Portable Design of an Automated Pneumatic Bending Machine

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Abstract — Industry routinely uses sheet bending for a number of tasks. Since most sheet metal bending equipment is hydraulic or screw-based bending clamps that take a lot of time and effort. Therefore, we provide a compact, portable, pneumatic-based sheet metal bending machine that bends sheet metal at a user-defined angle. This bending machine is designed in such a way that, it works automatically. This has a significant impact on automation.

Keywords — Pneumatic, sheet metal, clamps, rod, clamp bending.

I. INTRODUCTION

Many different industries often use bending. Most bending equipment is hydraulic or screw-based, which takes a lot of time and energy to bend. As a result, we suggest a small, pneumatic-based bending device that can bend sheet metal at whatever angle the user chooses. The bending machine is essential in the sheet metal industry. With a variety of applications, this machine works well for straight cutting. However, manual sheet cutters and benders are still used in several industries. That equipment needs human effort to operate. We made an effort to construct the pneumatic bending machine because it should be simple to operate and maintain. In order to produce the desired results, a pneumatic press controls the piston's movement under high pressure using compressed air. When compared to hydraulic presses, pneumatic presses may accomplish ten times as much work in half the time. Automation is frequently provided by robots, computers, hydraulics, pneumatics, and other mechanisms. Pneumatics is one of the most often used low-cost automation techniques.. The affordability and usability of pneumatic systems are their primary benefits. In massive manufacturing, automation is always essential since it lowers labour and material costs. The productivity, storage, safety, and comfort of the workforce have all risen as a result of the overall cost being decreased.

II. LITERATURE REVIEW

1. Akshay L. Soneraa, Dharmesh B. Chauhana, Tanvi K. Chaudhari published in 2017 Design of Pneumatic Press for Bending and Punching Operation.[1] This research paper gives the optimum design of pneumatic press for bending and punching operations. The author has also gone through various calculation to meet his objectives to produce the bend and punch in the sheet.
2. Ajay Musale, Darshana Deshmukh, Sagar Misal, Yogita Kale, Sachin Nehe published in 2018 Design and Fabrication of Pneumatic Bending by Using Ultra Sonic Sensor.[2] A pneumatic bending machine with ultrasonic sensors was developed in this research. Their main aim was to make an economical and which cannot be operated by unskilled operator. This paper also focuses on increasing the productivity and reducing the errors to minimum level.
3. P. Vijay Rengaraj, G. Shree Hari, K. Sibi Mayuran, T. Santhosh, R. Vivek, published in 2019 described about the Semi-Automatic Pneumatic Sheet Metal Cutting and Bending Machine.[3] The main purpose of this paper is to make cheap and portable pneumatic sheet metal cutting and bending machine, meeting the expectation of a small to medium scale industry. This paper eradicates hand-oriented techniques to the greatest extent possible by automating the overall procedure and thereby reducing the cost of the project. The main principle behind this is to use a pneumatic piston to operate the cutter and bender.
4. Lalit Awaze, Akash Shende, Pavan Pandit, Nishant Ghuse, Amit Dhomne, Abhishek Borkar, Dr.R.H. Parikh named Design and Fabrication of Pneumatically Operated Bar Bending Machine published in2021.[4] The main objective of this project is to make cheap and reliable rod bending machine which is pneumatically operated. Here the author focuses on how the manually controlled press can be converted into automatic machine that can save maximum operating time.
5. Dinesh Lamse, Akash Navghare, Rahul Chavhan, Ajay Mahawadiwar published in 2017 Design and Fabrication of Pneumatic Sheet Metal Cutting and Pneumatic Sheet Metal Bending Machine.[5] This research paper aims at developing a simple easy-to-operated pneumatic sheet metal cutting and bending machine that is both durable and dependable.

III. METHODOLOGY

We encase the sheet metal for bending between two sheets of mild steel that are secured together with wing nuts. These sheets aid in keeping the sheet metal in place and preventing movement while bending. Pneumatics are used to mechanically activate the entire system. The sheet metal is bent using a pneumatic cylinder. We have employed a pneumatic valve to regulate the pneumatic piston's extraction and retraction. There have been 5/3 pneumatic valves utilized. The use of 5/3 valves are justified by the ability to halt the extraction of the piston in the middle of it. The mechanism has been electronically activated to halt the piston at any desired angle selected by the user. We used a TIP122 transistor to regulate the piston's extraction and retraction. To determine the angle at which to stop the piston to achieve the necessary angle, we employed MPU6050 as a feedback device. The electronic system's microcontroller is an Arduino Mega. The circuit diagram for electronic connections is shown:

COMPONENTS:

The following are the components used in the project:

SR. NO.	Components Used	Specification	Use
1.	Pneumatic Cylinder	32 mm bore diameter, 100 mm stroke length	It transforms compressed air power into mechanical energy.
2.	Hinge	-	To provide flexibility to the assembly in order to obtain the desired clamp angle.
3.	Female rod end bearing	10 mm inner diameter	Connecting one end of the piston to the assembly.
4.	5/3 pneumatic valve	6 mm diameter connectors	It regulates the flow of pressurized air in a controlled manner.
5.	Non return valve	6 mm diameter	It allows unidirectional flow of compressed air.
6.	Flow control valve	6 mm diameter	It restricts the amount of flow of compressed air in the pneumatic circuit.
7.	Hose pipes	6 mm diameter	They facilitate flow of compressed air throughout the pneumatic circuit.
8.	Pressure gauge	6 mm diameter connectors	It regulates the amount of pressure present in the circuit.
9.	Arduino mega 2560	Operating voltage: 5 V	Microcontroller
10.	MPU6050	Power Supply: 3-5V	It gives feedback of the desired angle.
11.	TIP122 transistor	5A collector current voltage is 5V	It is used to actuate the pneumatic valve electronically.
12.	Pneumatic connectors	Union connectors	Establishes connections between various pneumatic components.
13.	Aluminum rods	10 mm diameter	Used to attach pneumatic cylinder to the assembly.

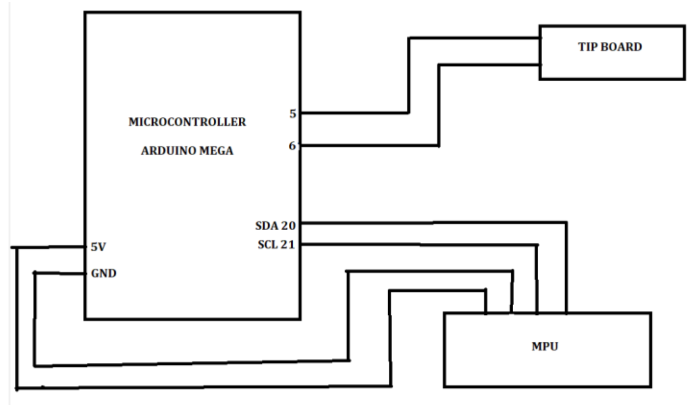

Fig 1
Fig 1 circuit diagram of electronic connections

is shown below:

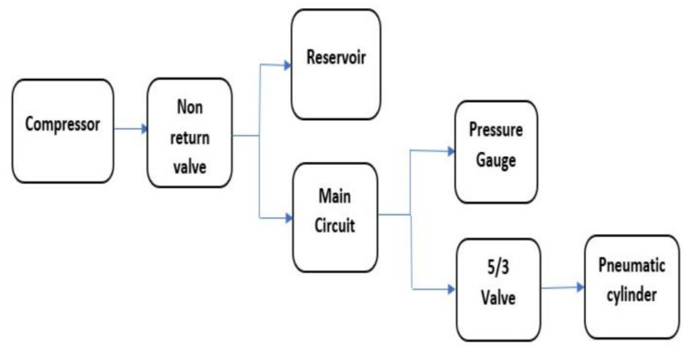

Fig 2
Fig 2 pneumatic circuit diagram

IV. RESULTS AND DISCUSSIONS

CAD model of the project:

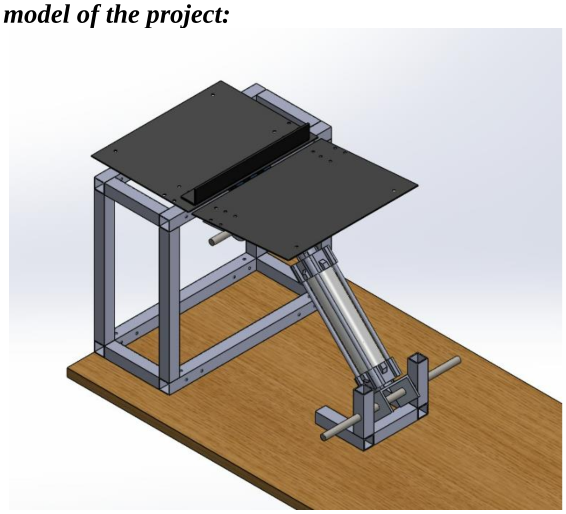

Figure 1 CAD Model isometric view

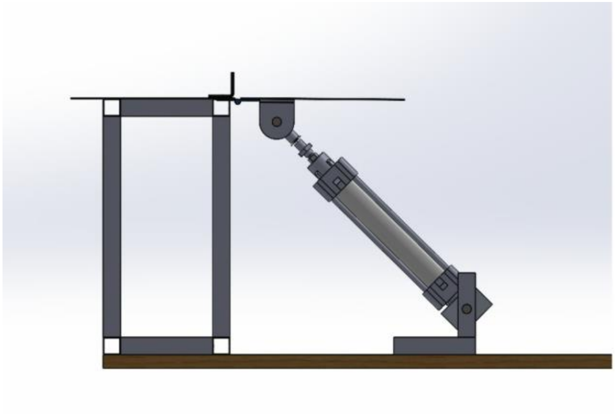

Figure 2 Side view without extraction

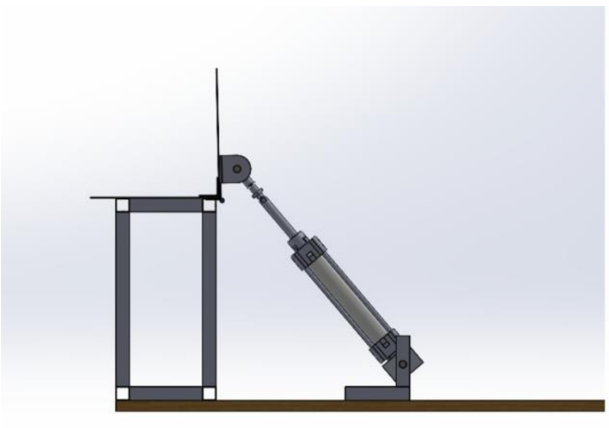

Figure 3 Side view with full extraction

The actual model:

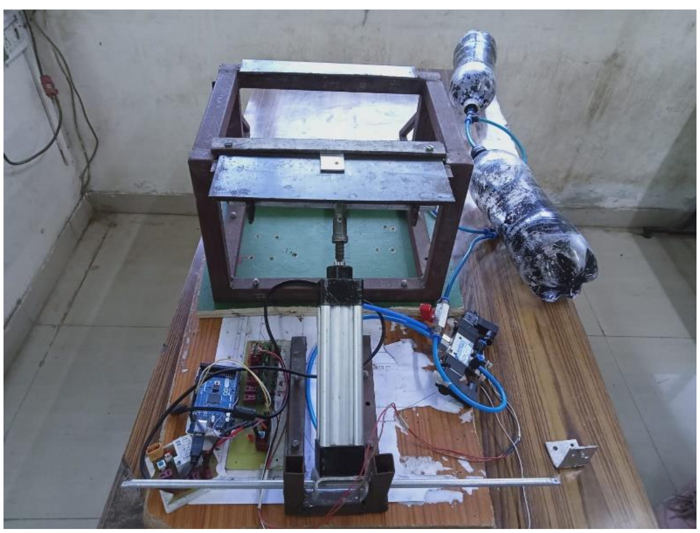

Figure 4 Actual model

Figure 5 Actual Model

Calculations:

$Ultimate\ yield\ strength\ of\ Aluminium = 400\ MPa = \sigma$

$$\frac{M}{I} = \frac{\sigma b}{y}$$

$Sheet\ metal\ to\ be\ bent\ is\ of\ thickness\ 2\ mm$

$$y = 1mm = \frac{d}{2}$$

$Dimensionof\ sheet\ metal = 100\ x\ 50\ x\ 2\ mm$

$$Polar\ moment\ of\ inertia = \frac{1}{12bd^3}$$

$Mass = 30\ g = 0.030\ kg$

$$I = \frac{1}{12} \times 50 \times 2^3$$

$$\boldsymbol{I = 33.33\ mm^4}$$

$$\frac{M}{33.33} = \frac{\boldsymbol{\sigma_b}}{1}$$

$$\boldsymbol{\sigma_b = \frac{\sigma}{Fos} = \frac{400}{1.5} = 266.66\ N/mm^2}$$

$$\boldsymbol{M = 8888.01\ Nm}$$

$Moment = Force \times Distance$

$$Force = \frac{8888.01}{50} = 233.89\ N$$

$$Pressure = \frac{F}{A} = \frac{233.89}{\frac{\pi}{4} \times d^2}$$

$$3 = \frac{233.89}{\frac{\pi}{4} \times d^2}$$

$$\boldsymbol{Diameter = d = 31.5\ mm}$$

$Thus, the\ selection\ of\ piston\ is\ done\ according\ to\ the\ requirements.$

$$\therefore Piston\ Stroke\ length = 100\ mm$$
$$\therefore Bore\ Diameter = 32\ mm$$
$$Piston\ Stroke\ diameter = 10\ mm$$

Results obtained after actuating the system:

Sr. No	Pressure	Angle
1	3	155 degrees
2	4	140 degrees
3	4.5	115 degrees
4	5	90 degrees

Cost:

Component	Quantity	Cost
1. MS Square Pipes	3.3 kg (250 per kg)	825/-
2. Pneumatic Cylinder (100 x 32 mm)	1	2000/-
3. MS Sheet metal	2 sheets	225/-
4. 5/3 Valve	1	1000/-
5.Hinge	2	40/-
6.Flow control	1	150/-
7.NRV	1	200/-
8.Pressure Gauge	1	213/-
9. Pneumatic Pipes		100/-
9.Pneumatic Connectors	3	210/-
10.Rod end bearing	1	250/-
11. Solid Rods	2	200/-
10. Nuts and Bolts		20/-
11. Lipo Battery	1 (1300 MAH)	1200/-
12. Arduino	1	750/-
13. TIP	1	400/-
TOTAL		**7783/-**

V. LIMITATIONS

It is challenging to draw a single conclusion because the findings produced by different software programmes vary. Before utilizing this technique, it is important to be aware of several topology optimization restrictions. It can be difficult to create the designs that topology optimization generates. Even though AM is fairly flexible in terms of what it can produce, it is still important to assess the design's suitability for manufacture before committing to it. The build quality and efficiency may suffer if we attempt to solve the topology optimization problem just in terms of the function.

VI. CONCLUSION

We may infer from this study's results that pneumatic clamp bending machines are very beneficial in a variety of industries, including automated systems and clamp bending. The cost of the hydraulic and pneumatic clamp bending machines differs significantly. Small-scale bending firms can benefit from this type of bending machine because they cannot afford the more expensive hydraulic bending equipment. It is pneumatically mechanized to cut down on work hours and manual labour. Using this machine, we may bend the clamp to the desired angle. Anyone, regardless of background, may operate this device. because to the low price and simple construction. Because of this, automation has a lot of promise. In this case the prototype which was prepared performed well and when bending actions were done it bent the sheet upto the desired mark but spring back action had taken place which was approximately 5% of the actual bending angle which can be counterparted by using more pressure in the cylinders.

VII. FUTURE SCOPE

The bending clamp has to be manually operated continuously. By reducing human effort, this pneumatic clamp bending device will enable the user to exert less physical effort. By employing this equipment, some of the harmful health effects of repetitive work will be reduced. The plate's loading and unloading represent the only manual effort involved in this operation. It might therefore be categorized as a semiautomatic machine. This machine can be made entirely automatic, with automatic plate loading and unloading included. This technique can be used to modify and automate outdated machinery, reducing the initial cost of purchasing new automatic machines. Due to time constraints and a lack of funding, we were only able to take into account and incorporate the following potential revisions in the study. An I.C. Engine-fitted compressor takes the place of an electric motor-operated compressor in areas with a lack of electricity. Additionally, this machine uses pressured air to move the cutting tool while it is cutting. As a result, there are a number of future enhancements that can be minimized.

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