DESIGN, FABRICATION AND TESTING OF 6 DOF SPOT WELDING ROBOTIC ARM

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***ABSTRACT*: In majority of the manufacturing and assembling industries, human labor is largely employed to do repetitive task, which usually requires precision and accuracy. It is unavoidable that humans will make mistakes while performing a task. Moreover, productivity will be lower as human have limited working hours and work slower as compared to machines. To overcome this human inefficiency, industrial robots are designed and built to accommodate the increasing demands for better productivity, product quality and precision in performing task. They are the future of industries, which are going to replace humans.**

This paper is focused on the project which aims at making a six-degree of freedom robotic arm for spot welding purpose. Here in this report all the points regarding designing, mathematical modeling, simulation, development of real model and fabrication has been covered. All the designed parts in the report are made in Solid Works Software. Also the transformer specifications and the electrodes, which is used for Spot Welding, are been discussed in this report. Arduino Programming is used for operating the robot in this project. The possible results, which would be achieved after completion of this project, are also discussed.

***Keywords*: DOF, spot welding, simulation, mesh analysis, thermal analysis.**

I. INTRODUCTION

Technological developments in the fields of mechanical engineering, electronics and computer science has played a great role in increased use of automation in manufacturing industries from last 20 years. Automation in the form of transfer lines, feedback control systems, assembly line operations, NC machine tools and robots are used in the industries for higher productivity, product quality and precision in performing tasks.

The rapid increase in demands of robots is observed worldwide from last 10 years due to the scarcity of labour force in developed nations, reduction in the cost of robots compared to the labour cost and capability of performing in dangerous working conditions. Here we discussed some of the basic information related to the robots.

A. GENERAL: The robotic Institute of Association (RIA) defined the robot as "A reprogrammable, multifunction manipulator designed to move materials, parts, tools or special devices through variable programmed motions for the performance of the variety of task**.** Robots can do infinite work without any breaks and days off. Robots take less time for operations; have higher accuracy and increases productivity.

When human operates are engaged in welding operation, it is observed that flash, flumes, heat and sparks make this task a hazardous job. The use of robots in welding operation will avoid them to come in contact with such environments and will also reduce costs. Robot operations are reprogrammable and highly beneficial for batch type and mass production. Consistent weld-ments are created with the use of robots. Our aim is to design a robotic arm for spot welding purpose, which can do this operation on a 0.5mm sheet of low carbon steel easily.

Some of the important aspects related to spot welding are discussed below.

B. SPOT WELDING: In resistance spot welding, two or more sheets of metal are held between electrodes through which welding current is supplied for a definite time and also force is exerted on work pieces.

The welding cycle starts with the upper electrode moving and contacting the work pieces resting on lower electrode, which is stationary. The work pieces are held under pressure and only then heavy current is passed between the electrodes for preset time. The area of metals in contact shall be rapidly raised to welding temperature, due to the flow of current through the contacting surfaces of work pieces. The pressure between electrodes, squeezes the hot metal together thus completing the weld. The weld nugget formed is allowed to cool under pressure and then pressure is released. This total cycle is known as resistance spot welding cycle.

II. PROBLEM DEFINITION

The purpose of the project is to accurately and efficiently carry spot welding on low carbon steel plate of 0.5mm thickness. The robotic arm has 180˚ reachability in frontal side so it can weld several jobs with same quality of weld. In case of manual operation, time of weld, force applied may vary and hence quality may also differ and comparatively more time is needed. Manual operation holds risk of operation on work place but working on robotic arm is safe and well insulated.

III. LITERATURE REVIEW

3.1 **Kurt E. Clothier and Ying Shang (Hindawi Publishing Corporation Journal of Robotics)**
This paper aims to create a straightforward and repeatable process to solve the problem of robotic arm positioning for local autonomy. This paper provides information about end gripper head kinematic head and the calculations of geometric parameters for reaching specific position. It also gives information about power system used for robotic arm and also working and performance of robotic arm on auxiliary souses of power. A geometric approach to solve for the unknown joint angles required for the autonomous positioning of a robotic arm has been developed.

3.2 **Puran Singh, Anil Kumar, Mahesh Vashisth (Universal Journal of Mechanical Engineering)**
From this research paper we get information about design of gripper and end effector for spot welding. In robotics, end effectors are a device at the end of a robotic arm, designed to interact with the environment. Gripper is an end effectors or tool to grasp any physical thing that may be a human hand or any instrument. To achieve this goal we intend to incorporate a simple linkage actuation mechanism. It also gives information about selection of stepper motor for end effector, force calculation for joints and basic components of project.

3.3 Shyam R. Nair (International Journal of Scientific and Research Publications)
In this paper, LAB View controlled robotic arm was successfully designed. The robotic arm was found to be user friendly and the integration of accelerometer was much helpful in attaining the feedback regarding the position of the arm. To select the real time object, the corresponding coordinate is inputted. To select the real time object, the corresponding coordinate is inputted. It used kinematic equations and matrix transformations for motion of the arm.

3.4 **K.Kishore Kumar ,Dr.A.Srinath ,G.Jugal anvesh, ,R.Prem sai, M.suresh; International Journal of Engineering Research and Applications (IJERA)**
In this paper, mathematics involved in study of robotics is shown. Mathematics involved in study of robotics is forward and inverse kinematics etc, is difficult to understand and hence using Robo Analyzer software, calculations are been done with joy of animations, which make the calculations look quite practical. We can easily identify velocity acceleration graphs and their values regarding the joints and links and simulation of robot end effector can be done.

IV. PARTS AND CALCULATIONS

1. ARMS: Arms are made up of PVC pipes of 60mm diameter, which are joined to motors with help of brackets.This material was chosen due to its low weight and aesthetic factor

2. BRACKETS: The following brackets were used of aluminium material.

BRACKETS	QUANTITY
Long U	4
Large U beam	1
Multi purpose	6

Table No.1: Types of brackets with their Quantity.

3. MOTORS: Servo motors of following capacities were used:

Motor capacity (kgf/cm)	Quantity
35	4
20	3

Table No.2: Types of Motors with their Quantity.

4. BASE: Wooden base(rectangular and hollow) was used to support a circular rotating sub-base with bearing.

5. TRANSFORMER: Transformer with an output of 2V is used. We are constructed the secondary coil with copper wire of 3.5mm diameter. Its input is 230V.

6. BEARING: SKF 51206 bearing is used taking load/ wieght calcuations into consideration.

7. ELECTRODE: Copper electrode of diameter 10 guage insulated with enamel

V. CALCULATIONS:

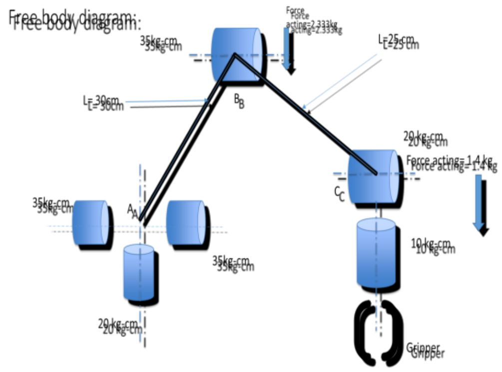

Fig No.1: Free body diagram of load distribution

T= F x D

Where

T= Torque of the motor,

F= Force applied,

D= Perpendicular distance of force from axis of rotation.

LOADS AT VARIOUS POINTS

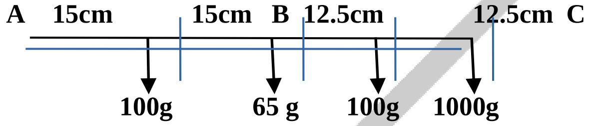

Fig. No. 2: Load distribution at various points

Therefore,

Torque at point A,

T_a= (1000*55) + (100*42.5) + (65*30) + (100*15) = 62.7 kg-cm.

In market, we found two 35 kg-cm motors, which would sum up to 70kg-cm, which is more than the desired value. Hence for point A two 35 kg-cm each motors are used.

Torque at point B,

T_b=(1000*25)=(100*)= 26.26kgcm.

In the market, below 35 kg-cm motors, 23 kg-cm motor was available which was not sufficient. Hence for point B, we considered choosing a 35 kg-cm motor.

Torque at point C, 20 kg-cm and 10 kg-cm for gripper is used.

VI. ANALYSIS /RESULTS

6.1 Mesh of gripper

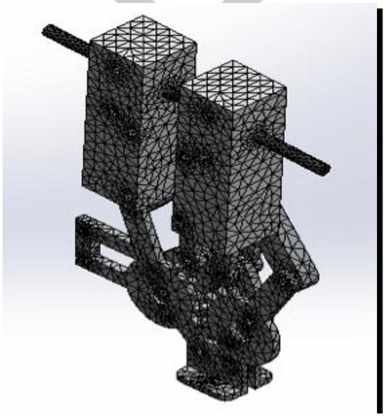

Fig. No. 3: Gripper mesh analysis using solidworks software

Mesh Information details	
Total nodes	**100264**
Total elements	**64304**
Maximum aspect ratio	**40.234**
Percentage of elements with Aspect ratio < 3	**92.2**
Percentage of elements with Aspect ratio > 10	**0.176**
Percentage of distorted elements (Jacobian)	**0**
Time to complete mesh (HH:MM:SS)	**00:00:14**
Computer Name	**Dell**

Table No.3: Mesh Information details

6.2 Thermal analysis

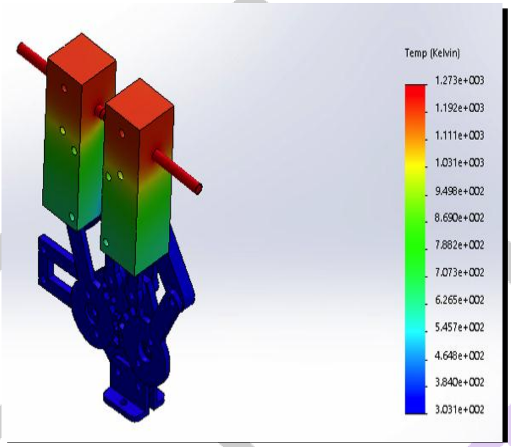

Fig. No. 4: Thermal analysis of gripper using solidworks software

Note: The analysis is performed on SolidWorks

Name :Copper Material	
Model Type : Linear elastic isotype	Solid body (Boss) Extrude 1(Part 1-3) Solid body (Boss) Extrude 1(Part 1-4)
Defaulter failure : Unknown	
Thermal Conductivity: 390W/m°K	
Specific heat: 390J/ kg °K	
Mass density: 8900Kg/ m^3	

Table No.4: Gripper Mesh Information details

The fabricated 6 DOF robot is shown in the following Fig. No 5. Arduino Programming is used for operating the robot in this project and spot welding of mild steel plate upto 0.5 mm thickness is tested.

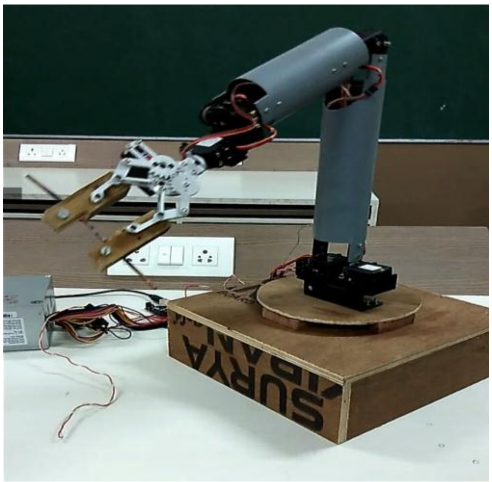

Fig No 5: Pictorial image of Fabricated 6 DOF Robot

VII. ACKNOWLEDGEMENT

We would like to thank the head of mechanical department for allowing us to work in college machine shop and workshop. Lastly, we would thank the workshop staff for their cooperation in transformer selection and testing.

VIII. CONCLUSION

In this project we have successfully designed, fabricated and tested 6 Degree of freedom for welding steel plate using Cartesian system.

Although the design and manufacturing phases finished successfully, it may be concluded that Cartesian coordinate robots are not objected for a welding operation. It is probable that a robot that has a higher degree of freedom and an arm-type manipulator is better for a welding robot. This study has substantial advantages for learning the mechanical parts of a precise motion and the motion control of mechanical parts. Particulars of DC motors etc. are examined in detail for this purpose.

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