Design and Analysis of 3d CNC Bending Machine Prototype and Manufacturing It Using 3d Printing Technology

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***Abstract* - This project proposes automated 3d bending prototype. Till recently, most of the bending applications were performed manually and even if bending machines are available, they cannot be afforded. Manual bending has a huge tendency to create errors, thus affecting the efficiency of the for the specified treatment, in parallel with the elongation of the treatment time. It can simultaneously increase the bending time due to some additional major adjustments and leads to bender fatigue. In general, the accuracy of the bend is inconsistent and depends on many factors, totally on the expertise of the bender. Hence, due to these limitations in the manual bending and some urgency to decrease the dependency on the bender's competency, this project introduces a system that can be used to create any type of bends on with great efficiency with the help of a microcontroller based bending mechanism.**

***Index Terms* - 3d bending Machine, Low cost, Automation and Easy to operate.**

I.INTRODUCTION

Prototyping is a vitally important stage in the product development cycle. Prototyping tools allow designers and engineers to quickly and inexpensively create functional models, fixtures, or products. The market for these tools has grown immensely in the past 20 years. New additive technologies like 3D printing and. subtractive manufacturing tools like laser cutters and CNC mills and lathes allow fast and accurate Manufacturing of many different prototype components. These technologies allow designers to bring their ideas into the real world much faster than was previously possible. Despite their advantages, current rapid prototyping technologies are limited by the maximum sizes of parts they can create and their often-high cost.

Wire bending is another emerging method of manufacturing that has enhanced the ability of designers to make use of negative space and frames in assemblies. Performing market research and user interviews showed us that current wire bending tools are either very expensive or limit the user to two-dimensional structures. We believe that this market gap is often filled by a reasonable, desktop scale,3D wire bender. With this in mind, we were ready to develop the requirements that we felt were important to realize during a prototype version of this 3D wire bender.

II. OBJECTIVE

Current affordable, wire bending technology limits the user to two-dimensional structures. Other approaches to 3D bending have issues such as collisions and inconsistent feeding or are extremely expensive, so the objectives of this project are:

1. To develop an efficient and automated 3D wire bending machine.
2. To design and develop a cost-effective 3D wire bending machine.
3. To analyses the suitability of the 3D wire bending machine for various applications.
4. The 3D wire-bending machine with higher integration and production efficiency.

III. METHODOLOGY

The working of this 3d wire bending machine. So first, the wire goes through a series roller, or straighteners. Employing a stepper motor the wire is precisely fed to the wire bending mechanism which also uses a stepper motor for the bending process with the assistance of a plunger there is also another stepper motor, called the z-axis, which actually enables the machine to form three dimensional forms. Of course, the brain of the machine is an arduino board which along which together with the opposite electronics components are attached on a bespoke P.C.B

Fig.no.01- Conceptual Model

To make 3d bending prototype flowing steps where taken under consider

- Study on Related Research Paper
- Analysis of Research Paper
- Industry Survey
- Planning For Future Work
- Design And Drafting of Model
- Manufacturing
- Assembly
- Testing
- Submit

IV. CALCULATIONS

a) Force Calculations

For the design process we consider various material properties such as yield strength, ultimate tensile strength, etc.

Finding Out the Force For Bending The Prototype Material That Is Copper (C110) Of Yield Strength 120MPa

Consider,

M = Moment about neutral axis

σb = Bending stress

y = Perpendicular distance to neutral axis

I = Moment of inertia

L = length of bar from actual bend=100mm

W = F= Force

Let assume cantilever beam with point load, which acting at the lose end.

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

$$I = \frac{\pi}{64} X\, D4$$

Where D=3mm

$$I = \frac{\pi}{64} X\, 34$$

$$I = 3.9760mm$$

Copper(C110) Which Has a Yield Strength Is 120 Mpa

Syt=120N/mm2

Let the FOS BE 2

σb=Syt/2

=120/2

σb= 60 N/mm^2

Putting all values in

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

$$\frac{M}{3.9760} = \frac{60}{1.5}$$

M=159.04 N mm

Therefore

M=W X L

159.04=W X 100

W=1.59N

So, the force required to bend the rod in 1.59N

b) Torque Calculation for Bender Assembly

Consider,

D = diameter of rod =3mm

F = force required to bend the rod = 1.59 N

ө = angle of acting force = 90º

Za = number of teeth on pinion gear = 18

Zb = number of teeth on spur gear =30

Ta = torque of motor =686.46 Nmm

Tb = torque transmitted to spur gear =?

Tr = torque required = ?

To Find Required Torque (Tr) For Bending

Tr =F x D/2 Sin (ө)

Tr =1.59 x 3/2 Sin (90)

Tr =2.385 N-mm

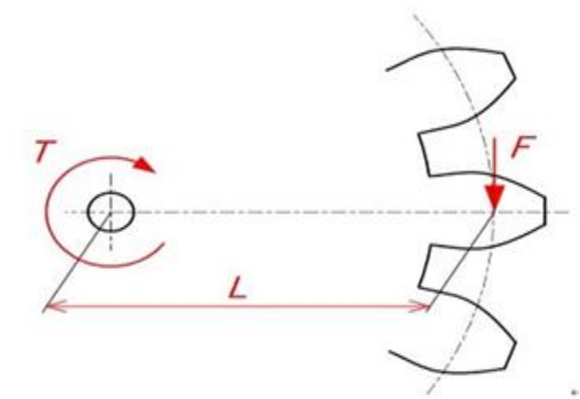
To find torque transmitted to spur gear (Tb)

Tb = ή (Zb / Za) x Ta

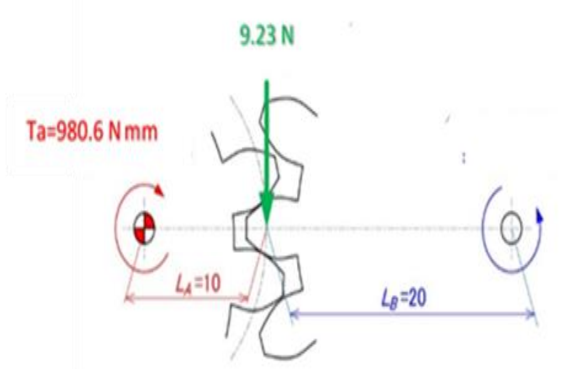
Tb = 0.95 (30 / 18) x 686.46

Tb = 1086.895 N-mm
i.e. (Tb=1086.895 N-mm) > (Tr=2.385 N-mm)

c) Calculation For Z Axis Assembly
Consider,
Ta = Motor's Torque = 980.665 N-mm
Za = Number of teeth on pinion gear=20
Zb = Number of teeth on spur gear=40
Pd = Pitch diameter of spur gear=60mm
F = Force (of bender assembly) =9.32 N
To find required torque (Tr)



Tr = F x R
Tr = F x Pd/2
Tr = 9.32 x 60/2
Tr = 279.6 N-mm



To find torque transmitted to spur gear (Tb)
Tb = ή (Zb / Za) x Ta
Tb = 0.95 (40 / 20) x 980.665
Tb = 1863.362 N-mm
i.e. (Tb=1863.362 N-mm) > (Ta=279.6 N-mm)

V. SOFTWARE DESIGN

Firmware and Computer Utility Design Based on the Need for a Reliable Communication Between a Computer and a Microcontroller on Prototype. It was clear that the easiest way to achieve this was to send text lines to Bus ports. While This Is Easy on The Firmware Side, Sending Full Text Files to Microcontroller It Can Be Hard to Do It Directly In Arduino Utility. Therefore, we needed a different system for sending text lines over a serial port. We have achieved this by using a c ++ based integrated design utility called Processing. We have created a simple interface that allows the user to select a specific type of text file on his computer, and then send that file line in line to the microcontroller.
Creating a text file format was the next step. We wanted the format to be simple and easy to understand for the user, while also easy to use and to determine which microcontroller detects these lines in serial communication. A simple folding language is created that contains only 5 commands: "begin," "end," "feed," "rotate," and "bend." The first two commands are formalities that go at the beginning and at the end of the file. The last three commands are device instructions that explain how it should work. The feed corresponds to several millimeters for the device to feed the wire, rotate the angular position entirely to degrees which defines the positioning of the head during bending, and the bend is at an angle of bending. These three commands must be followed by a colon, the corresponding number, and the line must end with a semicolon.

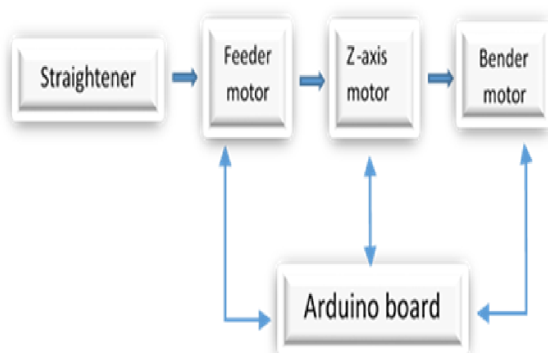


Fig 2 -Block Diagram

VI. TRIALS AND DISCUSSION

Experiments were performed on the 3D automatic bending machine and time was recorded.
Mechanical testing can determine how long it takes to complete one piece of the final product in working order. The full description is provided below:

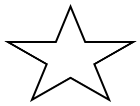
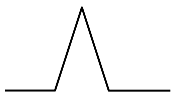
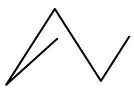
SR. NO.	Parts Name	PART DESIGEN	ROD DIA in mm	TIME in sec
1	Star		3	45
2	Square		3	22
3	V-Stand		3	12
4	3d V Stand		3	26

Table No.01 – Observation

The data provide insight into the relationship between required time to bend part in expected profile and dimensions of material which is to be bend. Loading and unloading of one piece almost takes only 5-8 seconds. Average time required for complete bending of forth component is about (26) sec. Taking into consideration machine workplace efficiency which is nothing but the collaboration of human worker with machine, it is comfortable to operate such machine because the total mechanism is automatically controlled.

Again, loading and unloading is not difficult since not any alternate tooling is used, it is very simple structure. By considering that, every component requires total time of (26) sec, so in one hour (140) final products can be made. Hence after effective working of 8 hours we can produce more than (1,107) components. The result of trial suggest that force required for bending is not constant for every component. For example, Force required to bend rod is diverse from the force required to bend rod.

VI. CONCLUSION

1. Design and development of 3d bending machine have been achieved successfully, in which the prototype is able to create any type of bend depending on the set point of the structure. This machine has been practiced implementing any bend using a wire with a 1 to 3 mm diameter made from S.S or Copper
2. Development of the algorithm programmed with this machine has proven that this algorithm is necessary for obtaining accurate products. The product accuracy has improved, the parameters of flange length, bending angle and bending radius witnessed an increase in its accuracy with respect to error rate from the standard measurements.
3. The precision of the product shows a high record, in which the proposed algorithm has helped to decrease the error rate in each parameter for all industrial operations. The overall accuracy has improved to be 96% after carrying out the proposed algorithm if compared with other machines that do not use the proposed algorithm.

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