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Design, Manufacturing and Testing of Feeding & Bending Mechanism

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With growing need of fast production to meet the requirement of industry, mass production machines like hydraulic, tracer control machine tool, special purpose automatic and semi-automatic machines were introduced with the advancement of technology. The use of these machines has considerably reduced the production costs by way of reduced machining time and labor cost. This has excited the research to develop another special purpose machine – CNC 2D rod bending machine. Presently available CNC 2D bending machine are very costly. The present research work focusses on developing a low-cost CNC 2D bending machine using pneumatic and single axis CNC system, capable of bending metal rod ranging from 3 mm to 6 mm diameter, in the length range from 1 foot to 8 feet, of rod material mainly stainless steel and mild steel with maintaining cladding material & appearance. The machine is not designed only but manufactured also. It sets the classical example of design for manufacturing.

***Keywords*:** Metal Rod Bending, Bending Mechanism, Feeding Mechanism.

1. Introduction

An automation industry is currently most booming industry for fast and easy production. Automation takes place in various product manufacturing. Automation has been covering many industrial applications like manufacturing, inspection, research and development, dispatch, material handling process, inventory control, food processing, medical, agriculture, power plants, automobile industries etc.

Metal rod bending machine means, “A machine which bends the rod by applying a specific angle consisting of different axis to control the feeding mechanism and bending mechanism by giving angle control.” Metal rod bending machines are classified into two different categories, one is 2D metal rod bending machine and another is 3D Metal rod bending machine. Both classifications are based on working of axis in bending machine. In 2D metal rod bending machine, two different axis are available; X axis as feeding axis of metal rod and Y axis as bending axis of rod. In 3D metal rod bending machine, one feeding axis and two bending axis, X axis as feeding axis, Y and Z axis are bending axis.

2. Literature

Authors of published technical papers highlight the mechanical design of the rod bending mechanism. Its related to the construction of rod, its structure and effect of a rod materials on different mechanical properties after bending. Feeding mechanism literature involves its components’ working behaviour while feeding the rod.

The feeding mechanism of bending machine is equipped with either a hydraulic system or pneumatic system in addition to an original power source providing to feed the rod. It is necessary to get an increment of the rod with high accuracy to eliminate the errors in the final

product. Servo pneumatic is utilized for the various industrial application to obtain position accuracy. Advantage of this device is cleanliness, high power absorption, easy maintenance, anti-explosive and long working life. [1] Nonlinear characteristics of the electro-hydro actuator results in a time-varying load uncertainty. That can be controlled by the approximate control model system which is integrated with position feedback control system. [2] Both systems have clamping devices for rod. The force for clamping the rod has to be optimum to stick with clamp while bending it. Pneumatic system does not require a feedback system. Therefore, Pneumatic system is cost-effective while hydraulic system involves high cost of the feeding mechanism.

Most of the literatures are dealing with analytical behaviour of bending the rod in bending mechanism. For example, if fabrication of coil from the metal wire is done then breath by height is affected. Small size of breath end increased and this portion should be machined after fabrication. Height is not affected compared with the breath. [3] Pre-tension force increases the parallel strength, but this strength effect is limited. [4] Bending moment increase as the increasing curvature in moment direction, that becomes unobvious and instability appears in product. [5] These parameters should be considered during the metal rod bending condition. As a bending mechanism component spur gear is the best cost-effective component. But the research relates to the vibration of spur gear is also important. Vibration can be reduced by linear function and periodic function model. [6]

3. Design, Manufacturing and Testing of Feeding & Bending Mechanism

3.1 Statement of Problem

Different mechanisms are available for bending operation. Various analysis has been done to improve the parameters of different component that should be handle the quality aspects. But some parameters like size of machine, cost, easy operating, easy assembly and easy maintenance have been recognize for the commercial use.

Design and manufacturing of compact size & lower cost CNC 2D metal rod bending machine which can maintain metal rod cladding and appearance.

3.2 Machine Details

2D Metal rod bending machine's specification that has been deal with different machine components. Some of the generalized component are base table, bending mechanism, feeding mechanism, operating system of bending mechanism, operating system of feeding mechanism, case cover of body, controller system and feedback system.

Above all are generalized component of 2D Metal rod bending machine which has required to design as per the application of machine. The major dimension of the machine is base table size, see Table 1. It is comparatively compact size with compared to available machines in recent market.

Table 1. Machine details

Sr. No.	Description	Dimension (Metric)	
1	Table Size	Length	1700 mm
2		Width	900 mm
3	Metal rod range	Diameter	2 to 6 mm
4	Metal rod range	Length	1 to 8 mm

The machine contains servo motor, pneumatic system for feeding the metal bar, proximity sensors and single axis CNC controller, also.

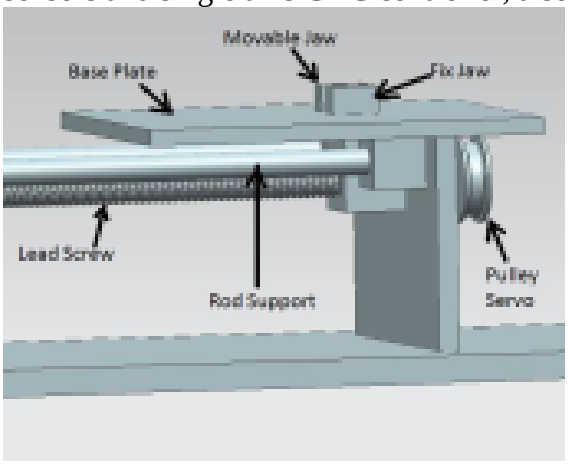

Fig. 1. Assembly of feeding mechanism

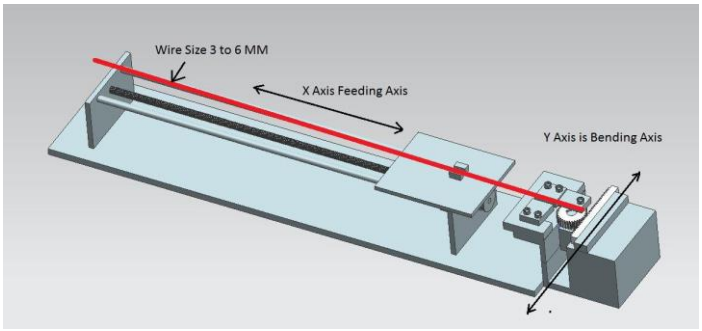

Fig. 2. Assembly of bending mechanism

Feeding mechanism is input mechanism for the machine. It feed the rod to the bending mechanism. It has to be designed simple with low maintenance cost. Designed feeding mechanism is shown in Figure 1.

Bending mechanism used to bend the metal rod by giving an angle. Development of this mechanism is very important for giving a low-cost solution. This mechanism satisfies the unique solution of machine as well as provide easy operating and low maintenance. The axes details are shown in Figure 2.

Fig. 3. Manufactured machine

Final assembly of machine is done with feeding and bending mechanism together with required components. It is shown in Figure 3. The final product of stainless-steel metal rod of diameter 6 mm which has to bend perfectly at 90° which is shown in Figure 4.

Fig. 4. Final bending metal rod

3.3 Analytical calculations of bending Mechanism

Case 1: 3mm diameter 250 MPa yield strength of MS Bar.

$$\partial b = \frac{MY}{I} \text{ Bending stress (Based on Yield stress limit)} \quad (\mathbf{1})$$

$$\partial b = \frac{FI}{I/y} = \frac{F*10}{(\pi/32)d^3} = \frac{F*10}{(\pi/32)3^3}$$

$$F_1 = \frac{250(\pi/32)3^3}{10} = 66.267N$$

Case 2: 6mm diameter 250 MPa Yield Strength of MS Bar.

$$\partial b = \frac{MY}{I} \text{ Bending stress (Based on Yield stress limit)} \quad \mathbf{(2)}$$

$$\partial b = \frac{FI}{I/y} = \frac{F*10}{(\pi/32)d^3} = \frac{F*10}{(\pi/32)6^3}$$

$$F_2 = \frac{250(\pi/32)6^3}{10} = 530N$$

Case 3: 3mm diameter 215 MPa Yield Strength of SS Bar.

$$\partial b = \frac{MY}{I} \text{ Bending stress (Based on Yield stress limit)} \quad (\mathbf{3})$$

$$\partial b = \frac{FI}{I/y} = \frac{F*10}{(\pi/32)d^3} = \frac{F*10}{(\pi/32)3^3}$$

$$F_3 = \frac{215(\pi/32)3^3}{10} = 56.990N$$

Case 4: 6mm diameter 215 MPa Yield Strength of SS Bar.

$$\partial b = \frac{MY}{I} \text{ Bending stress (Based on Yield stress limit)} \quad (\mathbf{4})$$

$$\partial b = \frac{FI}{I/y} = \frac{F*10}{(\pi/32)d^3} = \frac{F*10}{(\pi/32)6^3}$$

$$F_4 = \frac{215(\pi/32)6^3}{10} = 455.923N$$

These four cases finalize the required force that to be bend the metal rod. It needs to identify the pneumatic cylinder which will generate forces to bend the metal rod. Above forces calculated in equation 1,2,3 & 4 are generating from the Janatics A12 series pneumatic cylinder.

$$\text{Pressure} = \frac{Force}{Area} \quad \mathbf{(5)}$$

The A12 pneumatic cylinder generate 5 bar of pressure and it has 50 mm bore diameter. Equation 6 is showing the calculation of force for desired application. It has to be verified whether it is satisfying our requirement or not.

$$Fc = P(\frac{\pi}{4})d^2 = 0.5(\frac{\pi}{4})50^2 = 981.747N \quad \textbf{(6)}$$

Here, obtained result are shows that $F_C > F_1, F_2, F_3, F_4$. Therefore, required force Fc is satisfying the bending requirement. As per this force MS and SS rod of 3 mm to 6 mm can be bend properly.

4. Conclusion

The bending mechanism and feeding mechanism is safe design for the 3 mm to 6 mm metal road bending at 90 degrees. This machine is utilising mechanical components collaborating with the electronics components to generate interdisciplinary machine.

Important thing is to be notice that during the rod bending process there is no any descaling of the metal from the bent portion. It is big achievement. This machine has been applied in kitchen ware production successfully. It is observed that simple design of mechanism makes easy maintenance. This machine cost is nearly 35-45 % less than available bending machine in the recent market with same configuration. It is very clear to conclude that this special purpose machine satisfies the aim of bending the metal rod for the customer.

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