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Design and Structural Analysis of an advanced Welding Robot

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ABSTRACT:Since the main mechanical robots were presented in the early 1960s, the advancement of robotized welding has been really surprising and is today one of the significant application regions for modern robots. Robot welding is essentially worried about the utilization of mechanized programmable apparatuses, known as robots, which totally mechanize a welding interaction by both performing the weld and taking care of the part. Robots are very adaptable and consequently have been utilized for an assortment of welding types, for example, resistance welding and arc welding.

After related study we have achieved the design of a 6-jointed robotic weld where the base is fixed and the remaining joints move in vertical and horizontal directions. Here we used SOLIDWORKS 2020 for design and ANSYS to simulate the designed model

KEYWORDS: Degree of Freedom (DOF), Welding Robot, Joints, Revolute Pair

I. INTRODUCTION

Welding is an essential piece of cutting-edge mechanical assembling and automated welding is viewed as the primary image of present-day welding innovation. In the early uses of automated welding called the original mechanical welding frameworks, welding was proceeded as a two-pass weld framework, in which the main pass was committed to learning the seam calculation and was then trailed by the real following and welding of the seam in the subsequent pass. With improvements in innovation, the second era of mechanical welding frameworks came, which followed the seam continuously, performing all the while the learning and the seam following stages. The most recent innovation in automated welding is third-age frameworks, in which the framework works continuously as well as learns the quickly changing calculation of the seam while working inside unstructured conditions.

To stay on a serious level, different assembling organizations has moved to robot welding to keep up the degree of value and efficiency of its fabricated items, to build the creation stream and keeping surrenders as low as could be expected, while in a similar time saving the expenses for work and materials down.

Benefits of using a Welding Robot:

- Higher profitability: Arc time can be raised from 30-40 % up to 60-80% and arc travel speed can be higher.
- A robot with one administrator can replace 2-4 welders.
- Weld quality is more reliable and normally higher.
- Better working environment, since the administrator doesn't have to stand near the arc.
- Necessary redesign and new considering encompassing exercises related to the securing of the robot assists with raising effectiveness.
- The workshop doesn't have to manage challenges of selecting and keeping qualified welders.

A robot welding cell comprises of a robot with a control system, apparatuses or controllers for the workpiece, power sources and related welding equipment's.

A typical robot utilized in industry regularly includes 6 axes. A six-axis robot permits more prominent adaptability than a robot with less axes. To accomplish greater accessibility for welding, manipulators can be utilized which positions the workpiece.

The most utilized welding process utilized for robots are GMAW processes, that is MIG/MAG welding. Other usable processes are TIG, LBW and RSW.

General phases in Welding Robotic Operation in Industries

1. Preparation phase: In this phase, the weld administrator sets up the parts to be welded, the apparatus (power source, robot, robot program, and so forth) and the weld boundaries, alongside the sort of gas and electrode wires. At the point when CAD/CAM or other disconnected writing computer programs is utilized, a robot weld pre-program is accessible and placed online. Thus, the automated program may just need minor tuning for adjustment, which can be effectively done by the weld administrator performing chosen online recreations of the interaction.

2. Welding phase: Automatic equipment requires similar capacities as manual welding, i.e., the framework ought to be capable of maintaining a torch orientation that follows the ideal direction (which might be not the same as arranged), performing seam tracking, and changing weld boundaries continuously, along these lines imitating the versatile conduct of manual welders.

3. Analysis phase: The analysis phase is a post welding stage where the welding administrator analyses the acquired weld to ascertain in the event that it is satisfactory or whether changes are needed in the past two stages. Utilization of cutting-edge sensors, for example, 3D laser cameras, empowers execution of this stage online during the welding stage.

II. DEMERITS OF ROBOTIC WELDING

There are a few issues that happens utilizing Robot Welding:

1. Lack Of Fusion:

One of the fundamental issues of welding the component is lack of fusion in the position of the little space between the tubes. At the point when the robot begins from the upper position over the tubes, the descending pointing of the welding torch and long stick out prompts cold metal streams in front of the arc and not joining to the base metal. This have prompted lack of fusion and the tubes is along these lines not appropriately welded into the headers. Results of this is that manual fixing with TIG subsequently have been important to meet the necessities of leak test, quality levels and so on This has added to extra work and longer production times.

2. Burning Through Of Tubes:

On the off chance that the weld torch gets too close near the tubes, it effectively consumes them. It is consequently vital that the points programmed during the welding positioning should be actually done and no disturbances ought to happen during the laser searching.

3. Laser searching problems:

Large numbers of the happened issues and welding defects has its source from wrong weld positioning because of laser searching challenges. It is vital that the components in the upper header is perfect from irregularities and that the upper header is straightened well enough from the pre-fabrication welding.The upper header is particularly influenced by torsion from the pre-manufacture, which isn't as simple to straighten. The torsion for this situation at that point prompts that the closures of the of the upper header are crooked, and the hole plate isn't actually vertically arranged. The welding positioning are modified for a precisely vertical adjusted weld, and the laser search doesn't change (rotate) the welding situating for a screwy crease. Same issue happens if the headers are situated crooked in the apparatuses. Consequently, one must be exceptionally mindful so as to position the parts accurately and also watch that these are sufficient to weld.

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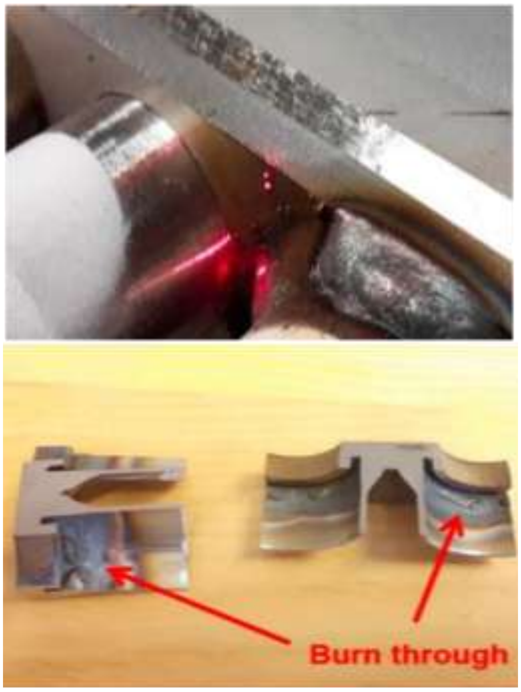


Laser searching disturbed by spatter and tubes affected by too much heat

III. MATERIAL AND DESIGN

Aluminium:Despite the fact that aluminium has a more exorbitant cost point than steel, it's simpler to shape and is lighter. Aluminium is a decent material over a robot's outside getting corroded after some time since aluminium doesn't rust.

Something else that makes aluminium a well-known choice for robot outsides is that it tends to be cleaned to a high sparkle. In this way, assembling a commercial robot that the customer will in the end need to flaunt, aluminium makes the body look decent while offering plentiful toughness. We can likewise work with experts that give aluminiumcleaning innovation three-way machines, which empower programming to meet double-sided processing needs.

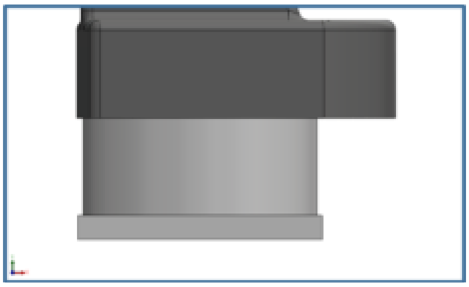
A few designers use aluminium on robot bodies to protect more delicate parts. In one model, Italian researcher made a robot sufficiently able to pull a 7,200-pound plane down a runway. The robot, which had four electric engines, four hydraulic actuators and a couple of PCs, housed its parts in an aluminiumenclosing, with proper ventilation holes.

DESIGN

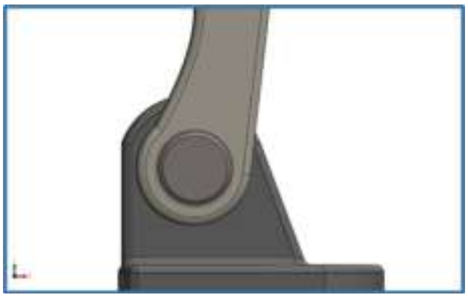
The Computer Aided Design (CAD) of the welding robot was made using SolidWorks 2020.
The robot consists of 6 Revolute joints and 7 links.

The Robot Designed Using Solidworks

- Joint 1-

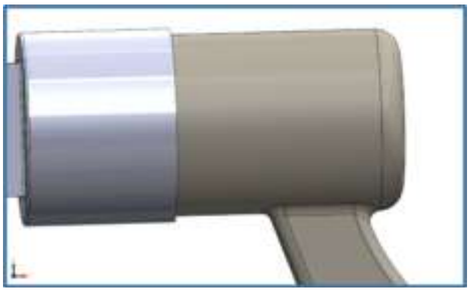


- Joint 2-

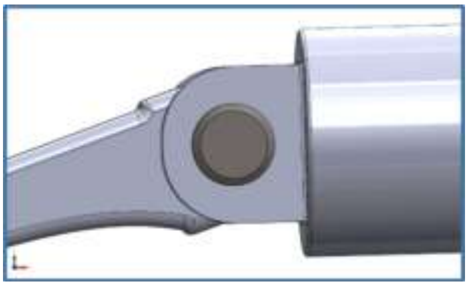


- Joint 3-

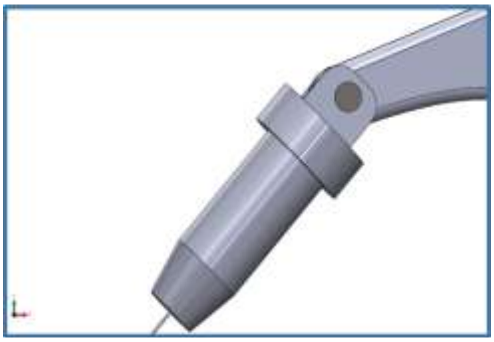
- Joint 4-



- Joint 5-



- Joint 6-



CALCULATION OF DEGREE OF FREEDOM (DOF) OF THE ROBOT :

Degrees of freedom of a mechanical system is calculated using the formula-

$$\text{dof} = \sum(\text{freedoms of bodies}) - \text{number of independent constrains}$$

$$\text{dof} = m(N-1) - \sum_{i=1}^{J} c_i$$

In the above equation-

N = number of bodies, including ground
J = number of joints
m = 6 for spatial bodies, 3 for planar bodies
c_i = constrain of i^{th} joint

The above equation can further be rearranged into-

$$\text{dof} = m(N-1) - \sum_{i=1}^{J}(m - f_i)$$

$\text{dof} = m(N-1-J) + \sum_{i=1}^{J} f_i$ - equation 1

f_i = degree of freedom of i^{th} joint

In our welding robot there are 6 revolute joints and 7 links. Hence, N = 7, J = 6.
Also, m = 6 because the robot can be considered as a spatial body.
Since, the robot only comprises of revolute joints, the value of every f_i is 1.
Substituting these values in the equation 1 we get:

dof = 6(7 – 1 – 6) + 6(1)
dof = 6

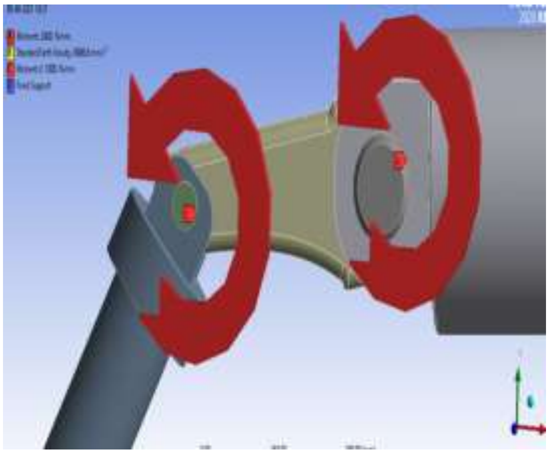
Hence, the degree of freedom of our welding robot is equal to 6.

IV. ANALYSIS USING ANSYS STATIC STRUCTURAL

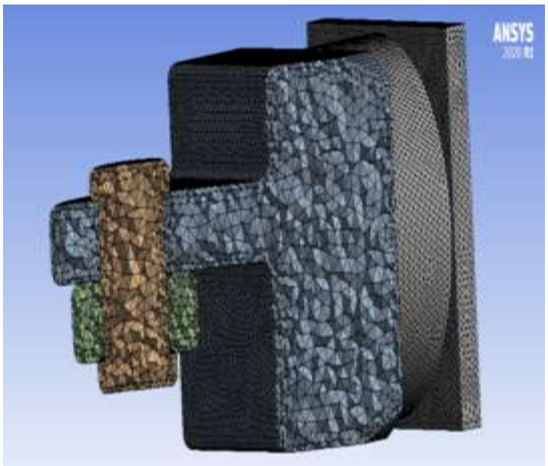
The analysis has been done using AnsysWorkbench.

STEPS

1. The CAD was imported in Ansys Workbench.
2. The material was defined to be Aluminum alloy.
3. The CAD was divided into small elements. This process is called **Meshing**.Meshing is an integral part of the engineering simulation process where complex geometries are divided into simple elements that can be used as discrete local approximations of the larger domain. The mesh influences the accuracy, convergence and speed of the simulation.
4. The base of the robot was fixed by defining fixed support.
5. Gravitational Force was defined in vertical direction.
6. Torque applied due to servo motors was defined at Joint 5 and Joint 6 in + Z direction.
7. Now total deformation was computed after defining all the necessities.



BOUNDARY CONDITIONS



GENERATED MESH

V. RESULT

The deformations shown in the second figure are multiplied by a factor of 3.7e+004. Otherwise, the deformations are not noticeable.

Results	
Minimum	0. mm
Maximum	0.34703 mm
Average	6.5306e-002 mm
Minimum Occurs On	Part1
Maximum Occurs On	Part4

The tabular result shows that the maximum deformation occurs in the rear arms which is in the order of 10-4m.

VI. CONCLUSION

This robotic welding arm can not only be used for welding in a straight line, but it can also prove to be efficient in the case of circular welding because of its 6 degrees of freedom. The robot can be easily to programmed in such a way that the welding speed is neither too high nor too low thus elimination the defects occurring due to very fast or very slow welding speed. Arc time can also be raised from 30-40 % up to 60-80% and arc travel speed can be higher.

The deformation taking place due to external torques and forces is insignificantly small (it is in the order of 10-4m). Hence, it can be concluded that the robotic welding arm has good hardness and toughness. These properties can further be improved by using more advanced techniques of topology analysis and other efficient mechanical simulation techniques.With the help of powerful microcontrollers and other powerful IoTdevices it requires hardly any time to process the code and send and receive signals from various components of the Embedded system and finally make the actuators (in this case motors) work in the way we want.

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