Design and Development of Articulate Robot for Machine Tending Applications

[1]Manjunath N, [1]Shaik Thahir Basha, [1]Kiran pattar, [1]Patan ayub khan, [2]Manjunatha G
[2] Assistant Professor, School of Mechanical Engineering, REVA University, Bengaluru, India

Abstract— The Robot is a mechanical device that can be defined as an automatically controlled, re-programmable, multipurpose manipulator in three or more axes (in three or more DOF), which may be either fixed or portable. Robots are now more than an electro-mechanical machine, as robots that control by a program or circuit to become the solution of the future as customer's demand. The automated glass handling robot, is one of the pick-and-place robot that are widely used in manufacturing industry. It is equipped with robotic arm and conveyor that not only speed up the process, which increases production rates, but it is also more accurate and do not fatigue. Glass handling robot also can perform task within a few seconds of cycle time by giving certain commands. The implementation of automated glass handling robots in the industry indeed enhances production capability and increase profitability. Robotics and automation is employed in order to replace human to perform those tasks, that are routine, dangerous, dull and in a hazardous area. In a world of advanced technology. Today automation greatly increases production capability, improve product quality and lower production cost. It takes just a few people to program or monitor the computer and carry out routine maintenance.

Index Terms— Tending, Articulated Robot, DOF, microcontroller, stepper motor, pick and place

1 Introduction

Articulated Robot is the robot which mostly comes to the mind when we think about industrial robots. This is because articulated robots are the most common robot type used in industrial settings. Articulated robots are defined as robots containing rotary joints. These joints are commonly referred to as axes in the robotic world. Articulated robots can be as simple as a two axes structure or complex with ten or more axes. Most industrial robots have four to six axes, with six axis being the most common. Articulated robots provide more degrees of freedom than any other robot type, which is why they are commonly utilized amongst manufacturers. Their enhanced range of motion closely mimics that of a human's, making them ideal solutions for production lines. The basic definition of tending is, the work of providing treatment for someone or something. In this particular case machine tending would be to load and/or unload a given machine with parts or material. Currently most of the applications involving machine tending are done by humans. Most machine shops are using their human workforce to load and unload machines and to restart the program once the finished part is out of the way. However, since qualified workers are becoming harder and harder to find, companies are introducing robots into their workshops to make up for the lack of employees.

1 .1 ROBOT HISTORY

The concept of artificial humans predates recorded history, but the modern term robot derives from the Czech word 'Robota' ("forced labour" or "serf"), used in Capek's play R.U.R. (1920).

The word robotics first appeared in Isaac Asimov's science-fiction story Runaround (1942).Along with Asimov's later robot stories, it set a new standard of plausibility about the likely difficulty of developing intelligent robots and the technical and social problems that might result. Runaround also contained Asimov's famous Three Laws of Robotics

2 LITERATURE SURVEY

Ganesan .A et al, [2015] said that articulated robot also called jointed arm robot are robot with more than two rotary joints and can be up till 17 joints. The rotary joints in this type of robot allow full range of motion through multiple plans. For straight line motion along any of the three coordinate X, Y, Z axis, the robot require minimum of three joints. Due to all the joints are in rotation, the robot can perform very precise and exact movement compare to others type of robot. The robots also have two main variant, horizontal articulated robot and vertically articulated robot. [1]

S.Pachaiyappan et al, [2014] shows the main interest of articulated robot are to protect workers in confine space such as highly contaminated areas or hostile environments. As studied by Tian Hao (2016), the advantages of robot are such as occupies minimum of floor space, achieve deep horizontal reach, high flexibility and dexterity. Extensive experiment have been carried out by using analytical method, providing an obstacle and use a machine learning method to compute an approximate model of their obstacle regions. Another sample application of articulated robotic arm is surgical robot. Surgical robots are robot use in medical field, the robots require having very precise and safe performance. [2]

Supriya saahu and B.B choudary [2019] stated that Vibration characteristics of the model such as natural frequency and mode shape are determined by means of modal analysis in FEA. The requirement of more capable material leads the modal analysis in systems like industrial robots. The occurrence of crack or damage in any engineering structure, rotating machines, causes premature failure and creates different operational problems. One of the criteria for fault detection is the change in dynamic behavior of structures. Due to the presence of crack, alteration of parameters such as the natural frequencies, mode shapes, and amplitude of vibration takes place. In this present experiment, an effort has been made to explore the behavior of cracked robot. In order to achieve the three mode shapes of robot with and without crack has been analyzed.

In stress analysis, Optimized structural design for the structures of the industrial robots has to meet criteria regarding dimensional design and shape, material consumption and adapt this to the functional requirements. For an optimized design of the robot structure, all the aspects of industrial applications where the structure will be integrated are considered. The results achieved for maximum shear stress for each load applied. The analysis on deformation and stress of the structure gives the idea about life, damage, and failure of robot. The shear stresses for six different gripper loads are founded. The bottom part of the structure having the lowest value of shear stress and the top part of the structure shows the maximum value of shear stress. The maximum value of shear stress obtained is for 125 N which is near the gripper. Taking these output values of shear stresses, a graph has been plotted by taking load (N) in x-axis and shear stress (Pa) in y-axis. From the graph, it is seen that as load increases the shear stress increases uniformly. [3]

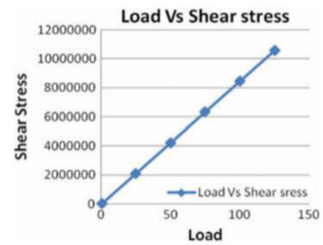


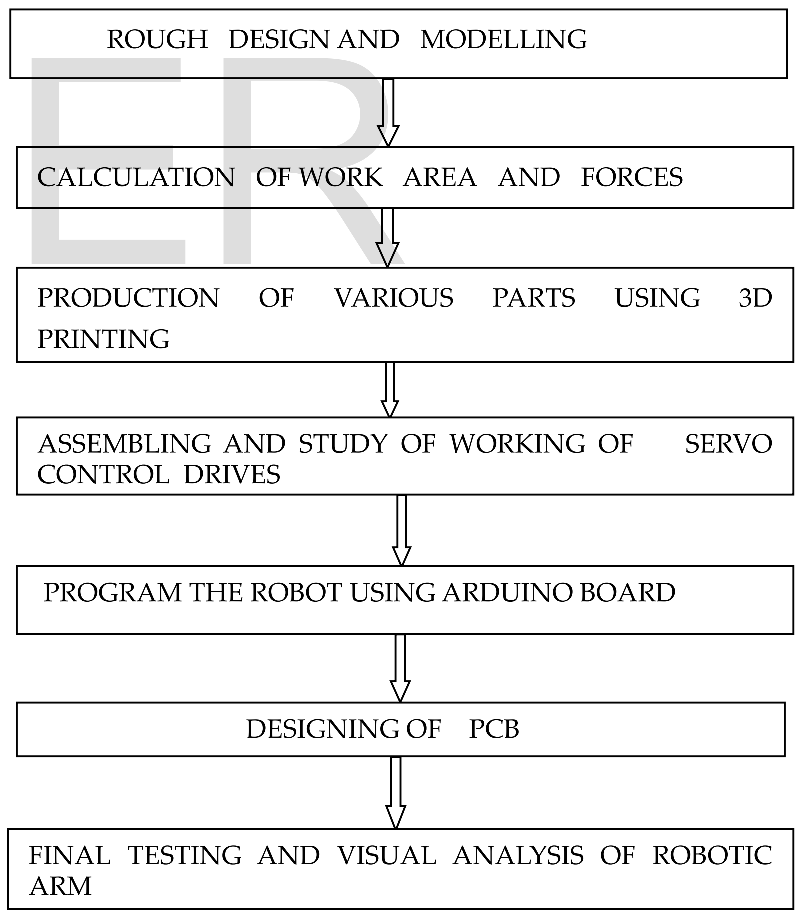
Fig. 2.1 Graphical representation of load vs shear stress

2.2 OBJECTIVES

1) To design and develop a 3 axis articulated robot using solid works software.
2) To develop a program and algorithm using python.
3) To manufacture and assemble with 3D Printing.

3 METHODOLOGY

The flowchart shows the methodology for design of articulated Robot for machine tending application.



4 DESIGN AND MODELING

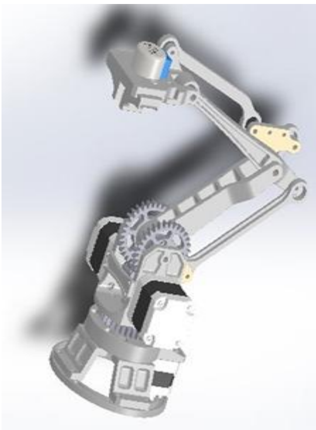


Fig 4.1. 3D Modelled using solid edge Software, and assembled the each part.

4.2 GEAR RATIO CALCULATIONS:

Gear ratio Calculations for Articulated Robot

- For Rotary motion R1 :-

No of teeth on Bigger gear =32
No of teeth on smaller gear =9

T1/T2= 32/9 =3.5

- For rotary motion R2 and R3:-

No of teeth on bigger gear N1=32
No of teeth on smaller gear N2=9

N1/N2=3.5

Since the no of teeth on gear of rotary motion R3 are same the gear ratio is 3.5.

4.3 MODELLING

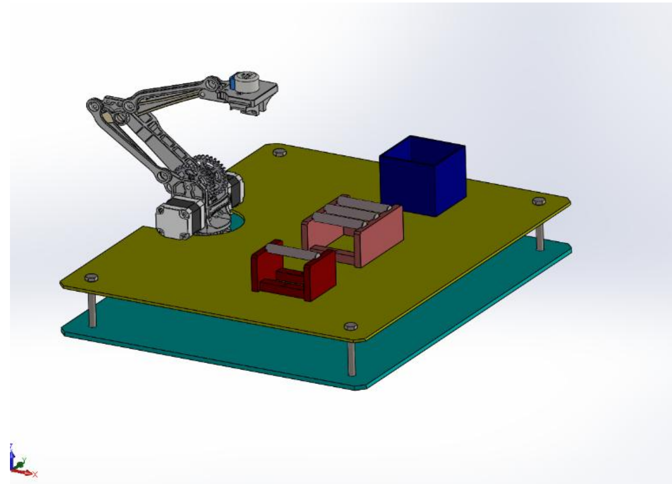


Fig. 4.2 Final Assembly Model

The above figure is the isometric view of the final assembled model of the articulated robot where the robot and sub-assemblies are fitted on to the base plate of dim (500*400mm). The complete design was done using solid works software.

5 ROBOT COMPONENTS

5.1 MECHANICAL COMPONENTS

1. PLA (Poly lactic acid) Components (3D PRINTED)
2. Radial Ball Bearing 624ZZ (Dimensions: 4mm x 13mm x 5mm (LxWxH))
3. F686ZZ Flanged Ball Bearing (Size: 6mm x 13mm x 5mm)
4. Thrust ball bearing 51105 (d: 25mm, D: 42mm, H: 11mm)

5.2 ELECTRICAL COMPONENTS

1. Arduino Mega microcontroller Board
2. Nema 17 Stepper Motor
3. Proximity Sensor
4. Switched Mode Power Supply (SMPS)
5. Tb6600 Stepper Motor Driver

6 Experimental work

The mechanical components required for the robot were accurately made by 3D Printing process. Some of the components were directly brought from the Market. After this the different parts where assembled mechanically as per the

International Journal of Scientific & Engineering Research Volume 11, Issue 6, June-2020
ISSN 2229-5518

above design configurations. Base section has 50mm height from the ground. Followed by lever, Lower shank & Upper shank with length size of 120 mm length each. Finally these links are connected to End Effector at the end with Stepper motor Gripper. Three Nema17 Stepper motors are used for base rotation, Upper Arm & lower arm. Gripper is controlled by BYJ28 Motor. Totally four motors are used. The mechanical design of the robot arm is based on a robot manipulator with similar functions to a human arm. Robotic arm system often consists of links, joints, sensors and controllers. The links are connected by joints to form an open kinematic chain. One end of the chain is attached to the robot base, and another end is equipped with a tool (gripper, or end-effectors) which is analogous to human hand in order to perform assembly and other tasks and to interact with the Applications. There are rotary joints and it connects neighbouring links.

Fig .4.3 Assembly of robot

6.1 ROBOT CONTROL SYSTEM

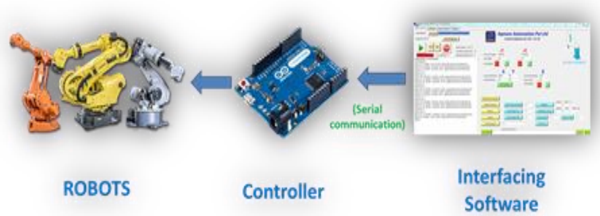


Fig. 4.4 robot control system

Robot control systems consists of 3 major sections:-

- Mechanical structure of the robot
- Controller & Drives
- Control Software

Mechanical section includes, all mechanical parts such as Stepper motors, linkages, Supports, bearings, pulleys & belts, screw rod & guides rods etc. Controller Drives incudes, Micro-controller & Stepper Drives used to control the movements & positions of Robots. Control Software is interfacing software used to teach the positions of the robot & Applications based on the requirements.

7 ROBOT CONTROL SOFTWARE

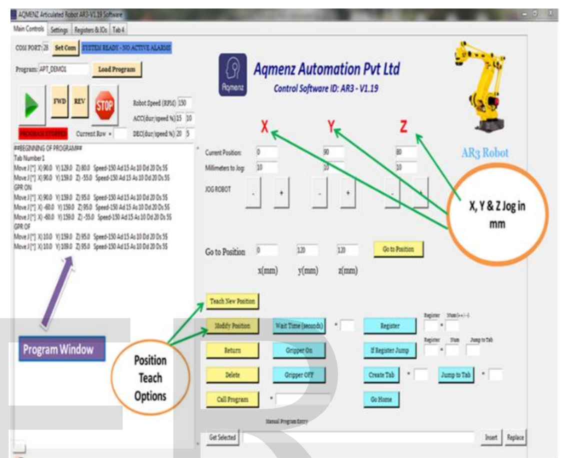


Fig 4.5 software interface

Control software as shown above is use to control the robot, Teach a new application or task to the robot. Using X, Y & Z options, we can jog the robot by entering the jog distance in mm as shown above. By clicking '+' button we can jog in forward movement & using '-'button robot can jog in reverse direction. Teach new position is used to teach x, y and z positions and inserted in the program window and stored in the program.

8 PROGRAMMING OF ARDUINO USING PYTHON

These five basic steps are used to program the aurdino using python software

1. Install the Python software into the Computer
2. Install Py Serial: Py Serial is a Python API module to access the serial port .Py Serial provides a uniform API across multiple operating systems, including Windows, Linux, and BSD
3. Python Code: The codes are generated based on how the robotic arms must move

The various positions and orientations of the robotic arm are calculated by using these matrices.

Transformation Matrix [H]:

The homogeneous transformation of rotation about OX axis by angle: [Hx, α]

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & c\alpha & -s\,\alpha & 0 \\ 0 & s\alpha & c\,\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The Homogeneous transformation of rotation about OY axis by angle: [Hy, β]

$$\begin{bmatrix} c\,\beta & 0 & s\beta & 0 \\ 0 & 1 & 0 & 0 \\ -s\beta & 0 & c\,\beta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The Homogeneous transformation of rotation about OZ axis by angle: [Hz,]

$$\begin{bmatrix} c\theta & -S\,\theta & 0 & 0 \\ S\,\theta & C\,\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The Homogeneous translation by a vector Pxyz: [H, Trans]

$$\begin{bmatrix} 1 & 0 & 0 & Px \\ 0 & 1 & 0 & py \\ 0 & 0 & 1 & pz \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Pxyz = H* Pabc

Where Pxyz: new position of robotic arm

Pabc: old position of the arm.

H: Homogeneous Rotation matrix.

When these matrices are programmed using python into the software interface, depending upon the work volume and maximum load capacity the robotic arm moves based on the input values given in mm.

Rotation Matrix [R]:

The Rotation about X axis: [Rx, α]

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & c\,\alpha & -s\,\alpha \\ 0 & s\,\alpha & c\,\alpha \end{bmatrix}$$

Pxyz = [Rx, α] *Pabc

The Rotation about Y axis: [Ry, β]

$$\begin{bmatrix} c\beta & 0 & s\beta \\ 0 & 1 & 0 \\ -s\,\beta & 0 & c\beta \end{bmatrix}$$

Pxyz = [Ry, β] *Pabc

The Rotation about Z axis: [Rz,]

$$\begin{bmatrix} c\theta & -s\theta & 0 \\ s\theta & c\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Pxyz = [Rz,θ] *Pabc

Where Pxyz: new position of robotic arm

Pabc: old position of the arm.

R: Rotation matrix.

When these matrices are programmed using python into the software interface, depending upon the work volume and maximum load capacity the robotic arm moves based on the input values given in mm.

9 RESULT

The operation sequence starts when the robot is powered on. It has an electronic gripper (end effector) and an inductive proximity sensor for sensing of metal objects which is placed on the end effector. The Arduino is programmed with python software. An application software is used to operate pick and place operations which also has a window for programming. The operator gives the jog in mm at x, y and z positions. The specimen will be kept on the job holder and when we give the value of the distance in x, y and in z direction, which is called as 'jog' in robotics terms , the ultrasonic sensor uses a sonar signal to determine distance to an object which is placed in the job holder. when we give command using software in the program window and x, y and z positions the end effector picks the work piece and places in the CNC job holder giving some time delay to assume the work is done and after that the work piece is picked and dropped in the job holder .The programming is done in a such a way that the cycle continues till all the work pieces are carried out with operation.

10 CONCLUSION

1. The prototype of the robotic arm with job holder, CNC model and a job collector has built as designed with solid edge software and it was able to work according to the instructions given. We have used an inductive proximity sensor to sense the metal objects.

2. The design of a robotic arm for handling metal work pieces was carried out from the beginning until to the prototyping stage.

3. Drawings and assembly designs were generated as a design data to be as references for future time. This detailed design could help during the improvement process to enhance the developed device in any possible way. It was picking and placing the objects as we stated in the objectives using python as a programming software.

4. Due to cost limitation to produce the robotic arm, the programming of the robotic arm was done by using the Arduino software.

5. The ability of the robotic arm to be programmed to work at different manner is another remarkable advantage of this device.

11 FUTURE SCOPE

- The study can be made by increasing the number of axes.
- The study can be made by using vision sensors to increase the efficiency.
- The study can be made by adding wheels to the robot and maximize its work area.

REFERENCES

[1] International journal for trends in engineering & technology volume 5 issue 1 – May 2015 - issn: 2349 – 9303 by K Gunasekaran

[2] International Journal of Scientific Review and Research in Engineering and Technology (IJSRRET) Vol. 1 (5), July – Aug, 2016 ISSN: 2455-3603 by Pradeep Kale , Mahmud Abdurrahman, Karunakar Pothuganti, Vikram Ghule

[3] Design and analysis of an articulated robot arm for various industrial applications (S.Pachaiyappan et al,2014)

[4] Design and control of 3-DOF articulated robotic arm using lab view and NI-myRIO (Ganesan A 2015)

[5] Development of manipulator including exchange type multi-articulated END-effectors for single port surgical robot (sung M.Seung et al ,2011)

[6] S. Sahu , B. B. Choudhury Department of Mechanical Engineering, Indira Gandhi Institute of Technology, Sarang, Dhenkanal, Odisha, India

[7] © Springer Nature Singapore Pte Ltd. 2019 S. Fong et al. (eds.), Information and Communication Technology for Competitive Strategies, Lecture Notes in Networks and Systems 40, https://doi.org/10.1007/978-981-13-0586-3_31

[8] S. H. LIM Evolutionary Computing Laboratory Faculty of Computing and Informatics University Malaysia Sabah Kota Kinabalu, Malaysia.

[9] J. TEO Evolutionary Computing Laboratory Faculty of Computing and Informatics Universiti Malaysia Sabah Kota Kinabalu, Malaysia.

[10] Lim, S. H., & Teo, J. (2015). An evolved climbing SAWR: From simulation to realization with 3D printing. 2015 10th Asian Control Conference (ASCC). doi:10.1109/ascc.2015.7244898

[11] Design And Implementation Of A Robotic Arm Based On Haptic Technology by A. Rama Krishna (International Journal of Engineering Research and ApplicationsVol. 2, Issue 3, May-Jun 2012)

[12] ROBOTICS ARM CONTROL USING HAPTIC TECHNOLOGY by Vipul J. Gohil(International Journal of Latest Research in Science and Technology ISSN (Online):2278-5299 Volume 2, Issue 2: Page No.98-102, March - April (2013)

[13] Design of a Robotic Arm for Picking and Placing an Object Controlled Using Lab VIEW by Shyam R. Nair (International Journal of Scientific and Research Publications, Volume 2, Issue 5, May 2012.