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Development of Six Axis Robotic Arm by Additive Manufacturing

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Abstract:- In this paper, we have utilized additive manufacturing for the development of a robotic arm at a low cost. The robotic arms available in the market are often very expensive and not customizable. Small industries cannot afford the setup and customization cost of robotics. However, by using 3D printing, one can develop complex products with their own customizations.3D printing offers a cost-effective solution for producing these arms in comparison to traditional methods. This enables small industries to automate their processes and increase efficiency, ultimately leading to higher productivity and growth in their business. The aim of this paper is to present our development of a 6 DOF robotic arm and the methodology we followed for its creation. The robotic arm we developed in this paper can be programmed to perform a wide range of tasks and can also be controlled using artificial intelligence techniques.

I. INTRODUCTION

Robotic arms are the key component of industrial automation. When AI is added to them, it becomes the evolution of industry 4.0. They have a wide range of applications and are used in every field, such as aerospace, medical, transportation, food, and beverages. They are typically made up of several joints and links that allow them to move and rotate in a variety of ways. Robotic arms can be controlled manually or through programming, and can be equipped with a variety of tools and sensors to perform specific tasks with precision and accuracy.

Additive manufacturing plays a crucial role in Industry 4.0 by enhancing productivity and efficiency. It is a process of creating 3-D objects by layering material on top of each other, rather than removing material like traditional manufacturing processes. It's just a opposite of Subtractive Manufacturing.

3D printing has revolutionized the production of robotic arms, enabling the creation of customized arms that can perform specific tasks with greater efficiency and accuracy by printing complex shapes and structures with high precision. Additive manufacturing is expected to reduce the cost of robotic arms for small-scale industries. These robotic arms can be designed and manufactured at a lower cost and in a shorter time frame than traditional manufacturing methods. In this way, additive manufacturing is transforming the field of robotics and paving the way for innovative applications in various industries.

II. LITERATURE SURVEY

The integration of 3-D and robotic systems has enabled the creation of automated and efficient processes. This literature survey provides a brief overview of the robotic systems produced through additive manufacturing.

Dilberoglu. et al. [2] have describes, a comprehensive review on additive manufacturing (AM) technologies and their impact on Industry 4.0. The analysis specifically highlights three key areas of AM: recent developments in material science, process development, and improvements in design considerations..

Saerang. et al. [3] have describes the design and fabrication of a 3D printed robotic which has a 6-Axis. The design of the new robotic arm was influenced by the UR5 manipulator, with the aim of achieving comparable levels of movement versatility.

Grzesiak. et al. [4] have described the development of the Bionic Handling Assistant as well as the additive manufacturing (AM) process of robot grippers and its possibilities.

Almurib. et al. [5] have described an overview of industrial robotic arms around the world, with a focus on the mechanisms and components that make up these machines. In addition, this paper will explore the broader field of robotics, including classifications based on actuator types, application areas, and methods of control. By examining these aspects of robotics, readers can gain a deeper understanding of the various types of robots and their potential uses in industry and beyond.

Harish. et al. [6] have proposed a pick and place robot concept utilizing Arduino and controlled via RF play station and successfully implemented. The robot is capable of locating the object to be lifted by utilizing its chassis and four DC motors to move to the designated location.

Mohammed Ali et al. [7] have describe the development of an Arduino-powered robotic arm, which can be controlled remotely via a mobile application. The robotic arm, with six degrees of freedom, was specifically designed and constructed for the purposes of this study.

Pillai et al. [8] have conducted a survey of 460 senior managers and owners of automotive component manufacturing companies (ACMCs) in India to investigate their adoption intention and potential use of InRos. The results suggest that factors such as perceived compatibility, external pressure, perceived benefits, and support from vendors play crucial roles in predicting the intention to adopt InRos.

III. METHODOLOGY

This paper will describe the methodology used to create a 6 DOF (degree of freedom, defined as the number of independent ways that a mechanical component can move without violating constraints) robotic arm through additive manufacturing.

This process is divided into three phases: CAD design, printing parts using additive manufacturing, and assembly and circuit design.

➢ *Cad Design*

Computer-Aided Design (CAD) is a software technology used for creating, analyzing, and optimizing designs digitally. It is widely used in most of industries.

We have used Solidworks software one of the widely used CAD Software. It provides a range of powerful tools for creating details 3D Models, simulating product behavior, and testing designs under real-world conditions The design of the parts are divided into three part:-

- *End Effector*

This consists of an assembly of eight different parts. The main function of the end effector is to move objects from one place to another within its working area.

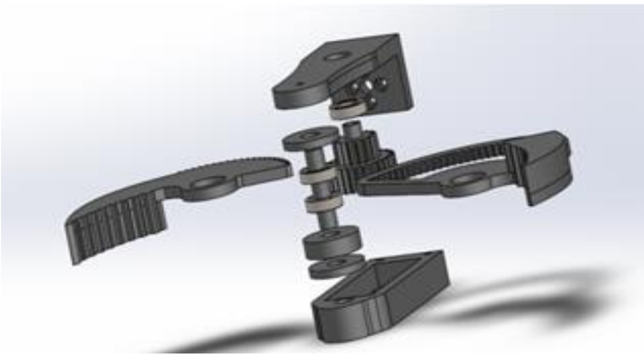

Fig 1 End Effector

- *Link Mechanisms*

This Consist of a assembly of 11-Different Parts Which Provide Different Motions to End Effector.The total height of the link mechanisms is 0.42527 m.

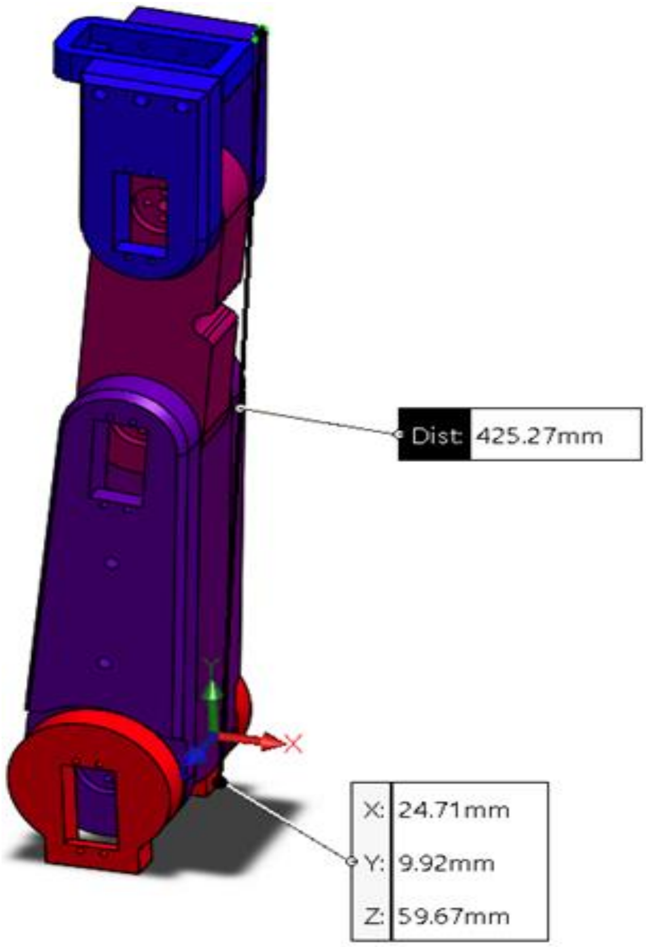

Fig 2 Links of Robotic Arm

- *Base*

This consist of a assembly of 9-Different parts which provide base support for the robotic arm and provide rotational motion in 360 degree direction. The height of Base is 0.094 m.

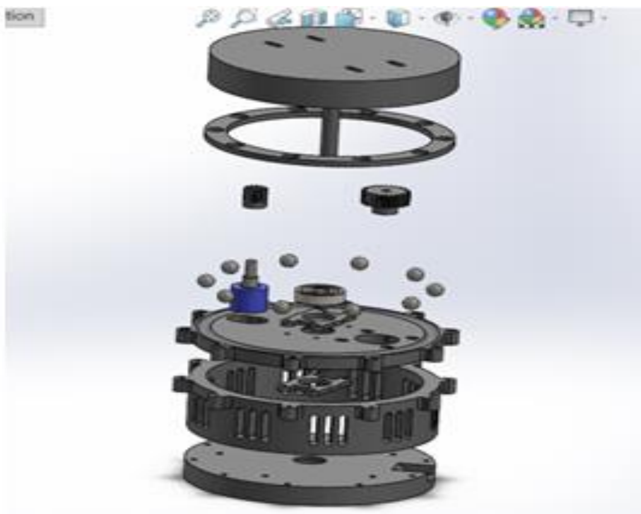

Fig 3 Base Support of Robotic Arm

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➢ *Printing of Parts using 3-D Printer*

3D printing is a process where a 3D part is printed layer by layer by melting ABS (Acrylonitrile Butadiene Styrene) polymer.

For printing purpose we used AION 500 MK2 3-D Printer with printing area of 500mm × 500mm × 500mm. The nozzle temperature for printing ABS on this machine is 245°C, and the bed temperature is 75°C. The porosity level of the printed ABS is not typically measured in percentage.

Porosity is a measure of the empty spaces or voids within a material, and it is usually expressed as a percentage of the total volume of the material

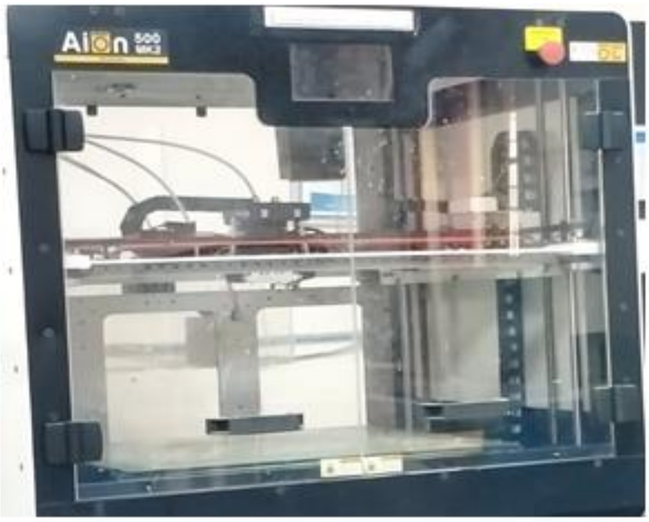

Fig 4 Aion 500 3d Printer

- *Properties of ABS:-*

✓ *Tensile Strength: 40-50 MPa*
✓ *Flexural Strength: 65-80 MPa*
✓ *Impact Strength: 10-20 kJ/m2*
✓ *Heat Deflection Temperature: 80-100 °C*
✓ *Density: 1.05-1.07 g/cm3*
✓ *Water Absorption: 0.2-0.4%*
✓ *Electrical Resistivity: 10^15-10^17 ohm-cm*
✓ *Coefficient of Thermal Expansion: 70-110 x 10^-6/°C*

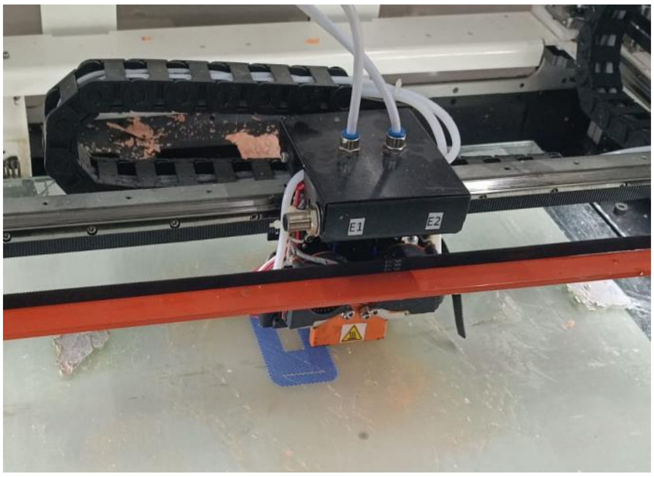

Fig 5 3-D Printer internal setup

Handling Cad data is first step in creating high quality printed parts.

Netfabb is the Software which helps in prepare the CAD Models for Additive Manufacturing. Netfabb allows us to read data from all commonly used CAD software. We can import our Solidworks file on Netfabb, and during the import process, Netfabb stores the parametric information associated with the file. You can choose the tessellation setting and create a mesh, and you can change this setting at any stage of the print process by simply re-tessellating the model using the underlying parametric information and optimizing your workflow. Netfabb has various tools to work with mesh files natively for your print preparation, and if there are any errors in the file, they can be addressed in just a few clicks using Netfabb's powerful mesh analysis and repair tools. After repairing the model, we save it in .STL file format for further use. The next step is to convert the .STL file into G-Code. G-Code is a programming command that control the motion of the nozzle in all XYZ direction. To convert the .STL file to G-Code, we used KISSlicer software, which slices STL files into printer-ready G-Code files. After converting the model into G-Code, we upload the G-Code into the machine and then start printing after some prior setup of the machine.

The prior setups include bed temperature, extruder temperature, cleaning the bed, extruder speed, and using glue on the bed.

Be careful with the prior setup. If the bed temperature is not within the specified range or if the glue is not applied perfectly on the bed, the product may get damaged as shown in **Figure 6**.

Fig 6 Damaged Part During Printing

After the material is printed, it is required to remove the supporting material and clean it before assembly.

➢ *Assembly and Circuit Design.*

Assembly of all parts is done using screws. The MG996R High Torque Servo motor is used for the rotation of links, and the NEMA-17 Stepper motor is used for base rotation.

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The load distribution is very important in terms of enabling a servo motor to deliver high torque. For our project, we used an adjustable power module to supply 5V and 3A of power.

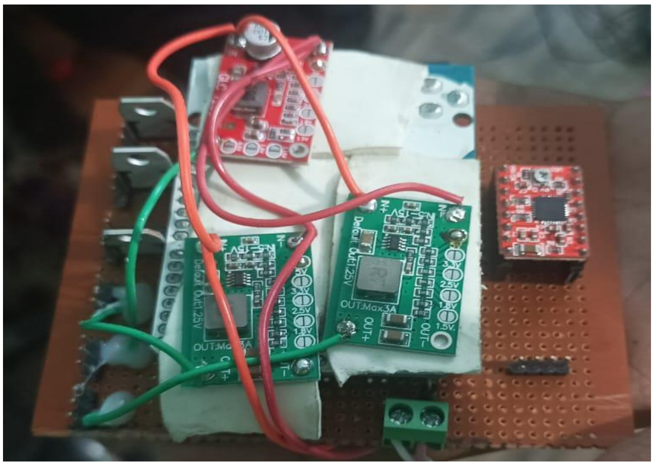

Fig 7 Robotic Arm Circuit to Control

With 6 DOF, the robotic arm can cover a wider range of area, making it very important for the industry. After assembly, the arm can be programmed as per the specific requirements. If it is integrated with IOT and AI, then it can become a key component of Industry 5.0.

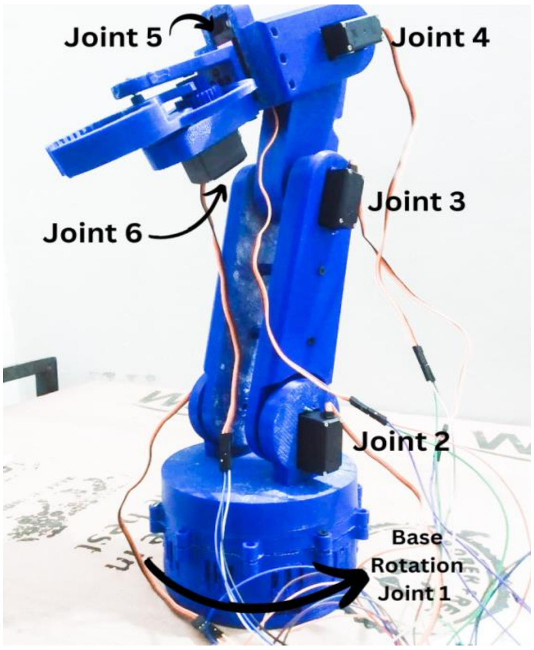

Fig 8 3-D Printed Robotic Arm

As a prototype, we used Arduino-UNO for programming for a specific task such as pick and place. It can be programmed for any work as you need.

IV. TORQUE CALCULATION

- *Let consider a weight 5KG that a servo motor wants to pick up.*

- The Force F = 5kg *9.80m/s^2
- F= 49 N

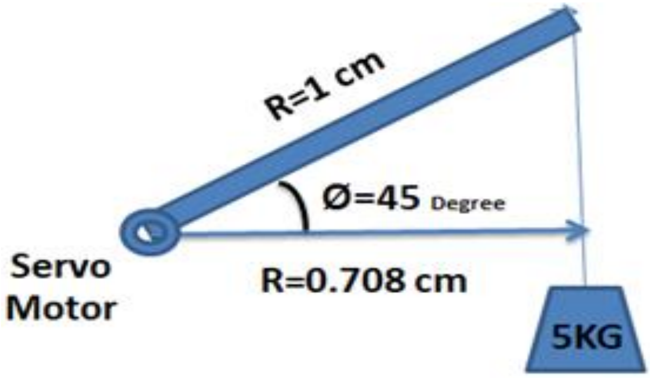

Fig 9 Force and Load Distribution Diagram

- *Now,*

- Torque τ = rF
- τ = (1.0cm*cos(45^0))*(49N)
- τ = (0.00708m)*(49N)
- τ = 0.3469 Nm
- τ =3.53 Kg-cm

V. CONCLUSION

Robotic arms combined with additive manufacturing provide a new opportunity for small industries to automate their businesses and expand in the field of AI. Additive manufacturing enables the development of customized robotic arms at a lower cost. Although additive manufacturing has some limitations, such as longer printing times, as technology continues to advance, these challenges are expected to be resolved.

While printing our project, we observed that the adhesion between layers can be affected by variations in bed and nozzle temperature, as well as printing speed. We found that if the printing speed is too high, the adhesion force between layers may be reduced, leading to a weaker bond and potentially causing the part to become damaged. High bed temperature can cause thermal stresses to build up within a printed part, which may result in warping or bending of the part. This is a common issue in 3D printing, particularly with materials like ABS that have a high coefficient of thermal expansion. Therefore, it is important to maintain consistent bed and nozzle temperatures, and adjust printing speed accordingly to ensure proper adhesion between layers and the overall quality of the printed part.

The integration of robotic arms and additive manufacturing is a promising development for small industries seeking to improve their manufacturing processes and competitiveness. With continued research and technological advancement, this trend is expected to continue and bring further benefits to a range of industries.

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