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Design and Fabrication of 3 Axis Welding Robot

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Abstract*: Robot is a machine that collects the information about the environment using some sensors and makes a decision automatically. People prefer it to use different field, such as industry, some dangerous jobs including radioactive effects. In this point, robots are regarded as a server. They can be managed easily and provides many advantages. A robot arm is known manipulator. It is composed of a set of joints separated in space by the arm links. The joints are where the motion in the arm occurs. In basic, a robot arm Consists of the parts: base, shoulder, wrist and end effector. The base is the basic part over the arm, it may be fix or active. The joint is flexible and joins two separated links. The link is fix and supports the wrist. The last part is an end effector. The end effector is used to hold. Vibration is the physical movement or oscillation of a mechanical part about a reference position. The Static analysis is not difficult to analyses. It is solved by analytical method.

***Keywords*: 3-axis welding robot, static analysis.**

I. INTRODUCTION

Automation plays a major role in growth and development of any industries. It helps in improving the quality & productivity to a greater extent. A robot is programmable computer capable of carrying out a complex series of actions automatically [1]. Robots can be guided either by an external device or by embedded controller within. Welding is a process, where in two materials are fused together through heating and then cooling the materials to form a strong joint. Gas Metal Arc Welding (GMAW) or MIG [2], Gas Tungsten Arc Welding (GTAW) or TIG, Flux Core Arc Welding and Stick Welding are the most common found types in industrial environments [3]. The problems of human welding process are poor gas coverage leads to contamination, welding aluminum in the wrong polarity, weld graininess, lack of fusion and etc. The welding robot troubleshooting this kind of problem [4]. The advantages of this robot are faster, consistent cycle times, no break in production and better weld quality. Hence the objective is to design and fabricate a 3-axis welding robot to improve welding quality at low cost. To automate the welding process whereby increase accuracy, speed and productivity [5-9].

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Actual market conditions are compatible with small/medium batch manufacturing, due to strong competition and dynamic market behavior [10, 11]. In these conditions, robotic production setups exhibit the best "cost per unit" performance if compared with manual work and hard automated setups is shown in Fig.1.

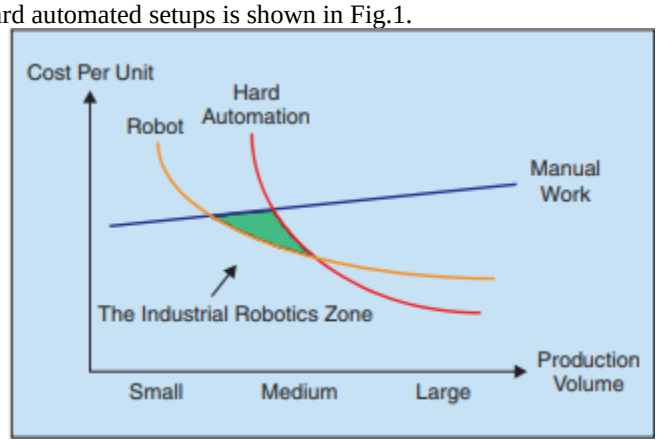

Figure 1. Industrial robotic zones.

Consequently, in the near future, powerful and more flexible machines will be required in order to handle requests from small businesses, which need more remote interfaces, powerful programming languages, force control, powerful advanced programming interfaces (APIs) for high level programming [12-15]. This means exposing the user to the flexibility stored (and barely used) inside the machines as a result of several decades of engineering as shown in Fig.2.

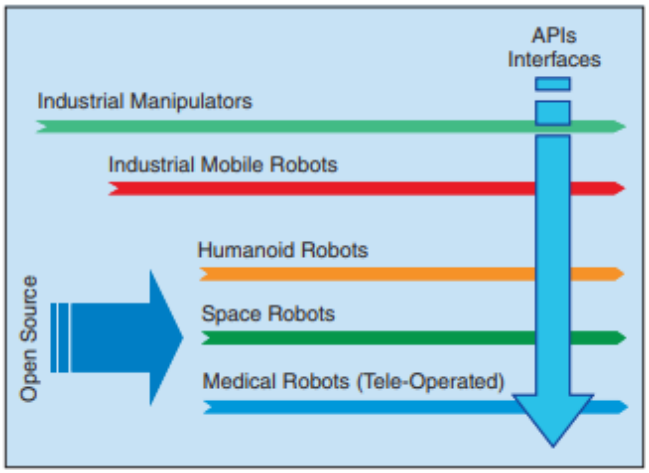

Figure 2. Traditional robotics and requirements of new research.

II. PROPOSED METHODOLOGY IN WELDING ROBOT DESIGN

The design and fabrication of a 3-axis welding robot with TIG welding interface is carried out by using an Arduino ATmega2560.

The design of a 3-axis welding robot starts with preparation of 2D CAD model as per the design to finalized dimension. The Mechanical structure of the robot model is fabricated using polycarbonate sheet and the axis manipulators are implemented using stepper motors. The entire process is controlled using a Arduino controller.

The programming is done using Arduino Software; a LCD display interface is used to indicate axis operations. The keypad interface is used to axis movement with respect to welding target. The welding path of two target point is stored in the Arduino controller. The end effector is customized to come with welding torch and automatic wire feeder assembly setup to suit welding process. We have chosen Metal Inert Gas Welding (MIG) method for our project. The entire process can be automated for continuous welding.

III. ESTABILISHMENT OF MECHANICAL HARDWARE

In this design, a model has created by using the Cre-O software. And the components are polycarbonate sheet it's like the thickness of the sheet is 8mm, Bearing, Arduino Atmega 2560 controller, Stepper motor, LCD Display, and keypad.

A. Polycarbonate Sheet

Polycarbonates are a group of thermoplastic polymers containing carbonate groups in chemical structures. Polycarbonates used in engineering are strong, tough materials, and some grades are optically transparent. They are easily worked, molded and thermoformed. Because of these properties, polycarbonates find many applications. Polycarbonates do not have a unique resin identification code (RIC) and are identified as "Other", 7 on the RIC list products made from polycarbonate can contain the precursor monomer bisphenol A (BPA). Polycarbonate is a durable material. Although is high impact resistance, it has low scratch-resistance. Therefore, a hard coating is applied to polycarbonate eyewear lenses and polycarbonate exterior automotive components. The characteristics of polycarbonate compare to those of poly methyl metacrylate (PMMA, acrylic) but polycarbonate is stronger and will hold up longer to extreme temperature. These young`s modulus around to nearer the steel still 2.0-2.4 Gpa (polycarbonate).

B. Stepper Motor

A stepper motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor`s position can then be commanded to move and hold at the one of these steps without any position sensor for feedback (an open loop controller), as long as the motor is carefully sized to the application in respect to torque and speed.

Brushed DC motor rotate continuously when DC voltage is applied to their terminals. The stepper motor is known by its property to convert a train of input pulses (typically square wave pulse) into a precisely defined increment in the shaft position. Each pulse move through a fixed angle. The stepper motor is divided based on application we choose the either Bipolar or Unipolar motor. Bipolar motor have a single winding per pulse. The current in a winding needs to be reversed in order to reverse a magnetic pole, so the dividing circuit must be more complicated; typically with an H-bridge arrangement (however there are several off the shelf driver chips available to make this a simple affair). There are two leads per phase, none are common.

C. Arduino Atmega2560

Arduino is open source computer hardware and software company and user community that designs and manufactures single-board microcontrollers. Also the microcontroller for building digital devices and interactive objects that can sense and control objects in the physical world. The project`s products are distributed as open-source hardware and software, which are licensed under the GUN Lesser General Public License (LGPL) or the GNU General Public License (GPL) permitting the manufactures of Arduino boards and software distribution.

S.No	Components	Materials	Size
1	Mechanical Setup	Polycarbonate	Length =55cm Breadth=10cm Height =33.5cm
2	X-axis Lead Screw	Acrylic	Length =23.5cm Diameter =2cm Pitch =0.2cm
3	Y-axis Lead Screw	Acrylic	Length =23.5cm Diameter =2cm Pitch =0.2cm
4	Z-axis shaft	Acrylic	Length =4cm Diameter = 2cm
5	Shaft Mountings	Mild Steel	Inner.Dia =25mm Outer.Dia=50mm Bearing =Roller

Table I. Details of mechanical components.

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM output), 16 analog inputs, 4UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a rest button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila. The Table I gives the complete details of mechanical component utilized for fabrication of hardware setup.

D. CAD Modeling of Mechanical Hardware

The modeling is conducted in CAD software to establish the schematic representation of the proposed design of welding machine. The modeling analysis is done in both 2D and 3D category to observe the mechanical hardware interface. The Fig. 3 and 4 shows the 2D design side and front view of the mechanical setup.

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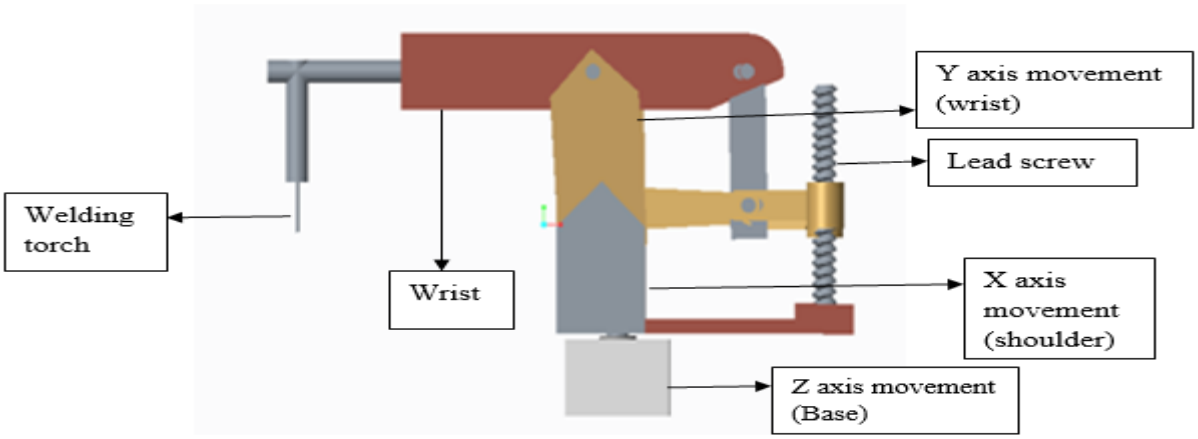

Figure 3. Side view of CAD modeling in 2D design.

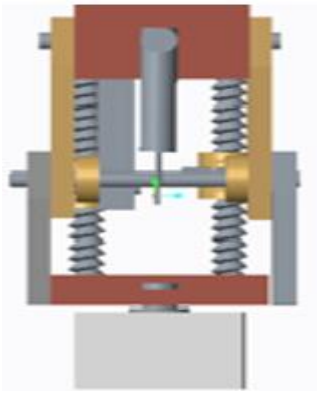

Figure 4. Front view

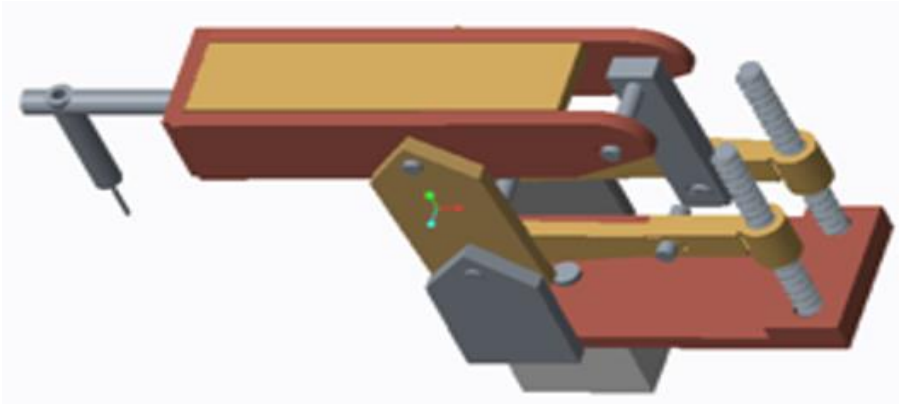

Figure 5. CAD modeling of 3D design

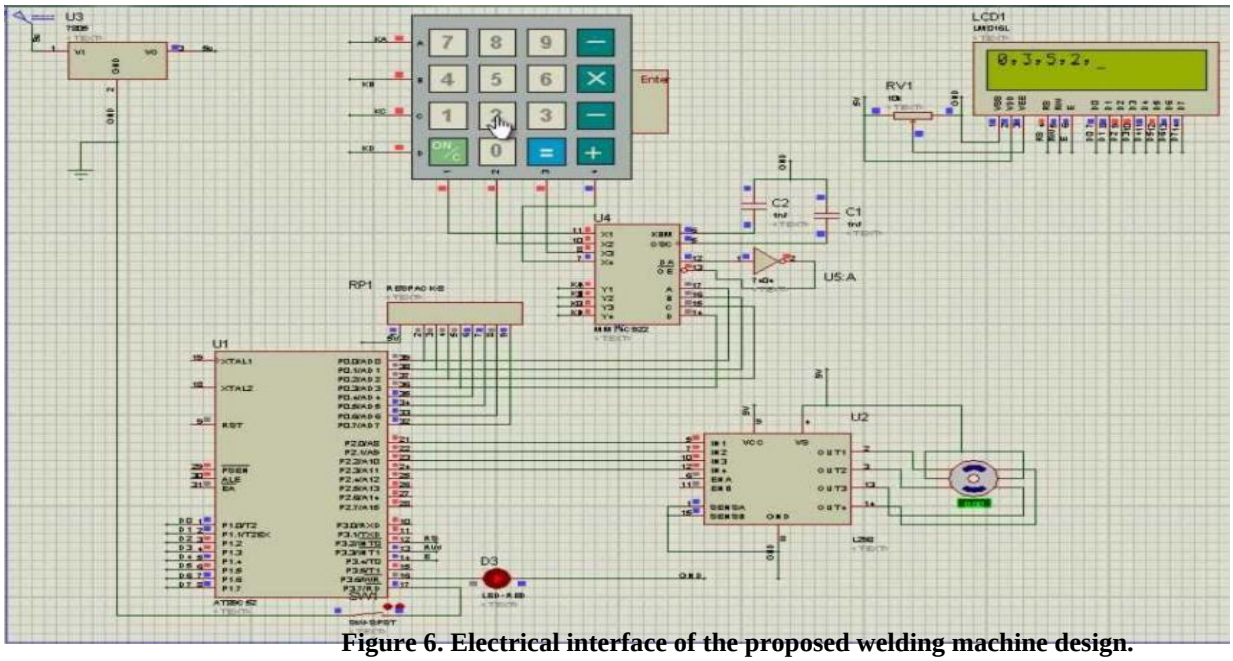

Figure 6. Electrical interface of the proposed welding machine design.

The Fig.5 infers the machine design structure shown in 3D view. The undertaken mechanical components are grouped together and complete analysis is verified.

IV. DESIGN OF ELECTRICAL INTERFACE

E. Motor Torque Calculation

As per the design of mechanical system, the x-motor and y-motor has to carry the maximum weight of 1.5kg and z-motor has to carry the carry the maximum weight of 2.5kg.

Power is given by

P= (2*3.14*N*T)/60

Here we take the motor rating current and voltage in the datasheet with prescribed ranges.

V=2.8 volt
I=1.68 amps
P=V*I
P=2.8*1.68
P=4.704 watts
T=P*60/(2*3.14*N)
T=4.704*60/(2*3.14*200)
T=0.225 N-m or 2.25 kgcm
Hence the motor with the torque of 2.25 kgcm is enough to drive the load and lead screw. The electrical design analysis conducted in proteus software is shown in Figure 4.

F. Motor speed calculation

The proposed work is in need of linear relation between the travelling distance and the time taken for its travel which uses 1.8degree per pulse 5kg torque stepper motor.

G. X-Axis and Y-Axis Stepper Motor Calculation

The implemented motor are convert the rotational into linear movement of the lead screw
1 pulse =1.8 deg
360 deg =200 pulse
360 deg =2mm for lead screw travel
1mm =180 deg per 100 pulse

H. Z –Axis Stepper Motor Calculation

The motor is directly to mounted in the shaft
1 pulse =1.8 deg
360 deg =200 pulse
5deg= 9 pulse
The Atmega 2560 microcontroller is connected to the motor drive, LCD, keypad. The x axis motor drive is connected to port pin A0 to A5. The y axis motor drive is connected to port pin A8 to A13.The z axis motor drive is connected to port pin 2 to 7. The keypad is connected to the Atmega2560 port pin from 23 to 37 and the LCD is also connected to the port pin 22 to 32.

V. WORKING PRINCIPLE OF PROPOSED DESIGN

The overall project image as shown in the Fig.7 and the axis movement of the robot to teach the keypad matrix and stored the values in the controller. Here the base plate for rotation about the Z-axis. This axis to teach in the keypad The welding robot to follow the path and welding the target. Compare to the convention method the welding process is accuracy and sequential operation are done this process.

VI. CONCLUSIONS & FUTURE SCOPE

The proposed design can be developed by interfacing the Atmega 2560 is successful to teach the welding as per the target points and only incremental mode of operation. The 3 axis welding robot is programmed by using an embedded program. The welding of operation is better than the convention method of operation**.**
The proposed methodology is only suitable an incremental mode of the welding operation. The stepper motor is only to work the open loop mechanism and accuracy is less compared to the servo motor. The further addition of the 3 axis welding robot is attached to a linear axis in the wrist. So the linear welding to achieve to their axis to addition. The Atmega2560 is consists of small amount of the memory, RAM and its work for maximum 2 hr operation. So the replace the controller by PLC is a better memory, RAM, and its work for based on the PLC capacity.

(B+ve is denoted the incremental and B-ve is decrement). The shoulder for linear movement along with X-axis (S+ve is denoted the incremental and S-ve is decrement). The wrist for linear movement along with Y-axis (W+ve is denoted the incremental and W-ve is decrement).

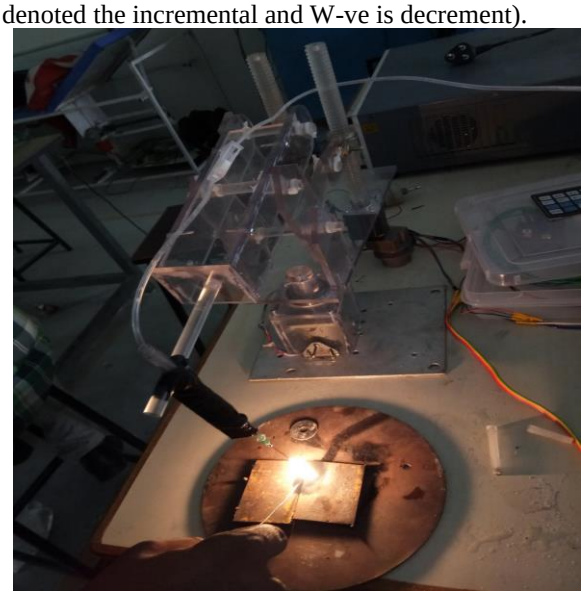

Figure 7. 3-axis welding machine working model

The P1and P2 points are to welding path stored to the controller by using teaching method. The welding torch has placed the end of the wrist and to regulate the gas. Here using the welding is calcium carbonate and water reaction. The start button is used to weld the path of the workpiece. The HW, HS and the HB are home position of all the axis.

I. Results and Discussion

The proposed 3-axis welding machine design successfully controls the 3 axis welding machine with teaching each axis by using the keypad. All the axis movements teach the axis with the starting and ending of the target to store in the Atmega 2560 microcontroller. Hence, the welding operator needs to know the two object weld and shortest path to carry following and correspondingly to weld the robot. The welding is constructed conventional method into the automated field in Robotics area. Because the production line to weld the object with the conventional method is not accurate.

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