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Multi-Function Press Machine Pressing, Angle Bending, and Radius Bending

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ABSTRACT

The multifunctional press machine is an innovation designed to support metal fabrication processes with three main capabilities: pressing, angle bending, and radius bending. This machine can be used for steel plates with a thickness of 1–5 mm and a width of up to 800 mm, equipped with a hydraulic system to produce precise and stable pressure. The design process includes the design of main components, material selection, and performance testing to ensure optimal results. This machine aims to improve production efficiency, reduce waste, and produce high-quality products that meet the needs of education and industry, particularly at the University of Riau Kepulauan. Testing showed that the machine is capable of producing angle and radius formations with high accuracy. Its applications cover the automotive, manufacturing, and construction sectors, making it a multifunctional tool relevant for education, research, and small to medium-scale production.

KEY WORDS: *Multifunctional press machine, angle and radius bending, efficiency and precision*

NOMENCLATURE

F: Maximum pressing force (N or kgf)
UTS: Material tensile strength (Ultimate Tensile Strength) (MPa or kg/mm²)
L: Length of the workpiece plate (mm)
T: Thickness of the plate material (mm)
R: Bending radius (mm)
W: Die opening distance (mm)
K: Constant factor (depending on the type of die)
σ: Material stress (MPa or N/m²)
P: Hydraulic pressure (bar or MPa)
D: Hydraulic cylinder diameter (mm)
h: Material height after forming (mm) Critical Strain

1.0 INTRODUCTION

Technological advancements in the field of metal fabrication engineering have driven innovations in tools and machines to enhance efficiency and precision in manufacturing processes. One such innovation is the development of a multifunctional press machine capable of performing three main processes: pressing, angle bending, and radius bending. This machine is designed to meet the needs of both industry and education, specifically in shaping sheet materials with specific specifications. The multifunctional press machine plays a vital role in material forming processes, such as shaping steel plates commonly used in the automotive, construction, and manufacturing industries. The machine excels in its flexibility to handle various plate thicknesses, ranging from 1 to 5 mm, with a maximum width of 800 mm. The pressing and bending processes utilize a hydraulic system to ensure stable pressure, resulting in high accuracy and optimal quality outcomes.

In the industrial world, the demand for multifunctional tools continues to grow. Such machines not only save time but also reduce operational costs by combining multiple functions into a single tool. For example, angle and radius bending typically require different machines; however, this machine can perform both functions in one integrated workflow. This becomes an added value for small and medium enterprises that have limited resources and workspace. On the other hand, in technical education, especially in universities such as the University of Riau Kepulauan, this machine provides significant benefits. Mechanical Engineering workshops require tools capable of accommodating various practical needs, ranging from simple material forming to more complex analyses of material properties post-forming. The multifunctional press machine not only serves as a learning tool but also supports research relevant to industrial needs, such as testing material properties after bending and pressing processes.

The flexibility of this machine is crucial for producing various plate shapes, from sharp angles and small radii to more complex forms. These forming processes require controlled and consistent pressure, which can be adjusted using the machine's hydraulic control system. This capability adds value for industries needing high-quality products with tight dimensional tolerances, such as in automotive component manufacturing,

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construction equipment, and various other manufacturing applications. In addition to its flexibility, another advantage of this machine is its ability to enhance efficiency and reduce material waste. In conventional manufacturing processes, different tools are often required for each type of forming, which not only consumes time but also increases the risk of product defects. The multifunctional press machine addresses this issue by simplifying workflows and enabling faster production with consistent results.

In the education sector, this machine offers students the opportunity to gain a deeper understanding of the working principles of metal fabrication machines and material properties. Through hands-on practicals, students can learn about material deformation processes, the impact of pressure on metal structures, and quality testing of formed products. This not only enriches their learning experience but also prepares them to face challenges in the workforce. The development project for this machine at the Mechanical Engineering Workshop of the University of Riau Kepulauan aims to create an efficient, practical, and reliable tool. The design process involves analyzing industrial and educational needs, selecting appropriate materials, and conducting performance tests to ensure optimal results. The machine is designed to be user-friendly and easy to maintain, with key components that can be replaced as needed.

Overall, the development of this multifunctional press machine not only provides practical solutions for metal fabrication processes but also opens opportunities for further research and innovation. This machine is expected to become a valuable asset for both education and industry, particularly in improving efficiency, productivity, and quality of work outcomes. By combining pressing, angle bending, and radius bending functions, this machine offers flexibility and precision that are difficult to match by conventional machines. The successful implementation of this machine is anticipated to serve as an example of how fabrication technology can be applied to address practical needs across various sectors. This machine is not merely a tool but an innovation that makes a tangible contribution to the advancement of technical education and the strengthening of technology-based industries in Indonesia.

1.1 Research Objectives

This study aims to develop and evaluate the performance of a multifunctional bending machine capable of performing angle bending, radius bending, and pressing on metal plates of various thicknesses. The machine is designed to support manufacturing, automotive industries, and academic activities at the Mechanical Engineering Workshop of Universitas Riau Kepulauan.

Specifically, this research aims to:

1 Design and optimize the multifunctional bending machine for greater efficiency and precision.
2 Analyze the quality of bending results based on pressure, speed, and material type.
3 Identify key factors affecting the success of the bending and pressing processes.
4 Evaluate the potential application of this machine in industrial and educational settings.

The findings of this research are expected to enhance the efficiency of metal plate forming processes and serve as a reference for the development of similar technologies in both industry and academia.

1.2. Scope of Research

This study focuses on the development and analysis of a multifunctional bending machine capable of performing angle bending, radius bending, and pressing on various types of metal plates. The discussion includes the design and specifications of the machine, covering material selection, key components, and working mechanisms to ensure optimal performance. Additionally, the study examines the material forming process by considering bending and pressing methods, as well as factors influencing the final outcome, such as plate thickness, material type, and applied pressure.

In terms of performance, this research evaluates the machine's efficiency, accuracy, and durability through a series of tests to assess its effectiveness under different operational conditions. Furthermore, it explores the potential application of the machine in industrial settings, particularly in the automotive and manufacturing sectors, as well as its role as a learning and research tool in academic environments. With this scope, the study aims to provide a comprehensive understanding of the design, functionality, and benefits of the multifunctional bending machine in various

1.3. Advantages, Efficiency, and Impact of Using Multi-Function Press Machines

The multifunctional press machine offers many advantages, including high precision in the forming process, flexibility in producing various shapes, and efficiency in terms of time and cost. This machine helps reduce material waste due to its accurate and controlled processes. Additionally, its durability ensures that the machine can be used long-term with minimal maintenance.

The efficiency of this machine not only supports cost reduction in production but also enhances industrial productivity. Its impact extends across various sectors, from improving the quality of work outcomes to developing the technical capabilities of the workforce. In the educational context, this machine makes a significant contribution to training students to face the challenges of modern industry, resulting in graduates who are ready for work and innovative.

1.4. Planning

Design is a fundamental stage in planning programs or systems, aimed at providing clear and detailed instructions for programmers and technicians involved in the process. This phase includes defining the structure, specifying components, and identifying potential constraints that may arise during implementation. Various techniques are also employed to comprehensively outline the tasks to be performed.

SolidWorks is a software application used for designing products, machines, and tools. It was first introduced in 1995 as a competitor to other CAD programs such as Pro-Engineer, NX Siemens, I-Deas, Unigraphics, Autodesk Inventor, AutoCAD, and CATIA. The company behind SolidWorks, SolidWorks Corporation, was established in 1993 by Jon Hirschtick and a team of professional engineers with the goal of developing 3D CAD software. Headquartered in Concord, Massachusetts, the company launched its first product, SolidWorks 95, in 1995 (Imam Sungkono, 2019).

Some advantages of using SolidWorks for engineering design are as follows:

1. The software has an interface that is relatively easy to use

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2. It helps minimize errors in the design process.
3. It allows for direct simulation of the design's motion.

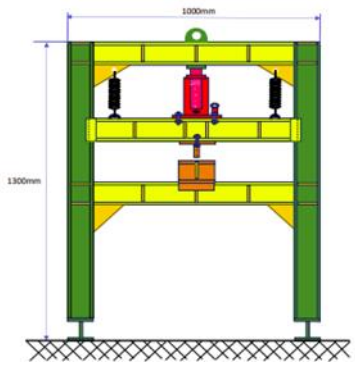

Figure 1: Multi Function Press Machine

2.0 METHODOLOGY

The research method used in the design and development of the Multifunction Bending Machine was carried out through an experimental approach focused on tool development. This study began with the identification of the problem, which was the need for a tool capable of pressing, bending angles, and bending radii in a multifunctional manner. In this stage, the author conducted an in-depth study on the technical requirements and the application of the tool in the Mechanical Engineering Workshop. The next stage was the machine design process. The initial design was created by considering the dimensions of the material to be bent, specifically thickness ranging from 1 to 5 mm and a width up to 800 mm. The choice of materials, such as ASTM A36 steel, was made to ensure the tool's durability and efficiency. The Design for Manufacturing and Assembly (DFMA) principle was applied to facilitate the production and assembly process of the components.

The production process involved several technical steps, such as material cutting using a saw machine, component forming with drilling and grinding machines, and joining through welding techniques. Once all components were assembled, the machine prototype was tested to evaluate the conformity of the bending results with the specified technical specifications.

This testing also included an evaluation of the material's durability and the performance of the components when the machine was used for various forming processes. Data collection was done both quantitatively and qualitatively. Quantitative data included measurements of the bending dimensions, material strength, and pressure applied by the machine. Meanwhile, qualitative data was obtained through observations of the material's condition after the forming process. Research instruments used included measuring tools to check the accuracy of the results, as well as material testing devices such as tensile tests and hardness tests.

The analysis was carried out by comparing the machine's performance with the initial design specifications. The evaluation focused on the machine's work efficiency, result accuracy, and the changes in material properties such as hardness, tensile strength, and microstructure after the forming process. The analysis results were used to provide recommendations for improving and optimizing the machine to better meet user needs.

2.1 Multifunctional Press Machine Concept

The concept of this research is based on the development of a Multifunction Bending Machine, a tool designed to meet the needs of metal material forming processes, particularly for applications involving pressing, bending angles, and bending radii. This concept arose from the need for a tool that can provide high precision results and better work efficiency, both for industrial and educational purposes. The machine is designed to handle metal plates with thicknesses ranging from 1 to 5 mm and widths up to 800 mm, commonly used in the automotive industry, manufacturing, and mechanical engineering practical work. In general, the concept of this tool integrates several functions in one machine, minimizing the need for additional tools and increasing production efficiency. With a system that adopts either hydraulic or mechanical mechanisms, the machine can generate sufficient pressure to form materials as needed.

In its implementation, this machine is built based on the Design for Manufacturing and Assembly (DFMA) principle. This principle aims to simplify the design, streamline the manufacturing process, and enhance assembly efficiency. The primary material used is ASTM A36 steel, chosen for its high strength and ease of forming and welding. Components such as dies, punches, and the hydraulic system are designed to provide flexibility and precision in the bending of angles and radii.

The machine's operation involves applying controlled pressure to the material to shape it according to the desired design. This concept not only prioritizes the precision of the results but also considers changes in material properties due to deformation, such as hardness, tensile strength, and microstructure. Thus, this concept encompasses technical, material, and result analysis aspects to ensure the tool operates optimally according to user needs. Overall, the concept of the Multifunction Bending Machine is oriented towards efficiency, flexibility, and reliability, making it not only relevant for industrial applications but also an ideal tool to support research and learning in the field of mechanical engineering.

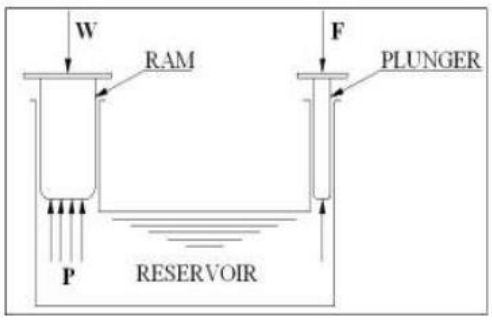

Figure 2: Hydraulic Press Machine Concep

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3.0 RESULTS

This section presents the findings obtained from the research and analyzes the results based on the data collected. The discussion aims to interpret the findings, compare them with previous studies, and evaluate their implications in the relevant field.

The results of this study demonstrate the performance of the multifunctional bending machine, particularly in terms of accuracy, efficiency, and material adaptability. The machine successfully performs angle bending, radius bending, and pressing on metal plates of varying thicknesses. The tests indicate that the machine operates efficiently with a high level of precision, producing bent metal plates with minimal deformation and defects. These findings align with the study conducted by Imam Sungkono (2019), which emphasizes the importance of accurate bending processes in industrial applications.

In terms of structural integrity, the machine's frame and hydraulic system provide sufficient force to bend materials with a thickness ranging from 1 mm to 5 mm, as designed. The evaluation further highlights that the applied pressure must be carefully calibrated to prevent excessive stress on the material, which is consistent with previous studies on material forming and mechanical stress analysis (Boothroyd et al., 2002).

Moreover, the study identifies key factors influencing the bending process, including material type, thickness, bending angle, and applied force. These factors directly impact the final product quality, as variations in material properties can lead to differences in bending resistance. According to Wiryosumarto & Okumura (2000), the bending radius and the applied force must be carefully controlled to maintain uniform deformation and avoid material failure.

Additionally, the machine's performance was assessed in industrial and academic settings, revealing its potential applications in automotive manufacturing, mechanical workshops, and university research projects. The integration of this machine into educational environments aligns with previous research that highlights the importance of hands-on training using computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies (Bohnart, 2018).

3.1. Manufacturing Tools

1. Drilling Machine

The drilling machine is used to create holes in metal components according to the design requirements. This process utilizes a drill bit (twist drill) selected based on the desired hole size. In the manufacturing of the bending machine, the drilling machine is used to drill the main frame and supporting components to facilitate the assembly process. The challenge in using the drilling machine is ensuring the hole's position and depth are accurate according to the design, so the components can be assembled perfectly.

2. Grinding Machine

The grinding machine is used to smooth metal surfaces, remove cutting residues, and prepare materials before welding or coating processes. In this process, polishing and cutting grinding wheels are used to achieve precise finishing. This machine is also used to ensure that interconnected components have flat surfaces so they can operate optimally.

3. Cutting Machine

The metal cutting machine is used to cut ASTM A36 steel material according to the required dimensions. Cutting is done on the main frame, mechanical components, and steel plates. Automatic cutting machines are often used due to their ability to produce high-precision cuts with good consistency.

4. Welding Machine

Welding is an important process for joining metal components, particularly in the main frame and machine support structure. The molten welding technique with E6013 electrodes is commonly used due to its ability to produce strong, durable joints. This process is performed carefully to ensure that the welds are free from cracks or defects that could affect the machine's structural strength.

5. Painting Tools

After the components are assembled, the machine undergoes a coating process to protect the material from corrosion and to provide an aesthetic appearance. This process involves several stages, including cleaning the material, applying an anti-corrosion primer, and the main painting with enamel or epoxy paint. This step is crucial to ensure the machine's durability in various environmental conditions.

6. Bench Vise

The bench vise is used as a clamping tool to hold materials during processes like grinding, drilling, or welding. This tool ensures the material remains in a stable position, allowing the work to be performed with more precision.

7. Welding Electrode

The E6013 welding rod with diameters of 2.6 mm and 3.2 mm is used for joining ASTM A36 steel materials. This electrode is chosen because of its ability to produce strong joints with good penetration, and it is easy to use in various welding positions.

8. Measuring Tools

Measuring tools such as steel rulers, calipers, and micrometers are used to check the dimensions of the material and the finished work. The use of these measuring tools is essential to ensure that each component meets the design specifications.

9. Safety Equipment

In the manufacturing process, safety equipment such as gloves, protective goggles, safety shoes, and welding masks are used to protect operators from potential hazards such as sparks, heat, or metal dust.

4.0 DISCUSSION

This study successfully demonstrates that the designed Multi-Function Bending Machine performs optimally in forming metal sheet materials with thicknesses ranging from 1 to 5 mm and widths up to 800 mm. The machine is designed with an integrated hydraulic system that enables high-precision bending of angles, bending of radii, and pressing processes, all performed with high accuracy and time efficiency. Technical test results show that the machine can achieve bending angles with a tolerance of ±1°, as well as consistent bending radii without significant material deformation. For 1 mm thick sheets, the required pressure is about 500 kg, while for 5 mm thick sheets, the pressure increases to 3200 kg. The hydraulic system performance is proven to maintain pressure stability during the forming process, resulting in precise bends for both sharp angles and curved radii.

In terms of material analysis, hardness tests and

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microstructure analysis show significant changes in the bending areas due to plastic deformation. Brinell hardness testing shows an increase in material hardness from 120 HB to 160 HB in the forming zone, due to strain hardening. On the other hand, the material's microstructure shows a change in grain orientation following the deformation pattern, where the grains on the outer radius experience stretching, while those on the inner radius undergo compression. However, no defects such as cracks or significant structural damage were found, indicating that the machine can form the sheet without compromising the material's integrity. Another advantage of this machine is its efficiency in processing time. The bending of angles or radii can be completed in much less time compared to manual methods, thus enhancing productivity. Moreover, the machine's functional flexibility, capable of performing various types of forming in one device, minimizes the need for additional tools, directly reducing operational costs.

The discussion on the results shows that the success of this machine not only relies on its design and specifications but also on the selection of the primary material, such as ASTM A36 steel. This material has mechanical properties suitable for the forming process, such as high tensile strength and good deformability. The application of the Design for Manufacturing and Assembly (DFMA) principle also proved to support the machine's production process, making it easier to assemble and operate. However, the study also identified several aspects that could be improved. One of them is the development of an automated control system to enhance the accuracy of the forming process. Additionally, more precise pressure adjustments are needed to handle materials with greater thickness or more complex types, such as stainless steel or high-carbon steel.

Overall, the results of this study indicate that the Multi-Function Bending Machine holds great potential for use in education, research, and industrial applications. Not only does it improve production efficiency, but it also significantly contributes to supporting practical learning in mechanical engineering and research related to material analysis after forming. With further development, this machine could become a more advanced and versatile solution for modern industrial needs.

4.1. Process Before Making A Multi-Function Press Machine "Pressers, Corner Benders, and Radius Benders"

Before the creation of the Multi-Function Press Machine: Pressing, Angle Bending, and Radius Bending, several preparations were made to ensure quality and efficiency. The initial stage involved identifying needs, determining technical specifications, and designing the machine using CAD software. ASTM A36 steel was chosen as the primary material due to its strength and weldability. Virtual simulations were conducted to predict performance and identify potential issues. Manufacturing tools such as drilling machines, grinders, saws, and welding equipment were prepared, along with precision measuring tools to ensure accuracy. A prototype was created and tested to evaluate hydraulic performance, forming results, and frame stability.

The machine was designed with safety features, such as mold guards and emergency stop buttons, as well as ergonomic controls for ease of use. Technical documentation, including specifications, operational guides, and maintenance procedures, was thoroughly prepared. With these preparations, the machine production process was carried out efficiently, resulting in a precise, reliable tool that met user needs.

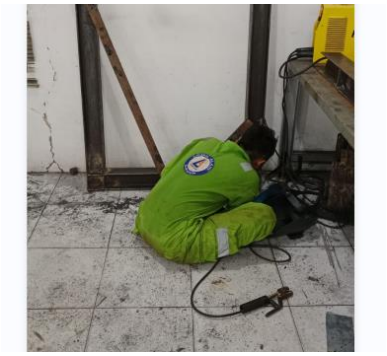

Figure 3: Process Before Making A Multi-Function Press Machine

5.0 CONCLUSION

This study successfully developed and analyzed the performance of a multifunctional bending machine capable of performing angle bending, radius bending, and pressing on metal plates of various thicknesses. The findings indicate that the machine operates with high accuracy and efficiency, making it suitable for applications in manufacturing, automotive industries, and academic research.

The research confirms that key factors such as material type, thickness, bending angle, and applied pressure significantly influence the quality of the bending process. Proper calibration of these parameters is essential to minimize material defects and achieve precise bending results. These findings align with previous studies, which emphasize the importance of controlled pressure and material selection in achieving optimal bending performance (Wiryosumarto & Okumura, 2000).

Additionally, the study highlights the potential of integrating this machine into industrial and educational settings, supporting practical training and advanced research in material forming. The use of CAD-based simulations and real-world testing demonstrates its effectiveness in both learning environments and production applications (Bohnart, 2018).

Despite the positive results, further improvements can be made by enhancing the machine's automation features and expanding its compatibility with different materials. Future research should focus on optimizing pressure control, reducing energy consumption, and implementing smart monitoring systems to improve overall efficiency.

In conclusion, the multifunctional bending machine offers significant benefits for industrial and academic applications, contributing to advancements in material forming technology and providing a valuable tool for future research and development.

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