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Metal Bending Machine for Lighter Projects

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Abstract : A metal bending machine is one of the machines commonly used in the manufacture of engineering products to shape material into the required shape. This project aims to design a smaller and more compact metal bending device that is able to bend soft metal materials. In this project, a small portable metal bending tool with the size of 400 mm in length and 87.4 mm in height has been designed and manufactured to be able to bend soft metals like mild steel flat bars. This metal bending machine is designed to have a minimal applied force. After conducting several performance tests, the results show that the metal bending machine is capable of producing bending angles on the bending workpiece from an angle of 10° to 60°. This product is small and compact, which makes the machine portable. The machine is simple and easy to operate and it is environmentally friendly because it will not leave any carbon footprint since it does not require fuel or electrical power.

Keywords: Metal Bending, Bending Machine, Rolling Machine, Metal, Steel

1. Introduction

Metal bending is a common process that has been widely used, especially in the manufacturing field. It is a process where the material is shaped to a required shape without affecting the volume of the material [1]. This metal can be bent into a lot of shapes, but most commonly, it is bent into V-shape, U-shape and channel shapes by using a specific machine. The chosen materials will be stressed far from their yield strength but not more than their ultimate tensile strength [2]. Even though the shape of the material has changed, the surface of the material will not be affected much, but there are circumstances where the bend of the metal will result in a small change in the thickness.

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In Malaysia, the manufacturing sector is one of the sectors that contributes to the nation's export revenue and job creation on a large scale to ensure the country's growth, even though there are global economic uncertainties. In other words, the manufacturing sector plays a vital role in the country's economic transformation. The main focus areas of this sector are talent pool development and Industry 4.0, where it revitalizes many related industries together with the opening of new opportunities for other sectors [3]. In August 2021, Malaysia's manufacturing sales grew 6.8 percent compared to the same month in the previous year, when they stood at RM126.5 billion [4]. Since this led to positive results in the manufacturing sector, many companies decided to give more new opportunities to the people that have expertise in this sector to ensure that this sector will grow bigger and have a more positive impact on the country's economy.

In order to ensure the number of skilled workers in the manufacturing field is sufficient, the Ministry of Higher Education, Dato Dr. Noraini Ahmad, has come up with an idea to empower the TVET (Technical and Vocational Education Training) program together with MQA (Malaysian Qualifications Agency) in 2020. This collaboration is made to make sure that the quality of this TVET program is always at the top and on par with worldwide TVET institutions [5]. Other than that, this collaboration is also to make sure that many students will choose this TVET program, and at the end of the day, we will have a sufficient number of graduate students that can perform well in the manufacturing process since more than 90% of these graduate students managed to get their jobs after finishing their studies.

The existing bending machine is too big, as it was made according to the actual size of the machine in the manufacturing industry. The bending machine is approximately 12700 mm in size, and the weight can reach up to 2500 kg [6]. Machines like these were sold in the market for an estimated price of RM11,000 - RM109,000 [7]. This existing bending machine was recognized as not suitable for use by the student, especially in terms of weight and price. Some of the institutions, especially those that offer TVET programs, do not have enough machines to be used by the students.

2. Existing Metal Bending Machines

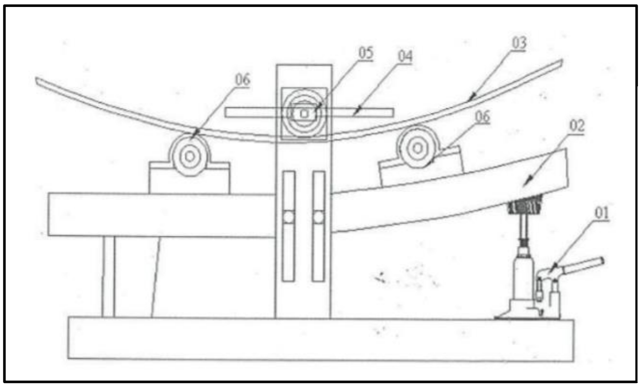
There are a variety of different thicknesses for the workpiece, although extremely thin pieces of metal would be considered foil or leaf, and pieces thicker than a quarter inch or a centimeter can be considered plate. There are many special-purpose machines used in the metalworking industry. However, some machines need to be designed specifically to fit their purpose, depending on the type of work the industry specializes in [8].

Figure 1(a), **Figure 1(b)** and **Figure 1(c)** show the several electric metal bending machines available in the market. These machines are typically large in size and use electrical power to operate the machine.

(a) (b) (c)

Figure 1: (a) Sheet metal bending machine [9], (b) Metal bar bending machine [10], (c) The process of rolling metal [11]

Figure 2 shows a sketch of a hydraulic bending machine by HARSLE [12]. There are also small and portable manual bending machines that have been made where it is user friendly and easy to transport anywhere at any time since the size is small and lightweight.



1. Hydraulic Jack
2. Workbench
3. Workpiece
4. Handle
5. Driving Roller
6. Driven Roller

Figure 2: Sketch of hydraulic bending machine [12]

One of the small and portable manual roller bending machines uses a chain sprocket-based roller mechanism to bend workpieces, especially rods, and pipes, where it is also widely used in the manufacturing industry. Between the machines, there is a supporting frame that was made to support the roller mechanism. The frame is made with a mechanism so that it will fit a movable roller at the centre through a screw mechanism. This is also used to adjust the bending angle. The mechanism is fitted through a slot that was made in the center of the frame. The workpiece that needs to be bent will be rolled across it to achieve the desired shape of the product. The rollers are fitted with bearings so that the motion will be smooth. One of the rollers is integrated with a hand-driven spindle wheel it is required to drive it manually and is also connected to the other roller by using a chain sprocket mechanism so that it will drive along with the spindle at the same rate. So, the combination of the screw-based mechanism together with the spindle-powered rollers will allow the user to get the desired bending products [13]. **Figure 3(a)** and **Figure 3(b)** show two small metal bending machines that can operate manually.

(a) (b)

Figure 3: (a) Manual Roller Bending Machine by IRJET [13], (b) Manual Roller Bending Machine by Mistry MakeTool [14]

Some of the existing bending machines are too big, and people cannot move them easily and cannot take them to another workplace. While the size is bigger, the cost is also affected, and the price is unaffordable. Thus, the purpose of this study is to design a compact-size metal bender for students and workshop schools, to manufacture a product that can improve the bending process of flat mild steel bars and to evaluate the product beforehand to make sure the performance is optimum.

3. Materials and Methods

The machine is made of two hollow square metal poles, several ball bearings, bolts and nuts, and a flat steel bar. The square metal pole and flat metal bar are made of mild steel because it is machinable and weldable, which makes it very suitable for being used for various types of steel fabrication processes since it is a malleable metal. Other than that, the ball bearings and the large bolts used for the machine are made of stainless steel because of their high durability and inexpensive cost.

3.1 Materials

The materials used for fabricating the product must be made of strong materials to better sustain it during the performance test. The selected materials are shown in **Table 1**.

Table 1: List of components for the product

Item	Part Name	Material	Quantity
1	Hollow Square Metal Pole	Mild Steel	2
2	Ball Bearings	Stainless Steel	12
3	20 mm diameter bolts and nuts	Stainless Steel	3
4	9 mm diameter bolts and nuts	Stainless Steel	3
5	Flat Bar	Mild Steel	1

All materials chosen and their quantities are based on the needs, properties, suitability, and availability in a local market.

3.2 Product Design

The design of the bending machine consists of a top frame, a bottom frame, a top roller, bottom rollers, a lever, and large bolts, as shown in **Figure 4**, while **Figure 5** shows the assembly of the machine. The metal top frame is connected to the bottom frame using a 9 mm diameter bolt and nut and can be rotated downward in a clockwise direction. The workpiece should be placed on top of the two bottom rollers, while the top roller will be lowered down with the top frame to bend the workpiece. The rollers are made of stainless steel ball bearings and are held securely with large bolts and nuts that are the same diameter and size as the bearing's inner diameter. The lever of the machine is used to rotate the top roller of the machine in order to roll and curve the workpiece to the user's desired shape.

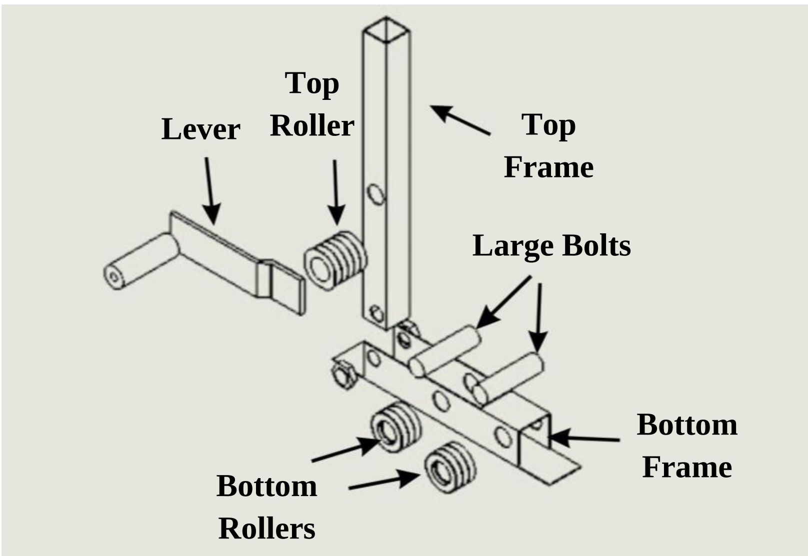


Figure 4: The main components of the bending machine

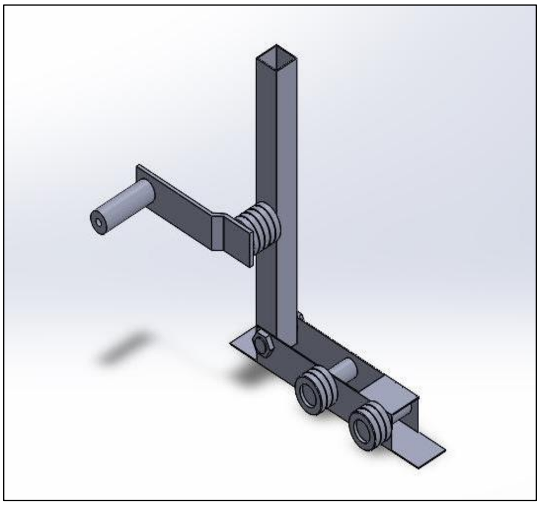


Figure 5: Assembly drawing of bending machine

4. Results and Discussion

After the fabrication process is completed, the product undergoes a performance test to see if it functions or works as intended. The bending test and the rolling test are the two tests that are carried out as part of the operating test. The machine theoretically should not have any problem with bending the workpiece to our desired shape. However, the materials that were used might potentially fail because of their condition. Therefore, it is safer to test the performance of the machine in order to observe any significant or subtle signs of potential failure, such as cracks or if the materials used are too ductile. The final product is shown in **Figure 6**.

Figure 6: Final product of the bending machine

4.1 Bending Test

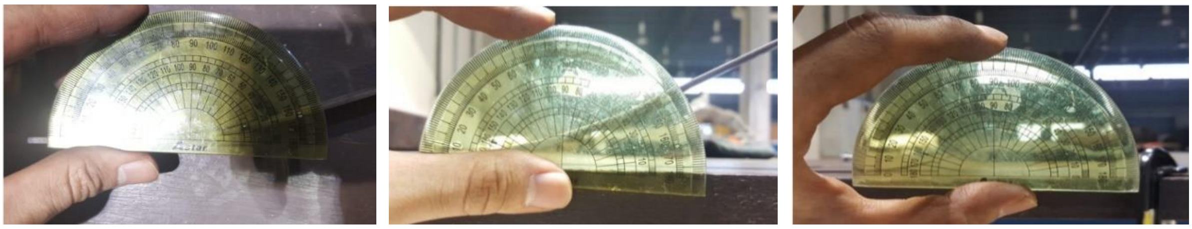
The following procedure, which refers to **Figure 7** was used to conduct the bending test.

i. First, make sure that the machine is clamped to the workbench tightly as shown in **Figure 7(a)**. This is to counter the reaction force while bending the workpiece and prevent the machine from possibly tilting or slipping off the workbench.
ii. Next, raise the top frame of the machine to provide room to place the workpiece above the two rollers at the bottom frame **Figure 7(b)**.
iii. After placing the workpiece on the bottom rollers, the top frame will be pivoted down **Figure 7(c)**, which will create a moment that will be applied to the machine. This will require human strength to bend the machine but since a moment is being applied, the amount of force required for the user will not be much since there is a large distance between the bending point of the workpiece and the force that is being applied.

(a) (b) (c)

Figure 7: Procedures for the bending test (a) clamping, (b) placing the workpiece, (c) bending process

Figure 8 shows the end result of the workpiece after going through the bending process for three different angles.



(a) (b) (c)

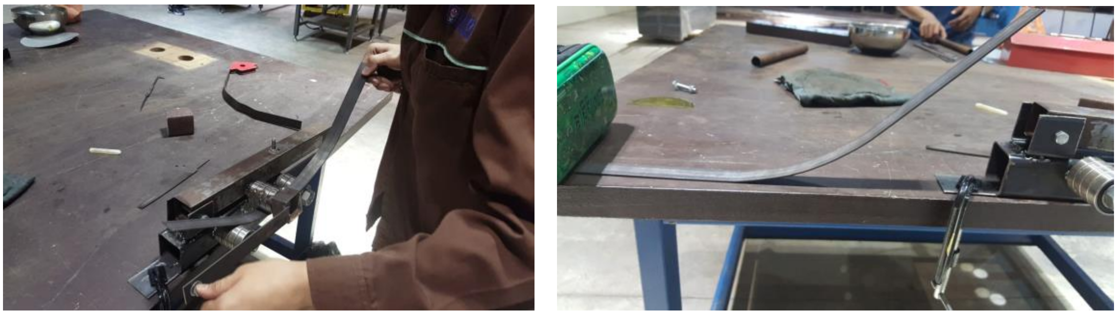
Figure 8: (a) Result at 20° bending, (b) Result at 40° bending, (c) Result at 60° bending

4.2 Rolling Test

For the rolling test, the test was conducted based on the following procedure, referring to **Figure 9(a)**.

i. After bending the workpiece to the desired angle, the handle can be rotated to roll the workpiece to create a curve.
ii. Finally, the workpiece can be removed from the machine once the bending and rolling process is finished.

The result of the rolling test is shown in **Figure 9(b)**.



(a) (b)

Figure 9: (a) Procedures for Curving Process, (b) Result for Rolling Test

4.3 Discussions

After completing the product, the tests were carried out to see how well the finished product performs its task. After several tests that were done on the machine, it successfully achieved the main project's goal, which is to bend flat metal mild steel bars at certain angles and curve them. Although the range of the desired bend was not set earlier in the scope of the project, the product's bending limit was later discovered to be 10°. This is due to the top roller being placed too high from the bottom rollers, which limits the machine's bending angle. In order to counter this, the user is advised to bend multiple spots on the workpiece in order to create a larger angle. For instance, bending the workpiece a single time will create a 10° angle, moving the workpiece slightly to the left and bending it again will create another 10° angle, which means that essentially we will have a workpiece with a total of 20° angle. This means that bending the workplace more than once will essentially provide 10° increments to it. The force that is required to bend the workpiece requires less force since the force that is being applied is at a distance from the bending tool, thus creating a torque. The further away the force is applied to the top frame from the bending tool, the less force is required for the user to bend.

Furthermore, the bent workpiece that will be produced will not have a sharp angle. The bent angle of the workpiece will instead be curved due to the ball bearings being used as the top roller of the bending machine. This results in the area of bend for the workpiece having a round curve to it rather than a sharp bend. A suggestion to make a sharp bend on the workpiece is that the top roller must be replaced with a triangular tool that will help create a more acute angle on the workpiece.

5. Conclusion

A small metal bending machine that can bend flat metal bars has been designed and fabricated. The final product can bend the workpiece at an angle between 10° and 60°. As the bending machine is small and compact, it makes the machine portable and allows the user to carry the machine to different locations when needed. The machine is also simple to use and easy to operate and does not require many procedures for the operation. The machine is environmentally friendly and will not leave any carbon footprint since it does not require fuel or electrical power to operate.

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References

[1] CSM, Customised Sheet Metal Ltd. 2021, March 19. “The power of bending metal: Customised sheet metal “. [Online]. Available: https://www.customisedsheetmetal.com [Accessed October 24, 2021]

[2] Efunda.com, “Bending: Introduction.” (2021). [Online]. Available: https://www.efunda.com [Accessed 24 October 2021]

[3] MIDA | Malaysian Investment Development Authority, “Manufacturing”. (2021). [Online]. Available: https://www.mida.gov.my [Accessed 24 October 2021]

[4] Department of Statistical Malaysia Official Portal Monthly, “Manufacturing Statistics Malaysia, August 2021” (2021). [Online]. Available: https://www.dosm.gov.my [Accessed 24 October 2021]

[5] Farhana Farush, “Pemerkasaan TVET, MQA Tingkat Kerjasama Dengan Badan Luar Negara. Getaran”. (2021). [Online]. Available: https://www.getaran.my [Accessed 24 October 2021]

[6] Indiamart.com, “Manual Sheet Metal Bending Machine”. (2021). [Online]. Available: https://www.indiamart.com [Accessed 24 October 2021]

[7] Allie Wube Dametew, “Design and analysis of multipurpose machines" Current issues, vol. 17, no. 5 2017. [Online]. Available: https://globaljournals.org [Accessed 1 November 2021]

[8] ECVV, “CNC Hydraulic Metal Bending Machine”. (2021). [Online]. Available: https://www.ecvv.com [Accessed 6 October 2021]

[9] Shane, “Load Analysis and Driven Power Calculation”. (2022). [Online]. Available: https://www.machinemfg.com [Accessed 5 January 2022]

[10] Alibaba, "Manual Bar Bending Machine". (2018). [Online]. Available: https://www.alibaba.com [Accessed 7 October 2021]

[11] Indiamart, "Sheet Metal Rolling Process". (2021). [Online]. Available: https://www.indiamart.com [Accessed 15 October 2021]

[12] HARSLE, "Design sketch of hydraulic metal bending machine" (2019). [Online], Available: https://www.harsle.com [Accessed 20 December 2021]

[13] Rohan Pachange, Aravind Patil, Naveen Naik, Nagalingappa Ajmani, Pawan Bant and Prof. Shivaprakash. "International Research Journal of Engineering Technology". Journal of Engineering Technology, vol. 6, no. 7 July 2019. [Online], Available: https://www.irjet.net/archives [Accessed 11 October 2021]

[14] Mistry MakeTool, "How to make a Roller Bender". (2020). [Online], Available: https://www.mistrymaketool.com [Accessed 17 October 2021]