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Prototype of Composite Material Pressing Tool using an Electropneumatic System A Learning Media

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ABSTRACT

This study aims to analyze the effect of pressure variations on the characteristics of the maximum load and extension of specimens in compression testing. Tests were conducted on five specimens, namely A, B, C, D, and E, with pressure variations of 4, 5, 6, 7, and 8 bar, respectively. All specimens have a thickness and width of 5 × 13 mm and an initial length (L_0) *of 50 mm. The parameters observed include the maximum load* (P_{max}) *and the extension value during the test. The test results show that an increase in pressure from 4 bar to 8 bar is followed by an increase in the maximum load from 55 N to 170 N. Conversely, the extension value decreases from 8.2 mm to 4.3 mm. At pressures of 4, 5, 6, 7, and 8 bar, the maximum loads obtained are 55, 88, 94, 112, and 170 N, respectively, while the extension values are 8,2; 7,8; 6,2; 5,8; and 4,3 mm. These results indicate a tendency for a positive relationship between pressure and maximum load and a negative relationship between pressure and extension under these test conditions. The highest maximum load was obtained at a pressure of 8 bar, while the lowest extension also occurred at that pressure. Thus, pressure variations affect the measured mechanical response of the specimen. However, further interpretation of material strength requires information on the material type, loading method, and test equipment characteristics.*

1. INTRODUCTION

Current developments in manufacturing technology and engineering materials require vocational and engineering education to adapt learning methods to industry needs. One material increasingly used in various industrial sectors is composite materials, according to [1]. Whereas [2] composite materials offer advantages such as high strength, light weight, and corrosion resistance, making them widely used in the automotive, aerospace, shipping, and construction industries. However, the formation and processing of composite materials require a sound technical understanding, particularly regarding the pressing process, which directly impacts the quality of the final product.

In vocational colleges, learning about the composite material pressing process is still dominated by theoretical methods and limited demonstrations. According to [3], the limited availability of representative practical tools is often a major obstacle in the learning process, resulting in suboptimal student understanding of the working principles of the pressing system and its control. Therefore, a learning medium is needed that can simulate and represent industrial processes realistically while remaining safe, economical, and easy to operate.

One solution that can be implemented is the development of a prototype composite material press tool based on an electro-pneumatic system. The electro-pneumatic system is a combination of a pneumatic system as a mechanical actuator and an electrical system as a controller, which has advantages in terms of movement precision, ease of setup, and energy efficiency [4]. The implementation of this system in the form of a learning prototype allows students to

understand the working principles of air pressure, electrical control circuits, and the integration of sensors and actuators directly through practice [5].

The development of this press tool prototype not only serves as a practical tool but also as an interactive learning medium that can improve students' cognitive, affective, and psychomotor competencies [6]. Through the use of this tool, [7] argue that students can learn the concepts of pressure, compressive force, automatic control, and occupational safety aspects within a single, integrated system. This allows learning to be more contextual and closer to real-world industrial conditions.

This study has a novelty in the form of an experimental evaluation of the effect of pneumatic pressure variations of 4–8 bar on two mechanical response parameters simultaneously, namely the maximum load and extension of composite specimens, using an electro-pneumatic composite press. Different from studies that only focus on the pressing process or the ability of the tool to produce compressive force, this study relates changes in operating pressure to the mechanical response of the specimen measured during compression testing. Tests were conducted at five pressure variations, namely 4, 5, 6, 7, and 8 bar, to identify the trend of the relationship between operating pressure and specimen response during compression testing. Based on this background, this study aims to design and develop a prototype of a composite material press tool using an electro-pneumatic system as a learning medium and produce composite material molds according to the desired standards using an electro-pneumatic system press tool. It is hoped that the results of this study can contribute to improving the quality of practical learning in the fields of mechanical and manufacturing engineering, as well as being an alternative solution in providing effective, efficient, and applicable teaching aids in engineering education environments.

2. RESEARCH METHOD

The research on the Prototype of a Composite Material Press Tool Using an Electro-Pneumatic System as a Learning Medium was conducted at the Workshop of the Machine Maintenance Engineering Study Program of the Bantaeng Manufacturing Industry Community Academy which has pneumatic and electrical system practice facilities. The location was selected based on the availability of supporting equipment such as air compressors, electrical panel devices, metal fabrication equipment, and pneumatic circuit simulation software needed in the design and testing process of the tool. This research was conducted over a period of approximately 6 months, which was divided into several stages of activity, namely literature study, design, manufacturing and assembly of the press tool prototype, functional testing of the tool and feasibility test as a learning medium. With a structured time allocation, it is expected that all stages of the research can run systematically and produce an optimal tool prototype both from a technical and pedagogical perspective.

Figure 1. Preparations made in the process of making a prototype of the tool

2.1 Preparation of tools and materials

The tools used in this research include design, assembly, and testing of prototype press tools based on an electro-pneumatic system. These tools include, computers it is used to design press tools, create 2D/3D engineering drawings, and simulate pneumatic and electro-pneumatic circuits using software such as Autodesk Fusion 360, SolidWorks, or FluidSIM 4.2 [8]. Computers also serve as a medium for documenting and analyzing research data. Mechanical fabrication equipment, electric welding machines for joining steel frames, drilling machines for making bolt holes and component mounts, hand grinders for cutting and grating metal materials and hacksaws as an alternative to manual cutting [9]. Testing equipment, pressure gauge to read air pressure in the system and stopwatch to measure actuator response time as system performance evaluation system. The materials used in this study consist of mechanical materials, pneumatic system materials, electrical system materials, and composite test materials. Mechanical materials, hollow iron as the main frame of the press tool, steel plate as the press table and mold holder, bolts and nuts as component fasteners and springs as additional mechanical return components. Anti-rust paint for coating the frame to resist corrosion and enhance the aesthetics of the learning media. Pneumatic system materials pneumatic double acting cylinder as the main actuator for compressing composite materials, air compressor as a source of pneumatic energy, Pneumatic hose for pressurized air distribution, Solenoid valve 5/2 or 4/2 to control the direction of air flow in the cylinder, pressure regulator to regulate the working pressure. Filter and Lubricator to filter air and maintain component life as well as Fittings and connectors for hose connections [10]. Electropneumatic system materials, power Supply 12V/24V DC as a power source for the control system, Push Button as a manual control input, Limit Switch/Proximity Sensor to detect

cylinder position, relay as a logic controller for the automatic system, electrical cables and terminal blocks as current conductors, Panel Box as a place for the control circuit to be safe and neat and Indicator Lamp as a marker for the working status of the tool. Composite materials natural fiber as a composite reinforcement, epoxy as a fiber binding matrix, catalyst for the resin hardening process, release agent to prevent sticking to the mold and glass mold as a form of composite product to be pressed. The fiber preparation stage involves cleaning the coconut fiber from dirt and any remaining material. The fibers are then separated from the husk, washed, and dried to reduce the water content that could affect the bond between the fibers and the matrix. The composite matrix is prepared according to the type of resin used in the study. During the manufacturing process, the fiber distribution is ensured to be even to create a relatively homogeneous composite structure and minimize void formation.

2.2 Design

Below are several steps in designing an electro-pneumatic press tool is determining needs by determining what will be produced or processed using an electro-pneumatic press to understand the specific needs of the tool to be designed, Concept design is first, create an initial concept design for the pneumatic press. This includes selecting the appropriate type of pneumatics, such as a pneumatic cylinder or other pneumatics, as well as other components such as air control valves and pressure regulators. Modeling and simulation using CAD (Computer-Aided Design) software, namely Solidworks 2017, to model your pneumatic press in detail. Perform simulations to ensure that the design performs as expected and meets all performance requirements according to [11]. Material selection: First, choose the right material for making an electro-pneumatic press. The material must be sturdy and resistant to high pneumatic pressure and the environmental conditions where the tool will be used, according to [12].

2.3 Manufacturing and assembly process

The manufacturing and assembly process for a pneumatic press can involve several stages, including component fabrication, which involves assembling the press components according to the design. This can include pistons, pneumatic cylinders, control valves, frames, and other components. Ensure tolerances and dimensions meet required specifications. Assembly involves assembling the components according to the design. Ensure all parts are properly and securely installed. The electro-pneumatic system is assembled by installing a pneumatic system consisting of an air compressor, pressure regulator, control valve, and air hose according to the specifications required by the press. Testing is carried out to ensure that the pneumatic press is functioning properly. Test the pressure strength, speed, and accuracy according to application requirements.

2.4 Functional testing of the tool

Functional testing of the tool is a crucial step in the research of a prototype composite material press tool based on an electro-pneumatic system. [13] argue that functional testing of the tool aims to ensure that all mechanical, pneumatic, and electrical components operate as designed and are capable of carrying out their primary function as a practical learning tool. The testing not only assesses the tool's operation but also its consistency, safety, and ease of use by students. This includes checking air pressure, the stability of the compressor's air supply, the performance of the pneumatic cylinder when reversing, and detecting leaks in hoses and connections. At this stage, it is observed whether the resulting pressure force is sufficient to carry out the composite material pressing process. This includes testing switches, push buttons, relays, solenoid valves, and control circuits. Ensuring that the electrical signal can activate the pneumatic actuator precisely and sequentially can be tested through simulations of compressing composite materials with certain pressure variations. The alignment of the actuator movement, the stability of the frame, and the surface finish of the material after pressing are observed [14]. FluidSIM 4.2 works by modeling system components based on their symbols, characteristics, and functional relationships. Before the circuit is directly assembled, all components are first arranged in a simulation environment according to the designed circuit diagram. Next, a simulation is run to verify that each component functions as intended and that the system's working sequence conforms to the desired operating principles.

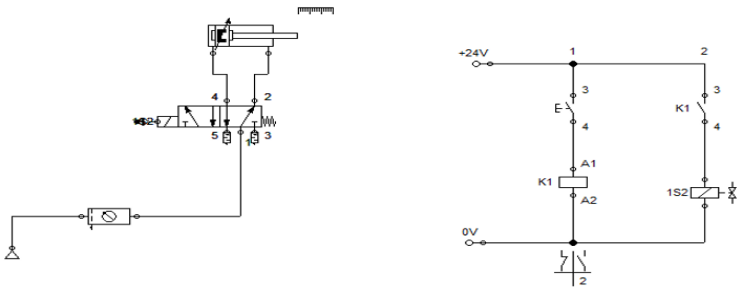


Figure 2. Pneumatic circuit simulation using fluidSIM 4.2 software

2.5 Equipment suittability test

The specimens used in this study have cross-sectional dimensions of 5 × 13 mm and an initial length (L_0) of 50 mm. The cross-sectional dimensions are used to determine the initial cross-sectional area of the specimen, while the initial length is used as a reference to observe changes in the length of the specimen during the compression test. The initial cross-sectional area (A_0) is calculated based on the multiplication of the width and thickness of the specimen, assuming that the cross-section is rectangular. The ratio of the fiber and resin mixture is based on the mass fraction the percentage of each material is calculated based on the total mass of the mixture. Where the composition of 30% fiber and 70% resin means that from a total mixture of 100 grams, 30 grams of fiber and 70 grams of resin are used. Compressive strength values range from 75–85 MPa depending on the type of fiber and resin used, with a relatively consistent strength distribution between specimens. Assess the performance of the tool during use, including frame stability, pneumatic cylinder compressive strength, electrical control system response, and consistency of composite material pressing results according to [15]. A tool is considered suitable if it can operate stably over several cycles of use without damage. This includes the presence of an emergency stop button, mechanical protection, electrical cable insulation, and a safe operator distance. This aspect is crucial because the tool is used by students who are still in the learning stage.

3. RESULT AND DISCUSSION

This research aims to design and develop a prototype of a composite material press tool based on an electropneumatic system that can be used as a learning medium in engineering education environments. The prototype is designed to be able to carry out the pressing process with stable pressure, easy operation, and introduce the components and working principles of pneumatic systems and automatic controls to students. In addition, this research aims to determine the quality of the composite material printing results processed using a press tool based on an electro-pneumatic system. This tool is designed to provide pressure automatically and controlled during the composite material pressing process, in order to produce homogeneous, dense, and defect-free printed products. To enhance safety during testing, the lab equipment is equipped with an Emergency Stop safety system. This button quickly stops the equipment in the event of an abnormal condition, such as overloading, sudden specimen damage, shifting of the mold, or potential hazards to the operator. The Emergency Stop button is placed within easy reach of the operator during testing.

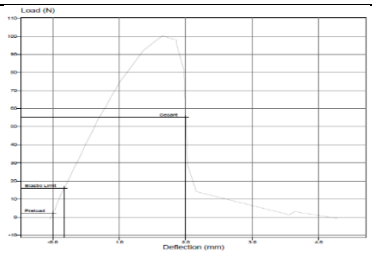
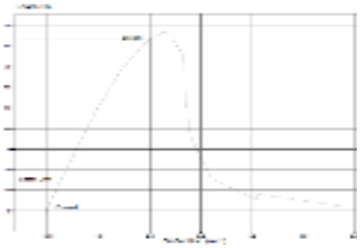
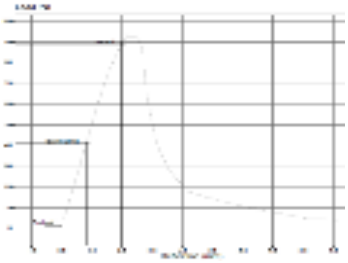
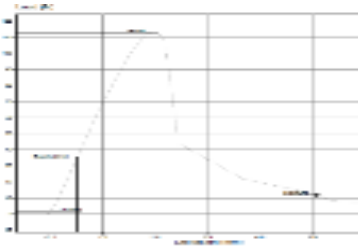
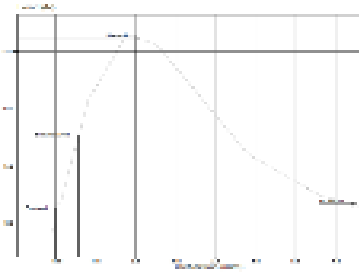
This research produced a prototype of a composite material press tool based on an electro-pneumatic system that functions well and can be used as a learning medium in engineering, particularly manufacturing and automation engineering. The developed prototype consists of main components such as a pneumatic cylinder, solenoid valve, pressure sensor, electrical control circuit, and a mechanical frame system designed to withstand pressure loads during the pressing process [16]. Based on functional tests, this tool is capable of producing a working pressure of up to 8 bar which can be automatically controlled through an electro-pneumatic system. As a learning medium, this tool provides high educational benefits because it can introduce students to the working principles of pneumatic systems, control logic, and the composite material manufacturing process directly. According to [17] students can learn the relationship between pressure, pressing time, and print results in a practical way. In addition, this prototype encourages project-based learning and integrative understanding across engineering disciplines. This electro-pneumatic press tool has been proven to be usable as a practical and experimental tool in the Pneumatic Laboratory of the Machine Maintenance Engineering Study Program, AK-Manufaktur Bantaeng, as well as an aid in teaching the theory and application of modern manufacturing technology. The design of a composite material press tool prototype based on an electro-pneumatic system was successfully completed with results in accordance with the initial goal, namely to create a functional, educational, and applicable learning tool.

The composite material molding results showed good quality with uniform material density and density. The pressing process was stable with adjustable cycle times as needed, and the tool demonstrated consistent performance across multiple tests. Research [18] found that the composite material pressing process using an electro-pneumatic system-based press produced molded products that met the expected standards, both in terms of dimensions, strength, and surface quality. This press was able to provide stable and even pressure across the entire mold surface, so that the resulting composite material structure showed density. Based on Table 1, a graph of the composite material compression test results obtained from testing using a prototype electro-pneumatic system press tool, the relationship between the compression force (N) and changes in material thickness or deformation (mm) and compressive stress (MPa) is visible. [19] argued that the graph generally shows a pattern of increasing compression force followed by a gradual decrease in material thickness until reaching the maximum load point. In the initial stage of testing, the graph shows a linear increase, indicating that the composite material is still in the elastic phase. In this phase, the material structure is still able to return to its original shape after the pressure is released. As the pressure from the pneumatic actuator increases, the graph begins to show a change in the slope of the curve, indicating that the material is entering the plastic phase, where permanent deformation begins to occur.

The available data cover five stress conditions, each represented by one specimen (A–E), for a total of five specimens and one measurement per stress level. These data are sufficient to indicate initial trends, but not sufficient to statistically assess interspecimen variation. Conformity to ASTM D695 cannot be confirmed from this table alone. The material type, specimen geometry, loading rate, and test procedure need to be verified. In addition, pressures of 4–8 bar should be described as treatment pressures. The test used five pressure variations at 1 bar intervals. Based on the data, increasing

the pressure from 4 to 8 bar increased the maximum load from 55 N to 170 N, while the extension decreased from 8,2 to 4,3 mm. These results indicate a trend toward increased load-bearing capacity and decreased measured deformation with increasing treatment pressure.

Table 1. Graph of composite material compression test results

Specimen	Pressure	Thickness width (mm)	Initial length L_0 (mm)	Max load P_{max} (N)	Extension (mm)	Compression test results graph
A	4 Bar	5x13	50	55	8,2	
B	5 Bar	5x13	50	88	7,8	
C	6 Bar	5x13	50	94	6,2	
D	7 Bar	5x13	50	112	5,8	
E	8 Bar	5x13	50	170	4,3	

The table above can be used to analyze the material's maximum compressive strength. If the graph shows a significant increase in compressive force before failure, it can be concluded that the composite has a good fiber and matrix structure. Conversely, if failure occurs at low pressure, there may be an imperfection in the molding process [20]. Higher pressure

can reduce voids by densifying the material and helping to remove air trapped during the fabrication process. Reducing voids reduces stress concentration and the potential for crack initiation within the composite. Pressure can improve matrix-fiber interfacial contact, resulting in more effective load transfer from the matrix to the fibers. Good interfacial bonding can reduce the risk of debonding and improve the composite's ability to withstand compressive loads. Increased compaction can improve matrix distribution and reduce interfiber gaps, resulting in a more homogeneous composite structure capable of more evenly distributing stress. The maximum load increased from 55 N at 4 Bar to 170 N at 8 Bar. However, the reduction in voids and the improvement in matrix-fiber bonding quality are still suspected mechanisms, not confirmed facts without microstructural observations or porosity measurements. The overall suitability of a device cannot be determined solely based on load and deformation data. The final assessment should include pneumatic system safety, sensor accuracy, repeatability of results, ease of operation, and user response. For practical purposes, the priority before students use device is to ensure the system has a pressure regulator, safety valve, connections appropriate for the operating pressure, guards for moving parts, and a safe pressure relief procedure.

4. CONCLUSION

This research successfully designed and realized a prototype of a composite material press tool based on an electro-pneumatic system as a learning medium. The developed tool is capable of carrying out the pressing process with pressure that can be controlled automatically, demonstrating stable and efficient performance in pressing composite materials. The integration of the electro-pneumatic system not only increases the effectiveness of the work process, but also provides an applicable and interactive learning experience for students in understanding the working principles of actuators, sensors, controls, and automatic circuit logic. Test results show that the prototype is capable of compressing material evenly and allows users to study technical parameters such as working pressure, cycle time, and automatic control. This tool is suitable for use as a practical medium for courses related to pneumatic systems, manufacturing, and materials engineering. In the future, further development can be focused on improving control precision, operational safety, and integration with digital monitoring systems.

In this phase, the relationship between load and deformation is proportional, meaning that the composite can still return to its original shape after the load is released. As the compressive load increases, the graph shows a yield point or elastic limit, where the material begins to enter the plastic phase. At this stage, strain increases more significantly than stress, which indicates the occurrence of permanent deformation in the composite structure. The peak of the graph indicates the maximum compressive stress, which is the greatest load that the material can withstand before failure. Overall, the results of this graph illustrate that composite materials have the ability to withstand relatively high compressive loads up to a certain limit, according to the characteristics of the fiber and matrix structure. The maximum compressive strength values obtained from this graph serve as an important reference in determining the application of composite materials in structures requiring high compressive strength.

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REFERENCES

[1] N. B. Sriyanto, D. A. Munawwaroh, A. Hidayat, and D. A. Baskara, “Analisis Uji Kinerja Mesin Pencetak Briket Serbuk Kayu Gargajian dengan Sistem Pneumatik,” *J. Mech. Eng. Appl. Technol.*, vol. 1, no. 2, pp. 13–18, 2023.

[2] J. V. Tuapetel and R. Narwalutama, “Perencanaan sistem pneumatik sebagai penggerak pada pintu gerbong kereta,” *STRING (Satuan Tulisan Ris. dan Inov. Teknol.*, vol. 6, no. 3, pp. 244–253, 2022.

[3] D. Oktavitasari, H. Witjahjo, and K. B. Rosadi, “Prototype Mesin Tekuk Plat dengan Sistem Pneumatic untuk Praktik Pembelajaran,” *J. Infotex*, vol. 2, no. 1, pp. 270–285, 2023.

[4] M. I. Azhari, F. Maghfurah, and R. Dewi, “Rancang Bangun Mesin Press Sablon Topi Menggunakan Sistem Pneumatik Dengan Silinder SC63X250,” *Pros. Semin. Nas. Penelit. LPPM UMJ*, vol. 087, no. UMJ-ST, pp. 1–8, 2023.

[5] T. R. Y. Muhammad Syafrun,Hammada Abbas, Fadhli Rahman, “Modifikasi Mesin Pembersih Kerak Oli Otomatis dengan Sistem Pneumatik,” *AL-GAZALI J. Mech. Eng.*, no. 29, pp. 62–69, 2023.

[6] F. B. Johannes Munintja Mawa, Adriyan Warokka, “Kaji Eksperimen Alat Angkat Bantu Kerja (Sistim Pnuematik) Untuk Lepas / Pasang Roda Kendaraan,” *Pros. Semin. Nas. Prod. Terap. Unggulan Vokasi Politek. Negeri Manad.*, vol. 1, no. 1, 2022.

[7] A. Halim *et al.*, “Rancang Bangun Mesin Press Limbah Oil dan Fuel Filter (B3),” *Pros. Semin. Nas. Teknol. Ind. X 2023*, vol. X, pp. 357–362, 2023.

[8] B. Sugiyanto, N. Bahri, N. Manurung, B. Ginting, and A. H. Sebayang, “Rancang Bangun Prototype Alat Pemipih Emping Jagung dengan Sistem Pneumatik,” *J. Teknol. Pertan. Gorontalo*, vol. 9, no. 2, pp. 36–44, 2024.

[9] I. Koto, S. R. S. Arya Sinaga, A. P. Simatupang, and H. A. A. Al-Azwari, “Uji Kinerja Mesin Pembuka Buah Nangka dengan Menggunakan Sistem Pneumatik,” *Cakrawala Didakt.*, vol. 1, no. 1, pp. 13–19, 2025.

[10] A. Kurniawan and H. Porawati, "Sistem Elektro Pneumatik Modul PLC 3 Silinder Kerja Ganda Gerak Berlawanan," *INOVATOR*, vol. 3, no. 1, pp. 25–30, 2020.
[11] Y. S. A. Elvis Adril, Asmed, Fardinal, "Perancangan Mesin Press Tahu Sistem Pnuematik dengan Kapasitas 50 Kg," *J. Tek. Mesin*, vol. 12, no. 2, pp. 130–133, 2021.
[12] R. W. dan R. W. Nazar Amir Saputra, "Rancang Bangun Sistem Otomasi pada Mesin Espresso dengan Sistem Pneumatik Berbasis Arduino Uno," *Momentum*, vol. 18, no. 2, pp. 76–82, 2022.
[13] K. Pramudya *et al.*, "Rancang Bangun Wheelchair Lift Alat Bantu Penyandang Disabilitas," *J. Transp.*, vol. 23, no. 2, pp. 83–92, 2023.
[14] C. S. C. Yudistira, Yeremia, "Otomatisasi Sistem Penggerak Electropneumatic pada Mesin Gerinda Potong," *J. Tekno Mesin*, vol. 10 N0 1, pp. 9–15, 2023.
[15] I. Taufik, N. Hidayah, R. W. Idayanti, T. P. Rahayu, and C. Fatikhin, "Konfigurasi Mesin Press Permen Ternak Otomatis Berbasis Sistem Pneumatik dengan Tiga Aktuator Double Acting Cylinder," *Sci. J. Mech. Eng. Kinemat.*, vol. 7, no. 1, pp. 1–8, 2022, doi: 10.20527/sjmekinematika.v7i1.208.
[16] M. Given and S. Liston, "Analisa Sistem Pneumatik pada Power Takeoff (PTo) yang Digunakan pada Mesin Mobil Pemadam Kebakaran Batasan Masalah Penelitian ini," *Zo. Mesin*, vol. 14, no. 3, pp. 28–37, 2024.
[17] S. S. U. Ria Gazali, Lukas Fedianto, M. Ganda Arya Permana, "Perancangan Modul Latih Elektro Pneumatic Berbasis PLC," *J. ELEKTRO Inform. SWADHARMA SWADHARMA*, vol. 02, pp. 49–54, 2022.
[18] Y. Agustina, Dwi, "Penggunaan Elektro Pneumatik dalam Efisiensi Waktu Pemotongan Kentang Berbasis Programmable Logic Controller," *Innov. J. Soc. Sci. Res.*, vol. 4, pp. 7378–7387, 2024.
[19] M. Ikhsan and Z. Razi, "Rancang Bangun Konstruksi Alat Pencetak Biobriket," *J. MESIN SAINS Terap.*, vol. 5, no. 2, pp. 2–6, 2021.
[20] M. K. Mawa, Johannes, "Perancangan Alat Pelepasan Pegangan Galon Aqua 19 Liter Menggunakan Sistem Pneumatik Pada PT . Hon Cuan Indonesia Manado Plant," *J. Mas. Nipake e-ISSN*, vol. 5, no. 1, pp. 59–71, 2025.