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Design and Fabrication of a Low-Cost Air-Powered Sheet Cutting Machine for Small and Medium-Scale Industries

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Abstract- ***Sheet metal cutting is a critical process in fabrication industries including automotive, manufacturing, and construction. Conventional cutting methods such as manual shearing and hand tools are labor-intensive, time-consuming, and pose safety risks to operators. To overcome these limitations, an Air Powered Sheet Cutter was designed and developed using a pneumatic double-acting cylinder actuated by compressed air. The prototype integrates an air compressor, control valve, receiver tank, and cutting blade mounted on a mild-steel support frame. The proposed design enhances cutting accuracy, minimizes operator effort, and improves productivity. Experimental evaluation demonstrated that the system can smoothly cut mild steel sheets up to 2 mm thickness with high repeatability and reduced cycle time compared to manual cutting. The pneumatic setup also ensures low operational cost, simple maintenance, and continuous working capability. This study confirms that pneumatic actuation is suitable for small and medium-scale industries where cost-effective and safe cutting solutions are required.***

Keywords: Pneumatic Sheet Cutter, Air-Powered Mechanism, Metal Shearing, Industrial Automation

I. INTRODUCTION

Sheet cutting is a widely used process in industries such as automotive, fabrication, construction, packaging, and aerospace for shaping and sizing sheet materials. Traditional cutting methods including shears, saws, and manual cuttersn are still common but are slow, labour-intensive, and prone to safety risks and inconsistent cutting quality. With the increasing demand for precision and productivity, industries are continuously shifting toward automation to achieve faster and safer cutting operations. Pneumatic systems have become an effective technology for industrial automation because they convert compressed air into mechanical force efficiently, offering high reliability, quick response, and low maintenance. They are already used in pressing, punching, and clamping applications, and their characteristics make them highly suitable for cutting operations. In this project, a double-acting pneumatic cylinder is used to actuate a cutting blade for smooth and accurate sheet cutting. Pneumatics is particularly advantageous in environments where electrical systems may be hazardous due to sparks or overheating. Since air is a clean and abundant resource, pneumatic systems are energy-efficient and environmentally friendly. The developed system consists of a compressor, pneumatic control valves, a double-acting cylinder, a cutting blade, and a sheet-holding frame, forming a compact and user-friendly setup capable of cutting materials such as aluminium, mild steel, and plastics. Overall, the air-powered sheet cutter offers a practical, safe, and economical solution that enhances productivity and accuracy in modern industrial workshops. Several researchers have contributed to the development and advancement of pneumatic sheet-cutting and shearing systems over the past decade. Omkar Savant et al. (2015) [1] demonstrated the integration of shearing and bending operations into a single pneumatic setup using two cylinders, proving that both processes can be accomplished with proper valve timing and a single operator. M. Khaja Gulam Hussain et al. (2016) [2] presented the fabrication methodology for a pneumatic shearing machine, including component selection and cutting force calculations, showing successful cutting of 1 mm mild steel with smooth edges. Structural strength and frame stability were analysed by Satish Bahaley et al. (2017) [3] through Finite Element Analysis, concluding that mild steel or cast iron provides sufficient rigidity at reduced cost. Automation using a microcontroller and solenoid

valves was emphasised by Pritish Chitte et al. (2018) [4], where repetitive cutting cycles were controlled electronically for improved productivity. Design optimisation of pneumatic cylinder dimensions, shear force, and blade clearance was addressed by Harshil J. Acharya et al. (2021) [5] through CAD-assisted modelling. Experimental validation proving that pneumatic systems reduce human fatigue and enhance safety was reported by Aniket Kayate et al. (2022) [9]. Sachin Kharche et al. (2023) [10] compared different pneumatic cutting configurations and confirmed their benefits for lightweight and compact cutting of aluminums and copper sheets. A practical low-cost cutting machine for small workshops was detailed by Kamble Swapnil S. et al. (2022) [11], highlighting the advantages of a double-acting cylinder with manual valve control. Sudarshan et al. (2024) [12] enhanced system reliability through simulation-based design and automation using a solenoid valve. Efforts to automate aluminium cutting using pneumatic power supported by CAD-based stress calculations were further reinforced in the work of Pritish Chitte et al. (2018) [13]. Renewable energy integration was explored by Ajit Kumar Singh et al. (2015) [14], who powered a pneumatic cutter with solar energy for use in remote locations. Design optimisation to reduce weight and improve efficiency was discussed by Mahale Kiran et al. (2022) [15]. Additional studies by Dinesh Lamse et al. (2017) [17] and Vishal Tambat et al. (2015) [19] introduced dual-operation pneumatic systems capable of cutting and bending using manually controlled directional valves. Conceptual modelling based on theoretical force calculations and component selection was undertaken by Dhruv B. Solanki et al. (2021) [18], while Chandrakant Saindane et al. (2021) [20] demonstrated the advantages of full automation using solenoid valve control to achieve repeatability, increased safety, and higher production rates. The objective of this work is to design and develop a low-cost air-powered sheet-cutting mechanism suitable for small and medium-scale industries. The proposed system aims to minimise manual involvement by using compressed air to generate the required cutting force, thereby improving operator safety by avoiding direct contact with the cutting tool. The mechanism is intended to provide consistent and accurate cutting performance for sheet metal up to 2 mm thickness while reducing physical strain on workers. Overall, the project seeks to enhance productivity, accuracy, and workplace safety through a compact and economical pneumatic cutting design.

II. METHODOLOGY

The development of the Air-Powered Sheet Cutter was carried out through a systematic approach involving design, fabrication, and testing. The system was designed with a rigid structural frame fabricated from mild steel square tubes to provide stability and resist vibrations during operation. A pneumatic double-acting cylinder was selected to supply the required cutting force, and a pneumatic circuit was configured consisting of an air compressor, receiver tank, pressure regulator, 5/2 directional control valve, and the cylinder. A cutting blade was mounted at the end of the piston rod to perform the shearing operation efficiently. The selection of components was based on specific operational criteria. The pneumatic cylinder was chosen with a stroke and bore size adequate to provide the necessary cutting force, while the air compressor was selected to deliver a working pressure of 6–8bar. The cutting blade was made of high-strength steel to ensure sharp and durable shearing, and the frame was designed to maintain rigidity and minimize vibrations. During operation, compressed air is stored in the receiver tank and, upon activation of the push button or control valve, flows into one side of the cylinder, extending the piston and driving the blade downward to cut the sheet. Reversing the valve supplies air to the opposite port, retracting the piston to its original position for the next cutting cycle. The flow control valve allows adjustment of the cutting and return stroke speeds, providing precise control over the operation. Experimental testing was carried out using mild steel sheets of varying thicknesses to evaluate the machine's performance. Key parameters assessed included the cutting ability, surface finish, operational time, repeatability, and overall safety. The tests confirmed that the pneumatic sheet cutter delivers consistent cuts with minimal operator effort, improved efficiency, and enhanced workplace safety compared to conventional manual methods.

2.1. Working Methodology

The working methodology of the air-powered sheet-cutting system is based on the conversion of pneumatic energy into linear mechanical motion to

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perform the cutting operation. Compressed air from the compressor is stored in a receiver tank and regulated to the required operating pressure using a pressure regulator. The regulated air is then supplied to a 5/2 directional control valve, operated manually or through a solenoid. When the valve is actuated, compressed air enters one port of the double-acting cylinder, enabling the forward stroke of the piston, which forces the cutting blade downward to shear the sheet. Reversing the valve position supplies air to the opposite port, allowing the cylinder to retract and reset the blade position for the next cutting cycle. The overall process ensures a steady, repeatable, and safe cutting action with minimal operator effort. The incorporated control system provides uniform cutting force, while the mechanical frame ensures proper alignment and rigidity during operation.The fabricated air powered sheet cutter shown in the Figure1.

Figure 1. Air powered sheet cutter

III. RESULTS AND DISCUSSION

The fabricated pneumatic sheet cutter was tested to evaluate its performance, productivity, safety, and cost-effectiveness. During the testing phase, the machine successfully performed cutting operations on mild steel sheets of varying thicknesses. The cutting performance is summarized in Table 3.1.

Table1: Cutting performance

Sheet Material	Thickness	Cutting Result
Mild Steel	1.0 mm	Smooth cut, no deformation
Mild Steel	1.5 mm	Smooth cut, minimal burr
Mild Steel	2.0 mm	Clean cut under full pressure

The results indicate that the system is capable of handling sheet metals up to 2 mm thickness, meeting the original design specifications. Cutting operations were completed significantly faster compared to manual shearing, demonstrating improved productivity. The pneumatic actuation eliminated operator fatigue, and the cycle time remained consistent over repeated trials, highlighting the system's reliability and repeatability. From a safety and ergonomic perspective, the design ensures that the operator remains isolated from the cutting zone, reducing the risk of injury. Unlike electrically driven systems, no fire hazards, overheating, or excessive noise were observed, making the machine suitable for small-scale workshop environments. In terms of cost advantages, the total fabrication cost of the pneumatic cutter was approximately ₹14,000, which is considerably lower than commercially available hydraulic or electrically powered cutting machines. This makes the system economically viable for small and medium-sized industries. Overall, the results confirm that the air-powered sheet cutter provides a reliable, safe, and cost-effective solution, combining precision cutting with improved productivity and reduced manual effort.

IV. CONCLUSION

The Air Powered Sheet Cutter developed in this work provides an efficient, safe, and economical alternative to manual sheet cutting systems. The pneumatic double-acting cylinder delivers sufficient force to cut metal sheets up to 2 mm thickness with high consistency, reduced cycle time, and minimal human effort. The system demonstrated excellent productivity, continuous working capability, and low maintenance requirements. The low cost of fabrication makes it particularly suitable for small and medium-sized industries and fabrication workshops. Future enhancements may include automated sheet feeding, integration of PLC-based actuation for repetitive

cutting cycles, and adaptation for curved or contour sheet cutting.

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