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ARDUINO 3D WIRE BENDING MACHINE

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Abstract- This project proposes automated 3D wire bending mechanism which is flexible and capable of making any type of bend for industry applications. This paper describes the problems in nowadays production of ribs, the most important assembling part of leverarch mechanism. The process of wire bending machine upgrade is presented and the control principle for ribs geometry stabilization is proposed. Till recently, most of the wire bending applications were performed manually and even if wire bending machines are available they can't be afforded. Manual wire bending has a huge tendency to create errors, thus affecting the efficiency of the wire for the specified treatment, in parallel with the elongation of the treatment time. Besides, 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, mostly on the expertise of the bender. Hence, due to these limitations in the manual wire 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 wire with great efficiency with the help of microcontroller based bending mechanism.

Keywords – *CNC wire bending, Concurrent engineering, Bend points planning, Bending code*

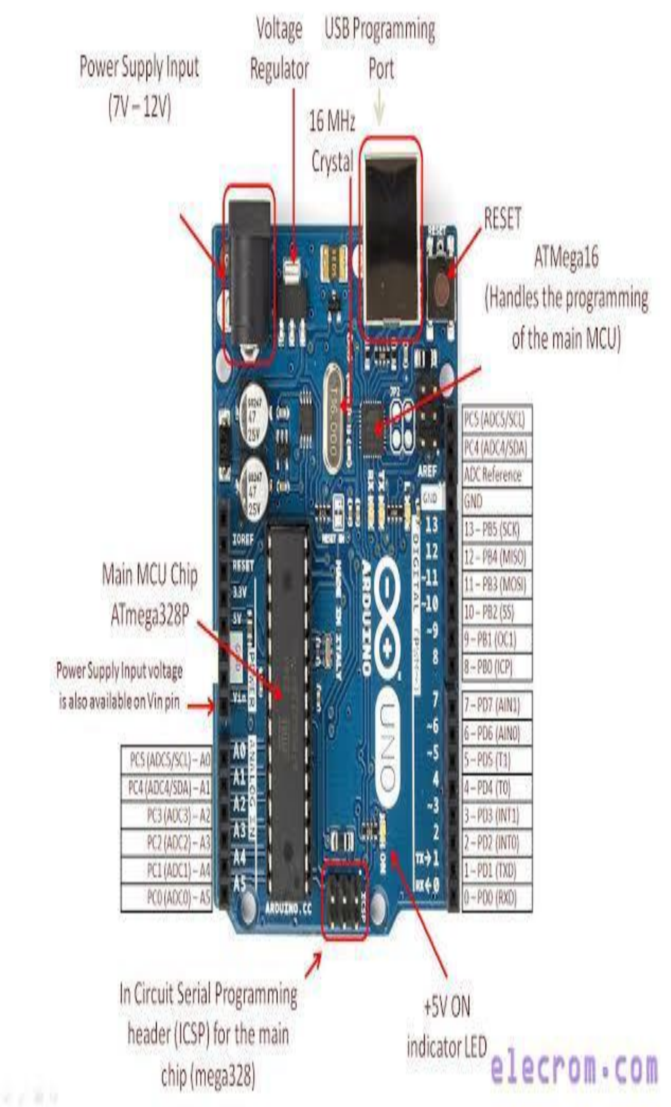
I INTRODUCTION

Based on features of any shape of wire with complex geometric patterns, a method for modelling 3D wire is proposed, and the machining simulation of the 3D wire and collision detection between the wire and the machine are introduced. By using double buffering technology, we obtain smooth animation during the off-line machining simulation Prototyping is a vitally important stage in the product development cycle. Rapid 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 can be filled by an affordable, desktop scale, 3D wire bender. With this in mind we were able to develop the needs that we felt were important to achieve in a prototype version of this 3D wire bender.

Initial prototyping is a vitally important step in the product development cycle. The completion of a successful prototype often dictates whether a project will continue to be pursued or if development will be halted altogether. In addition to identifying issues with the current design, prototypes present investors and potential customers with physical proof of a concept's feasibility. After realizing the significance of prototyping, it becomes vital for any start-up company or entrepreneur to have robust, accurate, and versatile rapid prototyping tools. An affordable tool like these reduce the overall timeline of a project, minimize overhead costs, allows for more in-house development, and in general allows firms to get products to market faster and with more confidence in their designs.

The industry for rapid prototyping tools has greatly expanded in the last twenty years. Additive manufacturing, for example, is one of the most recognizable and popular methods for designing and creating complex shapes. 3D printers have become smaller and more precise, allowing everyday users to create parts that, forty years ago, professional machinists would have great difficulty milling or turning on a lathe. Despite the numerous advantages to additive manufacturing, there are some marked drawbacks. Printing support material is often necessary to avoid distortion of the desired shape. This material can be difficult to remove after the print has finished, or require submerging the part in water or chemicals to dissolve soluble support material. Also, maximum part sizes are determined by the size of the print bed and the maximum height difference between the bed and the extruder nozzle.



Another type of rapid prototyping is known as Subtractive Manufacturing. Laser cutters, CNC mills, lathes, and water jets are a few examples of this technology. Many of these are essential tools for artists and engineers alike, allowing complex shapes to be cut and replicated easily out of versatile materials like plastic, wood and metal. These rapidly manufactured parts bring a designer's ideas into reality much more rapidly than was previously possible, and thus move the design process along faster and more productively. However, subtractive manufacturing has disadvantages as well. Beyond these tools being extremely expensive, parts are usually constrained to two dimensions. Laser cutters can sometimes distort edges of parts they create due to refraction of the laser in the media. Part sizes are also constrained to the maximum x, y, and z positions of the laser head or cutting bit.

1.1 PROBLEM STATEMENT

"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.

To overcome these issues to design all the parameters our team will attempt to create a prototype capable of consistently bending a wire in 3D while avoiding collisions." Such a design can be obtained via automatic or semi-automatic curve feature extraction from a 3D shape.

1.2 OBJECTIVES:

A. Main objective of this project is to increase spring production. Manual wire bending has a huge The tendency to create errors, thus affecting the efficiency of the wire for the specified treatment, in parallel with the elongation of the treatment time.

B. To develop efficient and automated 3D wire bending machine

C. To design and develop cost-effective 3D wire bending machine.

D. To analyses the suitability of the 3D wire bending machine for various applications

E. The 3D wire-bending machine with a higher integration and production efficiency.

II LITERATURE STUDY

TANG Wenxian, ZHU Hui , ZHU Mengxiu , LI Qinfeng , ZHANG Jian. Etal(2011),They studied on the wire-bending process, developing a DC wire-bending machine which is used to bend the wire to any angle. The DC wire-bending machine with a higher integration and production efficiency contained storing mechanism, straightening mechanism, feeding mechanism and wire-bending mechanism. The storing mechanism can be reset by itself without being adjusted manually when the feeding speed is different from the receiving speed of the processing equipment. The wire-bending mechanism for double-heads can achieve asymmetric bending. The clamping device of wire-bending mechanism is more stable and higher rotational accuracy.

Chen Minghui , Yao Bin , Lin Rongkun , Lu Rusheng .etal(2011) Based on features of any shape of wire with complex geometric patterns, a method for modelling 3D wire is proposed, and the machining simulation of the 3D wire and collision detection between the wire and the machine are introduced. By using double buffering technology, we obtain smooth animation during the off-line machining simulation. The computational cost of a collision detection algorithm is decided not only by the complexity of the basic interference test used, but also by the number of times every test is applied. To simplify the collision detection algorithm, an approximate method of representing wire model and machine model by using line segments and planes is applied.

HenrikLavric, MiroslavBugeza, RastkoFiser,etal(2011) They studied on the problems in nowadays production of ribs, the most important assembling part of lever arch mechanism. The process of wire bending machine upgrade is presented and the control principle for ribs geometry stabilization is proposed. The overall control scheme consists of inner - force control loops and outer – geometry control loop. The inner loops control the force on respective roller of the horizontal and vertical plane of wire straightener according to the predefined reference values. These values are modified with the superior loop in respect of geometry variations of the rib. Required displacements of rollers are obtained using wedge systems driven by stepper motors. The final geometry of rib is analyzed by image processing algorithm inside the image acquisition system.

Rahimah Abdul HAMID, and Teruaki ITO. etal(2018), They studied the idea of adopting CNC wire bending technology into dentistry wire bending. Till recently, the dentistry wire bending is traditionally performed in the hand-made operation. Innovations in the field of archwire bending in orthodontics have been reported which use robots to execute the desired wire bending operation. In contrast, CNC wire bending technology has not been successfully explored. In this regard, the manufacturing workflow which integrates CAD/CAM into the system is proposed. In addition, several interfaces to execute the bend points planning for different cases are introduced. The B-code generation program, which automatically converts the XYZ Cartesian coordinates for each bend point into the desired theoretical wire bending parameters (L, β, θ) has been developed with no consideration of the material properties. The feasibility of this methodology is demonstrated through an example, starting from the bend points planning, follows by the XYZ coordinates extraction and ends with the B-code generation. Moreover, the graphical simulation of the wire bending operation by the designed mechanism is also presented.

G. Antherieu , N. Connesson , D. Favier , P. Mozer , Y. Payan. Etal(2008) In this work, a new principle using two universal joints is proposed and developed to enable such pure bending conditions. This principle has been applied to design an apparatus suitable to test small size samples (such as wires of diameter < 1 mm) at small curvature radii (5 mm) and to specifically provide small size samples moment-curvature relationship. This article underlines and validates the abilities of this new apparatus by performing and analyzing tests on samples made of well-known material.

An innovative principle to perform pure bending at high deformation and allowing large displacements for specimen extremities has been proposed. This principle has been applied and an apparatus has been developed and tested. This apparatus is a tool to experimentally identify material moment-curvature relationship. The errors associated with the apparatus and with the measurement methods are estimated to be: 10−4 Nm on the bending moment measurement, and 0.08 % on the global radius of curvature. The bending apparatus has been tested on small samples (wires with a diameter of 0.5 mm) made of conventional work-hardened steel and copper. In both cases the curvature uniformity along the sample proved the device ability to apply pure bending load to specimens. The measured bending moments versus curvature were also analyzed and proved to be consistent with literature and theory. The apparatus was thus able to provide reliable experimental results at small curvature radii (5 mm). This pure bending apparatus will be used for further investigations, such as determining specific material behavior in bending.

Hyun-Deog Cho, Sung-Jong Choi .etal(2014) ,CNC wire bending machines are used in industries to make a type variety of wire products such as long links. The machines have a long arm device to rotate in order to remove forming errors by flexibility of wire. Generally, the machines which constructed servo motors in the arm have the rotating range of the arm under360 degree because the servo motors connect with fixed control devices on frame by many cables. The rotating angle under 360 degree limits working speed and forming geometry. Therefore this study developed a gear train to drive parts in arm and to be independent on arm rotation movement. The developed gear train can transfer four movements to four components in arm and is consists parallel of four pairs of satellite gear trains. This study constructed the CNC wire bending machine with the developed gear train and verified that the gear train could drive internal components independently on arm rotation.

The following conclusions were drawn from the development:

1. Rotation of the arm has no effect on the movement of the internal parts. A gear arrangement that does not strike is developed.

2. Gear arrangement of drive system can be arranged in parallel Applied to many internal parts movement by developing.

3. Calculation of the number ratio and CNC wire bending machine the validity of the developed drive system was verified through operation.

4. CNC wire bending machine with developed drive can rotate the arm at an infinite angle to speed up work could move internal parts motion directly from servo motor. It can be seen that precise power transmission is possible because it can be controlled.

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III 3D MODEL

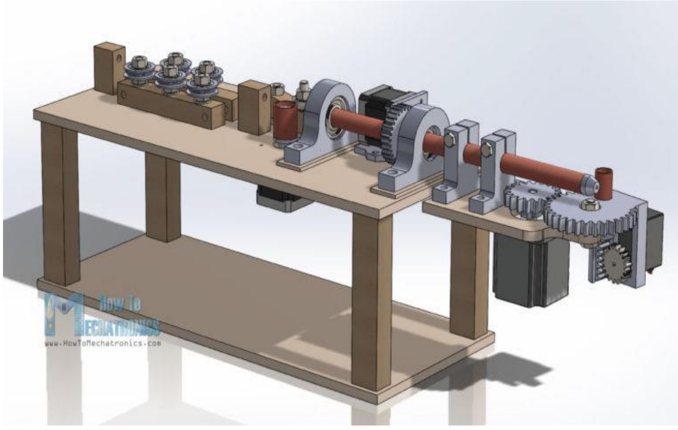

Figure 1: 3D Model

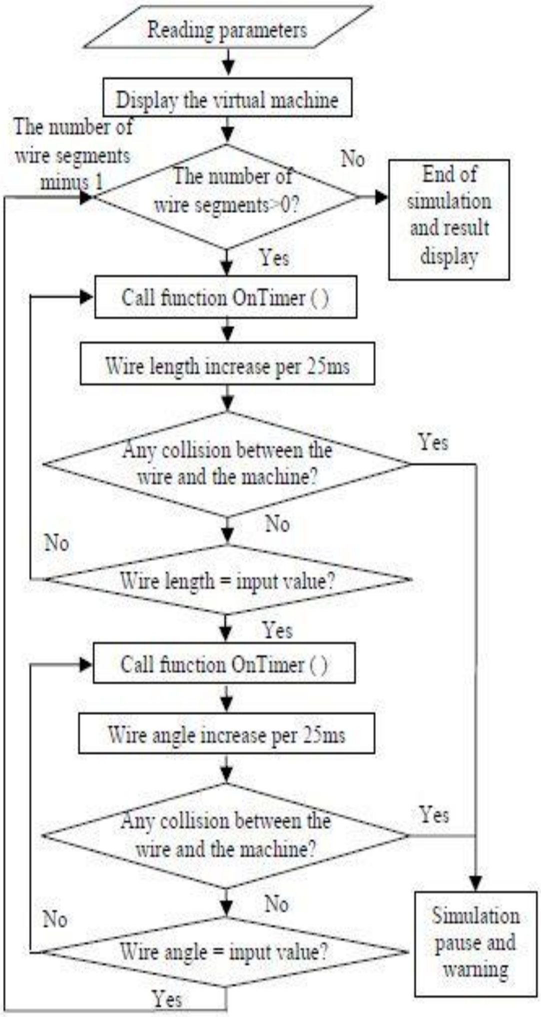

Figure 2. Work flow for the simulation process

IV THE IMPLEMENTATION OF MACHINING SIMULATION

When the simulation starts, the timer also begins to work. For example, when the timer is set as SetTimer (1, 25, NULL), it means the programme sends WM_TIMER message per 25ms. In the meantime, the variable Dis [T].L for wire length increases automatically, leading to increase of relevant variables of function DrawCartoon( ). In other words, for every 25ms, the wire length grows a bit. These increases look continuous to human eyes due to the duration of vision. Fig. shows the machining simulation at different time.

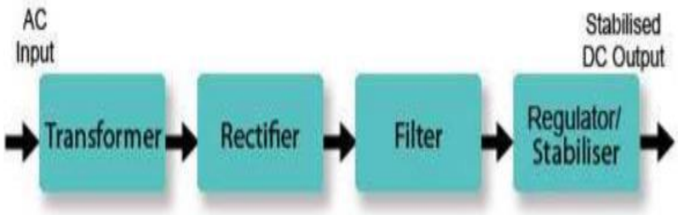

Figure 3 . Power Supply Block Diagram

V WORKING OF WIRE BENDING MACHINE

I continued with preparing the other parts, for which We used MDF and plywood. So once We took all dimensions from the 3D model, using a circular saw, We cut the pieces to size. We used 8 mm tick MDF and 18 mm tick plywood. Once We got them ready We started with the assembly. First We made the base out of two MDF plates and 4 plywood columns. For securing them We used a wood glue and some screws. Next on the top panel We attached the 3D printed bearing pillow blocks using some 8 mm bolts and nuts. We can notice here that We added 3 mm tick MDF plates between the top and the pillow blocks so that We get the proper height. Now in these blocks we can fit the 6202 bearings.

Stepper Motor – NEMA 17 The stepper motors are the most common type of actuators used in 3D printers. Ease of use and high precision without the need for high end feedback sensors make them suitable for 3D printing. Unlike standard electric motors, these motors do not rotate continuously, but move in a step-by-step fashion. To drive a stepper motor, a stepper motor driver is required. 3D Printers use four stepper motors – one for each of the three axes and one for the extruder. Most of the stepper motors have a step angle of 1.80. 1.80 step angle per full step is a commonly used step rating and is equivalent to 200 steps per revolution. Some 3D printers use larger step angle motors for higher speed, whereas for accurate printing, a lower step angle is needed. But this can lower the speed of operation.

The size of the motor is indicated by its NEMA number, which indicates the length of its faceplate. The NEMA number is the length or diameter in inches multiplied by 10.Larger motors can deliver more power and require more current and a larger driver. Stepper motors are available in a range of sizes. NEMA 17 is commonly used for 3D printers. Very small motors are used in robotics and animation systems. Larger motors are used in industrial and CNC machines. NEMA 17 motor has a diameter of 1.7 inches. For a square shaped NEMA 17 motor, the length of side is1.7” . The NEMA number also specifies the mount type code, length, phase current, insulation class, maximum allowable operating temperature, phase voltage, steps per revolution, and the type of winding code. NEMA DDMMLLLCCCIVVVSSSW is the full NEMA description. DD denotes diameter in inches, MM is the mount code, LLL is length, CCC is phase current, We is insulation class, VVV is phase voltage, SSS steps per revolution and W is a winding code. For example, NEMA34D018-012A053200F indicates that the stepper motor has 3.4” diameter with a flange of 1.8 inches long, has 1.2 amps phase current.

VI CONCLUSION

The upgraded wire bending machine was in full operation for almost three years. The assessment of the fall-out of completed leverarch mechanisms on the assembly line that was fed up with ribs from upgraded machine dropped from some 10 % to some 2 %. Second improvement was done in the visual appearance of ribs.

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