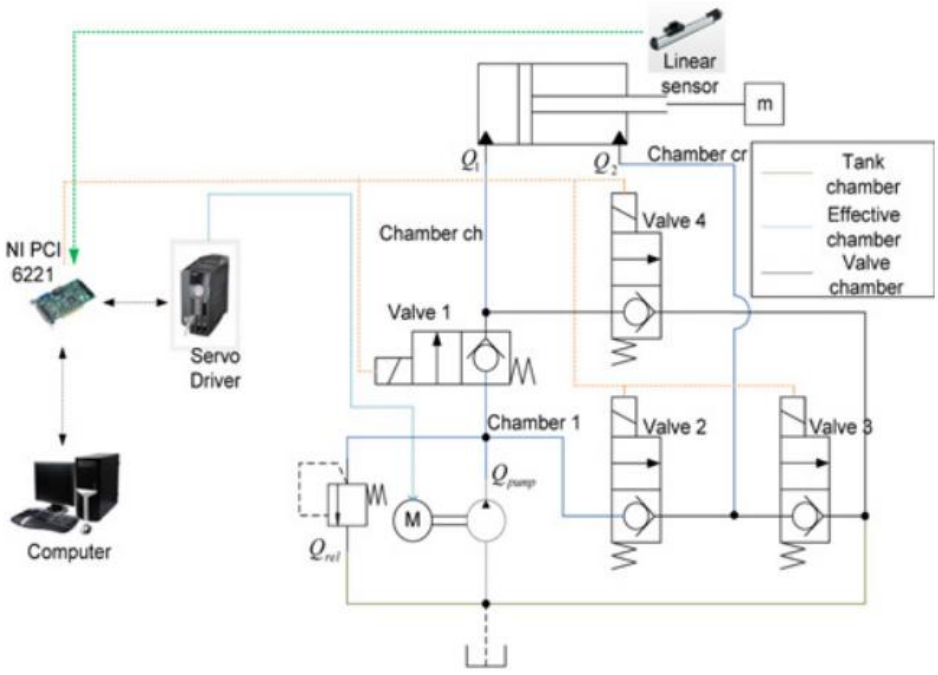


Figure 1. The setup for the EHA test rig [6]

This study aims to determine the hydraulic system and identify any damage present in the hydraulic cylinder of the plate rolling machine, subsequently undertaking the necessary repairs. The study aims to identify the causes of damage to the hydraulic system within the rolling press part machine, implement

appropriate corrective measures, and comprehend the working mechanisms of the hydraulic press part machine. The research specifically focuses on analyzing damage occurring within the hydraulic cylinder In the event of a breakdown in any of the components, the machine's efficiency decreases or, in some cases, the entire production system halts. One contributing factor to the disruption of multiple production units is the damage incurred by various production support machines, including the "Press Part" roll machine. The press part is responsible for closing the pores or holes in the paper and adjusting its size after undergoing the previous main drying process, which involves drying or evaporation [7]. Within this section, the wet paper web is subjected to compression between two pressing rollers, utilizing hydraulic pressure. The wet sheet is compressed to a pressure exceeding 35 bar, resulting in a moisture content of approximately 35-40% as it exits the pressing section. Upon discharge, the moisture content reaches 65-60%. It is crucial to note that the cost incurred in this section remains relatively low prior to entering the drying area.

## 2. METHODOLOGY

### 2.1. The Investigation Flow Diagram

This study's methodology is qualitative naturalistic research, which emphasises the natural implementation of the situation without manipulation and focuses on providing descriptive insights. Furthermore, as a follow-up to the conducted research, the researchers use an action research approach, working continuously to resolve issues within the factory [8]–[10]. The research design, which employs a case study design, is the dependent variable in this study. This design employs a straightforward research method with a natural context, focusing intensively and extensively on phenomena to develop models. The experimental method is used in the research methodology. Figure 2 depicts a visual representation of the investigation flow diagram.

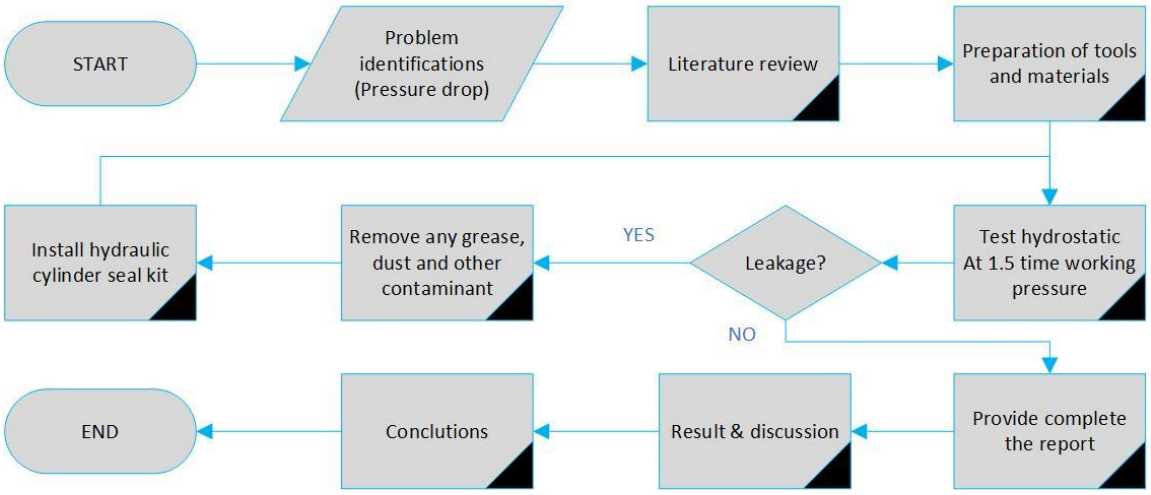


Figure 2. The investigation flow chart

### 2.2. The hydraulic cylinder

The hydraulic cylinder is essential to the FS (Paper Folding and Sealing) machine unit's paper press. The FS machine unit is responsible for folding and sealing paper in various packaging and sealing applications. During the paper press part operation, the hydraulic cylinder delivers the required force to press and compress the wet paper between the two pressing rolls [11]. The hydraulic cylinder employed by the paper press part is designed to withstand high pressures and provide accurate force oversight, resulting in efficient and consistent paper pressuring. It is controlled by a hydraulic system, which regulates fluid

flow and pressure in order to attain the desired degree of enlargement.

A case study approach employs a dependent variable to examine the hydraulic cylinder mechanism to investigate potential damage to the hydraulic system [12]. This design allows for a simple study approach within the context of nature, permitting an intensive and thorough investigation of the issues to create comprehensive representations. The experimentation approach is used in the research, allowing for controlled investigations to assess the achievement and behavior of the hydraulic cylinder system. The researchers hope to understand better how the system works by conducting investigations and collecting relevant data. Figure 3 is included to show the hydraulic operation on the paper group of the part-FS press machine, offering an understandable illustration of the investigational flow of the study.

Figure 3. Opening the hydraulic cylinder process of a part-FS press machine in the paper industry:

### 2.3. Function and Proof Pressure Test

The hydraulic cylinder is mounted on a test stand throughout the function examination, and the hydraulic lines are connected. It is then cycled within its full stroke a minimum of three times. We closely monitor the way the cylinder works throughout these cycles. It will be rejected if the cylinder exhibits erratic behavior, such as excessive chatter, sudden movements (slapstick), stalling, or misalignment that cannot be corrected [13]. This test ensures that the hydraulic cylinder operates smoothly and consistently, meeting security standards and performing as intended.

In order to determine the root cause of the failure in the FS-part press machine, conducting a comprehensive inspection is imperative. This inspection was initiated after receiving an inspection report from the mechanic and production manager, highlighting the damage to the cylinder part of the paper unit roller machine. Before addressing the known issues acknowledged by mechanics and users, a meticulous inspection of the standard manual must be carried out [14]. An integral step within the inspection process entails examining reports provided by mechanics and operators who have identified damage to the part-fs press roller on the cylinder loading machine equipped with a press part roller. Visual inspection plays a

crucial role in assessing the condition of an oil hydraulic cylinder. It involves visually examining the cylinder to detect any indications of damage, wear, or abnormalities [10]. Figure 4 shows the process of function test the hydraulic cylinder.

The hydraulic cylinder function test is followed by the proof pressure test. The cylinder is fully extended in this demonstration, and the pressure remains attained for at least thirty (30) seconds. The pressure being applied is 2500 psi or as specified on the assembly print. We examine the cylinder thoroughly for external leaking or structural distortion. If the cylinder is double-acting, we fully retract it and hold the pressure for another thirty (30) seconds [11]. The applied pressure is 2500 psi, or as specified on the assembly print. During this step, we check for any external leakage or structural distortion once more. During the proof pressure test, cylinders that exhibit external leakage or structural deformation are rejected. This test ensures the hydraulic cylinder can withstand the specified pressure without breaking down, ensuring its dependability and safety under pressure. We ensure that only cylinders that meet the pressure specifications are used in the intended services by rejecting cylinders that fail this examination.

Figure 4. The function test for hydraulic cylinder.

Pressure examinations in the engine roller are carried out using a manometer, a specialized device for closed-tube pressure measurement of liquids or gases. A pressure manometer comprises a clear or strong metal tube with an indicator or needle that displays the measurement indicator [12]. This gauge measures pressure in psi (pounds per square inch). It is critical to ensure the pressure gauge's accuracy to obtain consistent readings of the engine roller's normal oil pressure [15]. Figure 5 depicts the pressure gauge devices used in the proof pressure test process.

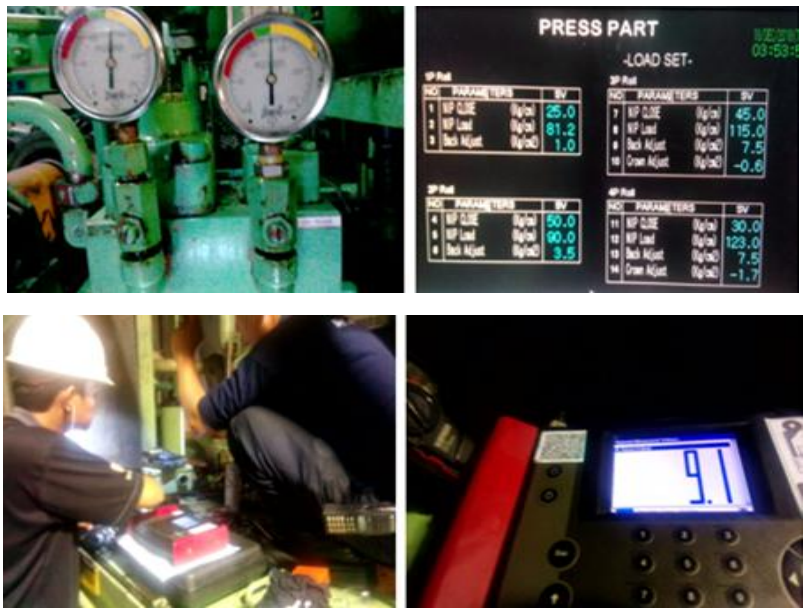


Figure 5. The proof pressure test for hydraulic cylinder.

## 3. RESULT AND DISCUSSION

### 3.1. Hydrostatic Test Analysis

Pressure tests for the hydraulic cylinders were conducted, and 10 cylinders were tested. Each cylinder underwent a pressure test at the specified test pressure set at 10-20 MPa [16]. The objective was to assess the performance and structural integrity of the cylinder under the applied pressure. Of the 10 pressurized cylinders up to 15 MPa, all performed well and could withstand the pressure without any problems. However, on testing at 20 MPa, of the 10 cylinders tested, 7 cylinders (70% of the total) showed good performance, successfully withstanding the pressure without problems. These cylinders showed no external leakage or structural deformation during the test. However, 3 cylinders (30% of the total) did not pass the pressure test and were rejected due to visible external leakage or structural deformation. The test results highlighted that the hydraulic cylinder's compressive section damage lay in the weak roller drive, which reduced the hydraulic cylinder's oil pressure and made the machine unable to drive the rolling section.

### 3.2. Failure Analysis

The hydraulic cylinder pressure test provided helpful information about their performance and integrity. Seventh (70%) of the ten cylinders tested performed well, dealing with the specified pressure of 20 MPa without issue. During testing, these cylinders demonstrated no outside leakage or structural stability distortions, demonstrating their dependability and suitability in hydraulic system design. However, three (30%) cylinders were not accepted and were unsuccessful in the pressure examination. Outside leaks or structural stability distortions were apparent on the rejected cylinders, increasing concerns about their durability and integrity. Outside leaks from these cylinders demonstrated the possibility of problems with their seal piston hydraulic parts, which could result in fluid leakage and hydraulic system inefficiencies [17]. The lack of visible structural distortions on the rejected cylinder demonstrates no design, material integrity, or production procedure issues. The absence of distortion does not affect the cylinder's capacity to withstand pressure and perform during the process.

The piston hydraulic seal is harmed by ageing, wear, and heat. These three variables can all result in localized seal damage. The problem of age is essential because the friction among the hydraulic oil and the shafts and seal leads to the seal to grow brittle and utilized over time. Seals are also subjected to harmful external forces such as extreme temperatures, axial loads, aggressive surroundings, and dangerous chemicals. As a result, when developing the seal, the pressure of the fluid in the entire system, the potential for pressure peak periods, the temperature range, the speed of the rod that drives the piston, the situation of the working surface, and the kind of working fluid must all be considered. On the other hand, damage to the sealed box is caused by aging, rust, and heat caused by hydraulic oil corrosion. The hydraulic fluid and the working environment near the heat source can also generate heat. Seals and seal boxes must be carefully designed to function optimally in various working environments. Figure 6 depicts damage to the piston hydraulic seal.

Figure 6. The Seals endure damage by aging (a), heat (b) and wear (c).

### 3.3. Replacement of seal piston hydrolic

This study analyzed the hydraulic seal system used to prevent leakage from a reciprocating system. The analysis shows that hydraulic seals are divided into four types: piston seals, rod seals, guides, and dust seals. The piston seal is placed inside the piston, while the rod seal is inside the housing. The guide reduces friction between the piston and cylinder, while the dust seal prevents dirt from entering the system. Figure 7 shows the use of seals on a piston.

The installation of hydraulic piston seals is a crucial process in maintaining optimal hydraulic system performance. Seals are installed on the piston of the hydraulic cylinder, and two seals must be installed following established standards. Installation must be done correctly, without rotating the seal, because if the seal is rotated, it can cause leaks in the hydraulic system. Leaks in the piston seals can impair the system's performance and cause operational problems.

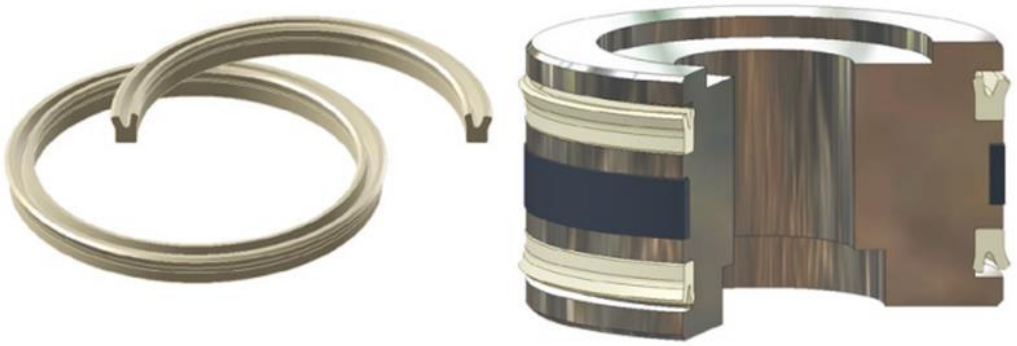

Figure 7. Seals on a piston

Installation of new seals on the piston must adhere to standard procedures and correct techniques to ensure the effectiveness of the seals in preventing leaks and maintaining stable hydraulic pressure. Figure 8 shows the appearance of installing a new seal on the piston neatly and precisely according to the specified standards. In performing the installation, it is necessary to pay attention to the accuracy of the seal position on the piston and avoid twisting, which may damage the seal. Knowledge of the type and characteristics of the seal material is also important so that the seal can function optimally under various operational conditions.

Figure 8. The installing a new seal on the piston

Once all the components have been properly installed, the next stage is to perform a test run and pressure check using a pressure gauge. It is important to ensure that the pressure indicated by the pressure gauge is within the normal range, which is usually between 10 to 20 MPa. This test run aims to ensure that the problem with the hydraulic part roll press has been fully resolved and will not reoccur.

During the pressure testing trials, surveillance is carried out for possible leaks in the seals of the hydraulic part roll press. The findings from this leak examine are critical in ensuring that the seal works

properly as well as ensuring the issue does not reoccur. The findings of pressure and leakage examination on the hydraulic seal roll press part are shown in Figure 9. The findings indicate that the pressure gauge's tension is within the standard range and that there are no leaking in the hydraulic roll press part seal, indicating which the problem with the hydraulic roll press part machine has been addressed. All components and seals are in good working order, and the equipment is ready to be utilized with stable and reliable performance as well.

The basic requirements of a cylinder fluid sealing structure were determined in the present investigation, which included accomplishing the lowest possible coefficient of friction and avoiding near-zero leaking. The significance of appropriate seal development was also highlighted, with seals utilising materials that have suitable modules and hardness. The seal development should also take into account friction and durability against corrosion, ease of manufacturing or disintegration, and the ability to work across a wide range of temperatures.

Figure 9. The testing pressure and leakage checks on the hydraulic seal roll press part

The analysis findings demonstrated the significance of hydraulic seals for maintaining the rotating, moving mechanism leak-free [4]. Piston and rod seals are critical in preventing hydraulic fluid leakage, which can degrade system performance. Guiding also helps to reduce friction between the piston and the cylinder, which improves the system's reliability and longevity [15]. This research emphasizes the significance of selecting the proper material when designing an optimized seal. Materials with appropriate modules and hardness are required to withstand the stresses and friction encountered by the seal during operation. Furthermore, corrosion resistance is critical in guaranteeing the seal performs well in possibly adverse conditions.

In the context of piston rod seals, employing small working solution layers and oils delivers extra advantages in terms of decreasing friction and avoiding piston rod face oxidation. Consequently, a seal design that considers these various factors will guarantee that the hydraulic mechanism functions correctly, lowering the risk of damage and leaks while improving productivity and the service life of the hydraulic parts.

## 4. CONCLUSION

The damage analysis of the hydraulic press part roll system concludes that the aging of the seal causes damage due to contamination of the hydraulic oil with water and dirt. Proper replacement of the hydraulic cylinder seal kit with good preventive maintenance can solve the problem. The hydraulic system has the advantages of being lightweight, easy installation, and low maintenance costs; however, it should be noted that damage to the hydraulic cylinder roller pressure section can occur if the seal does not function properly. Good seal replacement is essential to maintain efficiency and avoid future problems. This analysis provides a reference for hydraulic system designers and users in selecting and designing seals that suit the application requirements and work environment. By understanding the importance of hydraulic seals, the quality and performance of the system can be improved, and the risk of leakage or damage can be

minimized.

## AUTHOR'S DECLARATION

### Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation, and discussion of results. The authors read and approved the final manuscript.

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### Availability of data and materials

All data are available from the authors.

### Competing interests

The authors declare no competing interest.

## REFERENCES

[1] E. Apriani and H. D. Kurniasari, "Pembuatan Kertas Daur Ulang Dari Limbah Serat Kelapa Muda Dan Kertas Bekas Sebagai Alternatif Kertas Seni Untuk Industri."

[2] E. Bohman, "Understanding Buckling Strength of Hydraulic Cylinders The Hydraulics & Pneumatics," *https://www.powermotiontech.com/technologies/cylinders-actuators/article/21887243/understanding-buckling-strength-of-hydraulic-cylinders*, Feb. 10, 2017.

[3] G. Nicoletto and T. Marin, "Failure of a heavy-duty hydraulic cylinder and its fatigue re-design," *Eng Fail Anal*, vol. 18, no. 3, pp. 1030–1036, Apr. 2011, doi: 10.1016/j.engfailanal.2010.12.019.

[4] S. Uzny and Ł. Kutrowski, "Strength analysis of a telescopic hydraulic cylinder elastically mounted on both ends," *Journal of Applied Mathematics and Computational Mechanics*, vol. 18, no. 1, pp. 89–96, Mar. 2019, doi: 10.17512/jamcm.2019.1.08.

[5] A. Jalu Putra Perdana, A. Rijanto, and D. Nizar Zulfika, "Pengaruh Seal Terhadap Tekanan Hidrolis di PT. Kepuh Kencana Arum Mojokerto, Jawa Timur," *Majamecha*, vol. 1, no. 2, pp. 144–155, 2019, doi: https://doi.org/10.36815/majamecha.v1i2.560.

[6] S. A. Nahian, D. Q. Truong, P. Chowdhury, D. Das, and K. K. Ahn, "Modeling and fault tolerant control of an electro-hydraulic actuator," *Int. J. Precis. Eng. Manuf.*, vol. 17, no. 10, pp. 1285–1297, 2016, doi: 10.1007/s12541-016-0153-2.

[7] R. A. Prasetyo and H. Mahmudi, "Analisa Pengaruh Kecepatan Produksi Terhadap Gramatur Pembuatan Kertas," *Jurnal Mesin Nusantara*, vol. 4, no. 2, pp. 108–113, Dec. 2021, doi: 10.29407/jmn.v4i2.17293.

[8] J. Malenje, "Challenges facing Business Process Automation in Public Universities in Kenya," *Journal of Emerging Trends in Computing and Information Sciences*, vol. 5, no. 4, 2014.

[9] A. Sani, "Library Automation Management System Based On Open Source Senayan Library Management System (SLIMS) (Case Study of the Library of H. Bata Ilyas STIE Amkop Makassar)," *Journal of Management & Business*, vol. 1, no. 1, pp. 46–65, 2017, [Online]. Available:

http://www.journal.stieamkop.ac.id/index.php/seiko/article/view/72%0Ahttp://www.journal.stieamkop.ac.id/index.php/seiko/article/download/72/72

[10] M. H. Kurniawan, M. Arif, and K. K. Ayuningtiyas, "Implementation of Making Monitoring Control System (MOS) Applications to Know Cylinder Repair Codes in Paper Production Areas," *Bulletin of Computer Science and Electrical Engineering*, vol. 3, no. 2, pp. 97–105, 2022, doi: 10.25008/bcsee.v3i2.1165.

[11] H. Wang, G. Ma, B. Xu, Q. Yong, and P. He, "Design and application of friction pair surface modification coating for remanufacturing," *Friction*, vol. 5, no. 3, pp. 351–360, Sep. 2017, doi: 10.1007/s40544-017-0185-3.

[12] D. Setiawan, "Analisa Hidrolik Sistem Lifter Pada Farm Tractor Foton FT 824," Universitas Muhammadiyah Surakarta, Surakarta, 2015.

[13] S. Ardi and R. Setiawan, "Analisa Kebocoran Silinder Hidrolik pada Mesin Gravity Casting di Industri Manufaktur," in *Seminar Nasional Politeknik Batam*, 2010, p. 2010.

[14] T. Papatheodorou and P. Hannifin, "Influence Of Hard Chrome Plated Rod Surface Treatments On Sealing Behavior Of Hydraulic Rod Seals," Germany, 2005. doi: https://doi.org/10.1016/S1350-4789(05)00600-8.

[15] T. McBride, "Seals for Hydraulic Cylinders," *The Hydraulics & Pneumatics Article* , Dec. 19, 2021.

[16] P. Luo, J. Hu, and S. Tan, "Design and Realization of Hydraulic Cylinder," *Reg. Water Conserv*. 2017.

[17] W. Bauer, *Hydropneumatic Suspension Systems*, 1st ed. Springer Berlin, Heidelberg, 2011. doi: https://doi.org/10.1007/978-3-642-15147-7.