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Design and Fabrication of Sheet Metal Cutting Machine

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Pneumatic, metal cutting, actuator, sheet metal cutting machine.

Abstract

The main goal of this research project is to create an automated sheet metal cutting device that is suitable for small-scale industry requirements. The machines that are currently on the market are renowned for their large size and expensive hydraulic or pneumatic systems, which lead to high maintenance costs. However, there are a lot of safety and precision issues with handheld manual cutters. Our suggested prototype will make use of the effectiveness of a pneumatic system and be painstakingly designed using state-of-the-art Solid Works software to solve these problems. Our invention will be used at a small business's metal fabrication worksite to verify its functionality.

1. Introduction

This research project intends to revolutionize small-scale enterprises by developing revolutionary automated sheet metal cutting equipment. Design and build a prototype that combines a pneumatic system to improve cutting accuracy while lowering the need for manpower and removing safety issues associated with existing manual cutting methods using SolidWorks software. The research focuses on solving the inefficiencies of traditional methods, such as increased energy usage, longer production times, and a lack of established safety management systems. The ultimate goal is to provide a cost-effective and efficient solution for small-scale enterprises looking for ways to optimize their manufacturing operations. The project has the potential to significantly affect the sheet metal cutting industry once a functional prototype is available for testing.

2. Literature Review

2.1 Introduction

With many possible uses in various industries, including mechanical and medical engineering, sheet metal fabrication is an intricate but vital process. The cutting stage takes place when the metal sheets are sized using specialized instruments like saws, lasers, or plasma cutters [1]. The next step is bending, which is frequently accomplished with the accuracy of a press brake and permits the exact shaping of components to guarantee a seamless fit during assembly [1]. Punching, which is accomplished with a punch press, makes the holes that fasteners need to go through and stamping double-checks the accuracy before welding, which fuses the parts permanently [1].

2.2 Manual and automated sheet metal cutting machines

According to [2], sheet metal cutting machines fall into two primary categories: automated and manual. They are an essential part of the commercial manufacturing industry. Automated machines are meant to work independently, efficiently cutting metal sheets into various shapes and sizes with little effort and time [2],

whereas manual machines rely on hand-operated methods and instruments, like simple hand shears that are usually used by small enterprises. For example, compared to traditional non-automatic sheet cutters, automated pneumatic sheet cutters with affordable pneumatic sensors have been demonstrated to greatly increase productivity and reduce the need for human labor [2]. Numerous studies, including those by Prakash et al. [3] and Ranjan et al. [4], emphasize how important automation is to increasing productivity and reducing costs associated with manufacturing when it comes to sheet metal cutting. Furthermore, Bagul and Mansuri [3] delineate the advantages of automated pneumatic sheet metal cutting, specifically concerning time-saving strategies and ease of use. In the end, research highlights how important it is to automate sheet metal cutting equipment to improve efficiency and lower production costs [3][4].

2.3 Prominent studies related to automated sheet metal cutting machines

The article, Pneumatic Sheet Metal Cutting Machine by Kailas is about pneumatic systems that are used in a variety of industries and factories due to their simplicity, dependability, and ease of use. This project resulted in the development of a simple, user-friendly pneumatic sheet metal cutting and bending machine with a pressure range of 6–8 bar. The pressurized air travelling through the tubes pushes the cylinder out, which is then communicated to the punch. Depending on the situation, different types of punches can be used, and the working pressure can be adjusted to suit the work material [5].

In an article by Katre titled Design and Fabrication of Sheet Metal Cutting Machine by Using Pneumatic Power, the study shows that, having utilised the electrically controlled DCV. Pneumatic compressors make the operation easier, to compress the air, and positive displacement compressors force air into a chamber whose capacity has been reduced. Positive displacement air compressors frequently employ a piston-type design to pump air into an air chamber while maintaining consistent piston motion [6].

Author Prasad with the title of Design and Development of Pneumatic Sheet Metal Cutting Machine, the paper shows these industries use simple handheld sheet cutters and basic sheet metal cutting procedures. Calculations of pressure. The project's practical applicability is taken into consideration while doing the design calculations to determine the ideal cutting pressure [7].

2.4 Existing design of system for automated sheet metal cutting machines (ASMCM)

With advancements in technology and an emphasis on getting the best results at the lowest possible cost, the automated sheet metal cutting machine (ASMCM) models that are currently in use employ a variety of techniques. An intelligent sheet metal automated manufacturing line functions with accuracy and efficiency by integrating several components, such as laser cutters, double-linked benders, and numerical control machine tools. Rectangular synchronized blades that control the feeding process make this easier. One innovative technique is to scan the patterns with an electronic device before cutting them into sheets. This reduces costs and labor significantly. A literature review also emphasizes the development and application of a pneumatic sheet cutter, which automates the process of cutting aluminum and galvanized iron sheets of various thicknesses.

With many compelling examples that reinforce their efficacy, pneumatic systems have become the preferred option for ASMCM, and they have seen tremendous growth in popularity. One interesting accomplishment in this field is the development of an automated sheet metal cutting machine that is based on pneumatics [8]. Another is the effective use of a pneumatic actuation system to spin aluminium metal sheets [9]. Furthermore, a state-of-the-art automated pneumatic shearing machine has been developed that precisely cuts aluminium sheets by using an Arduino and a solenoid valve [10]. In addition, pneumatic system technological developments have led to the development of an automated metal and paper-cutting machine that makes use of a double-acting cylinder [11].

3. Methodology

The methodology is a systematic analysis of research methods used in a field of study, providing a step-by-step explanation of the research process. Reporting methodologies are crucial for effective communication, decision-making, and data accuracy.

3.1 Research Project Design

Our research project begins at the UTHM Campus located in Pagoh. We conduct design and fabrication work on-site, with testing conducted in the university's laboratory. We start the process by defining project requirements, getting input from our supervisor, and coming up with ideas and sketches. Selecting the right material is an important first step. Next, using the most recent version of SolidWorks 2022 software, create detailed drawings. Finally, we use Finite Element Analysis (FEA) to perform a comprehensive design evaluation.

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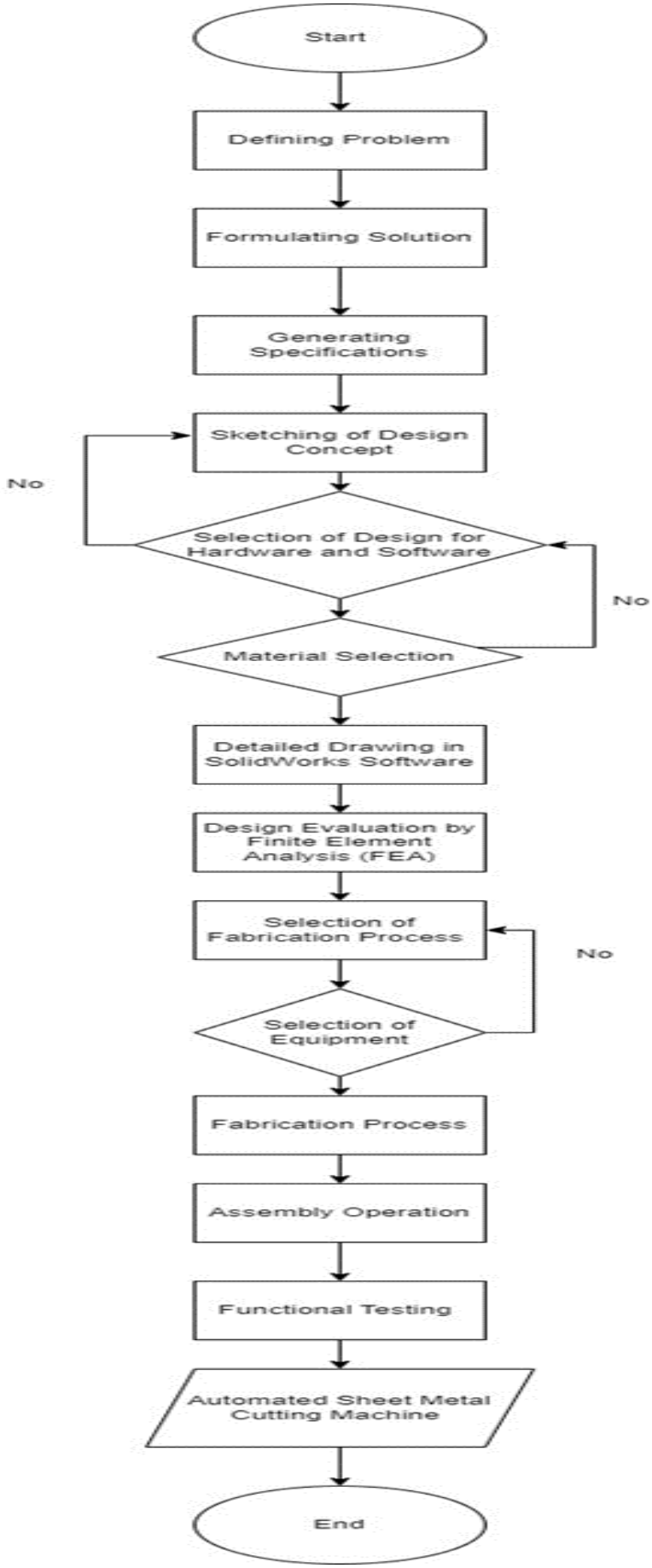

Fig.1 *Flowchart*

3.2 Design of automated sheet metal cutting machine

A common problem during metal sheet cutting is wear and tear on stoppers, which has been carefully considered in the design of the automated sheet metal cutting machine. Using a cutting-edge mechanism driven by a strong pneumatic actuator, this creative solution makes it possible to produce precisely shaped metal sheets in a single, quick motion. From the selection of materials to the advanced software, every part of the machine has been meticulously thought out. For example, the framework is made of AISI 1020 cold-pressed steel, which is dependable and long-lasting, and the pneumatic actuator has a force of 1 MPa. Furthermore, the machine's software specifications now include SolidWorks 2022's modern design and analysis features. Figure 1 below shows the final design for the metal sheet cutting machine prototype done with SolidWorks 2022 software.

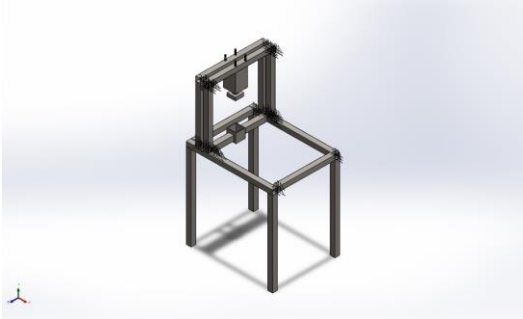

Fig.2 *Isometric view of the prototype design*

3.3 Fabrication of automated sheet metal cutting machine

Several methods are used during the fabrication process, such as cutting, welding, and finishing. While welding is done with specialized Metal Inert Gas (MIG) equipment, cutting is done with tools like a grinder and metal-cutting band saw. After the framework is put together, the excess weld is ground away and painted with an anti-rust coating to provide protection. The prototype is also constructed by welding, and limit switches, solenoid valves, and pneumatic actuators are fastened firmly during the assembly phase.

3.4 Functional testing

After the pneumatic actuator is attached, the stiffness of the framework is closely examined during functional testing using SolidWorks 2022. 20 trial runs of the prototype are used to evaluate its capabilities and safety, and the collected data is compared to the project's goals and objectives.

4. Results and Discussions

4.1 Results

The prototype aims to address the problems mentioned in the problem statement by using less energy and time to cut metal sheets, increasing precision over conventional techniques, producing a safer design, and lowering production rejection rates. It is to boost overall production efficiency and drastically reduce the need for rework in quality control.

4.1.1 Final design

SolidWorks 2022 software was utilized to meticulously create the final design of the prototype machine, guaranteeing an accurate and comprehensive representation.

4.1.2 Results of FEA

Evaluated the stress, strain, and displacement variables of the frame structure using Finite Element Analysis (FEA) and SolidWorks 2022. The results of the software provided the highest stress, least static displacement, and greatest strain displacement values. This investigation showed the distribution of stress, static displacement, and strain displacement. The figure below shows the fixture done in the software.

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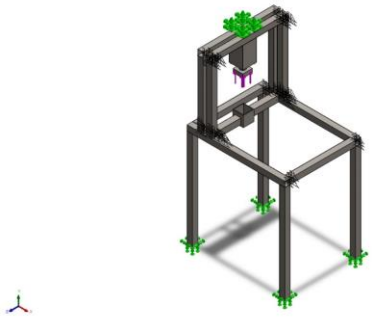

Fig.3 *Fixture image showing the fixed geometry*

4.1.3 Development of prototype

Precise welding procedures for the framework, careful sheet metal cutting and polishing, and the installation of pneumatic actuators for support were all necessary in the fabrication of the prototype. Furthermore, great care was taken to guarantee that safety precautions were taken and that every part was painstakingly painted for both rust resistance and aesthetic appeal. To guarantee successful completion, the prototype was put through extensive functional testing after construction. Figure 3 below shows the real prototype.

Fig.4 *Front view of the prototype*

4.1.4 Functional testing results

Several elements were carefully examined throughout the functional testing phase, including the stability of the structure, the findings of the SolidWorks FEA, the accuracy and efficiency of the machining, and safety. To assess the prototype's efficacy even more, a productivity study comprising 5 tests was carried out, especially for the flow movement of the whole mechanism. The goal was to improve a sheet metal cutting machine's functionality by using an automated pneumatic system and SolidWorks software. Among those 5 trials, all of them were positive with proper flow of movement and did not sludge or causes any problem.

The project was successful because it reduced the need for excessive design and material usage through extensive research and simulations. The data provided insightful information that highlighted the importance of strains, stress, and displacement during the product's manufacturing process. While pursuing the second project goal of designing an automated metal sheet cutting machine, progress was also made in improving the model. The prototype was constructed flawlessly, despite the additional step of applying anti-rust paint to prevent any corrosion. From beginning to end, precise SolidWorks designs were utilized to guide the manufacturing process. In this project, dimensional precision was evaluated and the cutting time of our prototype machine. We found that the sheet metal was dented due to inadequate pressure from the actuator. It seems that increasing the pressure could prove crucial in overcoming this issue. Currently, the existing research on this topic only covers hand cutting with pneumatic actuators, but conducting further studies could greatly enhance its effectiveness and efficiency. Figure 4 below shows the dented mark after the trial run was conducted.

Fig.5 *Dented mark*

5. Conclusion and recommendation

A sheet metal cutting machine design improvement using SolidWorks software and an automated pneumatic system was successfully constructed. A prototype model was fabricated, and its functions were evaluated. This project showcases the potential of SolidWorks software for designing and automating sheet metal cutting machines, leading to increased efficiency, reduced production time, and improved product quality. The project's success opens the door for further research and development in the sheet metal cutting machine industry. Objectives of the project were achieved successfully.

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