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DESIGN, FABRICATION AND ANALYSIS OF ROBOTIC ARM

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ABSTRACT

This project focuses on replacing the plastic body of a robotic arm with aluminium in a simple and efficient way. The model is facing a common issue encountered is the slipping of the robotic arm or its end effector during gripping or manipulating objects. This can lead to loss of control, decrease accuracy, and potential damage to both the object and robotic system. By analysing this issue, we conclude that to improve grips stability and control during various manipulation tasks. For this reason, we have to change Robotic arm's plastic body into an aluminium body to improve strength. By using lightweight aluminium and maintaining the original dimensions, the new body can be easily integrated with existing parts like motors and sensors. The process involved taking the original dimensions of all parts of the robotic arm. After taking dimensions, we designed 2D Drawing on AUTOCAD for ensuring smooth transition. After upgrading, the arm performs better, lasts longer, and can handle heavier tasks, making it ideal for both industrial and research applications.

Keywords: Simple And Efficient Way, Robotic Arm.

I. INTRODUCTION

Robotic arms play a vital role in industries such as manufacturing, healthcare, and automation, where precision, durability, and strength are essential. Many entry-level and educational robotic arms are constructed using plastic due to its low cost and ease of manufacturing. However, plastic components often lack the strength and durability required for demanding applications, leading to deformation, reduced lifespan, and operational limitations.

Replacing the plastic body with aluminium can significantly improve the structural integrity and load capacity of a robotic arm. Aluminium is lightweight, strong, corrosion-resistant, and easily machinable, making it an ideal alternative. However, the challenge lies in transitioning from plastic to aluminium without redesigning the entire system or making complex modifications.

II. MATERIALS AND METHODOLOGY

Material Selection

ALUMINIUM: - Aluminium is commonly used in robotic arms due to its lightweight, strong, and corrosion-resistant properties. It offers a good strength-to-weight ratio, making robotic arms faster and more efficient. Its easy machinability and thermal conductivity also make it ideal for precise, durable components.

STEEL: steel is a strong and durable material used for parts that require high strength, rigidity, and wear resistance. It is often chosen for structural components, joints, and actuators. Steel's higher density compared to aluminium provides greater strength but can make the arm heavier.

Here's a simple chart summarizing the key properties of aluminium for use in robotic arms:

Property	Description	Impact on Robotic Arm
Lightweight	Aluminium is much lighter than many other metals	Enhances speed, flexibility, and reduces power consumption. Improves overall agility
Strength-to-Weight Ratio	High strength-to-Weight ratio compared to many other materials.	Allows for handling moderate to heavy payloads without compromising mobility.
Corrosion Resistance	Naturally forms a protective oxide layer, preventing corrosion	Increases durability and reliability in various environmental conditions(humidity, chemicals)

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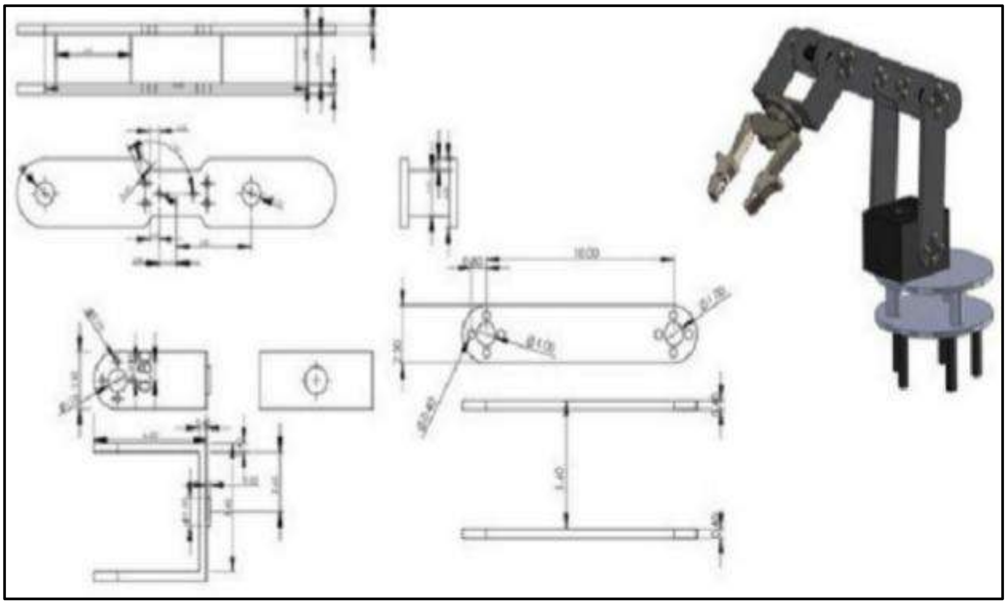
Machinability	Easily machine into complex shapes	Enables precise fabrication of robotic parts, ensuring high accuracy in movement
Thermal Conductivity	High ability to dissipate heat	Prevents overheating of motors and electronics, enhancing performance And longevity

1. MEASUREMENTS OF PARTS DESIGNED IN AUTOCAD



2. CURRENT SETUP ANALYSIS

A. Material: Plastic or 3D-printed parts
B. Actuators: Servo motors for joint movement
C. Base: Mounted on a platform with interface circuits and power connections
D. Control: USB connection with microcontroller or PC interface
E. Gripper: End effector with a claw-type mechanism for picking object

III. MODELING AND ANALYSIS

FIGURE NAME	INFORMATION
 **Fig.1. Long U Shaped Bracket**	3-pcs : A Long U-Shaped Bracket is a support and mounting framework that is used to mount and hold mechanical assemblies in robotic arms. It can be fabricated from aluminum or mild steel, in which case it offers strength and resistance but has a light configuration as well. U-shaped in design, the bracket can be mounted on other devices, such as servo motors or joints, to enable free articulation and movement control.
 **Fig.2. Small U Shaped Bracket**	1-pcs : The Small U-Shaped Bracket is the same in function as the long U-Shaped Bracket but is designed for small connections and support of small components. Because of its small size, mounting servo motors, sensors, or linkages on the robotic arm assembly is the most ideal application for it.

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 **Fig.3. Side Covered Bracket**	1-pcs : A Side Covered Bracket is a structural and protective item for covering exposed mechanical joints or electrical parts. It is made of metal or high-strength plastic and protects against dust buildup, offers mechanical stiffness, and protects internal wiring and moving parts.
 **Fig.4. MultiFunctional Bracket**	2-pcs : The Multi-Functional Bracket is an adaptable mounting piece used to mount different configurations within the robotic arm. Because it has adjustable slots and multiple holes for mounting, it allows individualized positioning of actuators, sensors, or motors. Brackets play a vital role in offering flexibility in robotic arm construction.
 **Fig.5. Large Bottom Plate**	1-pcs : Large Bottom Plate is the base support of the robot arm and it contributes to structural support. Made from composite, aluminum, or mild steel, it distributes the arm's weight uniformly, reducing vibrations and ensuring smooth movement. It is also a mounting point for control electronics and power supplies.
 **Fig.6. Power Adapter**	1-pcs : Power Adapter is a robust module providing the necessary electrical power to the robotic arm. It converts the AC mains voltage to stable DC voltage appropriate for microcontrollers, servo motors, and sensors. Typically rated from 5V to 24V, the adapter provides a safe and stable supply of power to guard against voltage swings that might compromise performance.
 **Fig.7. Clamper**	1-pcs : A Clamper is an end-effector tool that is utilized to grasp, hold, or manipulate items. It is normally operated by servo motors or pneumatic actuators with the ability to precisely control force and motion. The clamper can be designed differently depending on the application, from two-fingered grips to suction-type systems, with the capability of manipulating any object with stability and precision.
 **Fig.7. LFD -06 Digital Server**	2-pcs : The Digital Servo LFD-06 is an accurate actuator applied in robotic arm motion control. The digital servo is powered by pulse width modulation (PWM) signals, providing smooth and accurate movement and less lag. The digital servo provides greater torque, improved positional accuracy, and improved response time than analog servos. LFD-06's programmable control, low power dissipation, and high-speed of rotation make it best suited to be applied in robotics where precise and reproducible motion is required.
 **Fig.8. Winding Tube**	A Winding Tube is a safety tube designed for storing and safeguarding electrical cables in the robotic arm. Constructed with flexible, resistant materials such as PVC or rubber, it minimizes wire twisting, guards against mechanical wear and tear, and provides a neat cable organization. The winding tube is a safety-critical system in avoiding signal interference and for a general improvement in appearance and efficiency of the robotic system.

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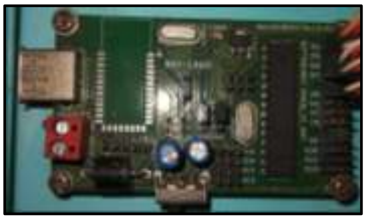
 **Fig.9. Bearing**	1-pcs : A Bearing is a vital mechanical unit deployed to decrease friction and allow smooth rotational motion in the robotic arm. Bearings allow rotating shafts, joints, and linkages, making smooth motion with little wear and tear. Generally constructed of stainless steel or strengthened polymers, these units maximize the longevity, accuracy, and efficiency of the robotic arm by minimizing mechanical resistance and allowing smooth articulation of moving components.
 **Fig.10.Ld1501 Digital Servo**	1-pcs : LD1501 Digital Servo is a high-speed motion control actuator for robotics applications. It has a faster response time, more torque, and better position accuracy than analog servos because it is based on a state-of-the-art microcontroller control system. It runs through pulse width modulation (PWM) signals to deliver smooth and stable motion. LD1501 is widely applied in robotics, automation, and mechatronic equipment and thus an appropriate option for articulation and gripping mechanisms of the robotic arm.
 **Fig.11.ldx 218 digital servo**	2-pcs : The LDX 218 Digital Servo is a reliable and powerful servo motor with high precision and quick response time. Its use in robotics, automation, and RC applications makes it a versatile tool in precision control environments. Whether you are building a robot, designing a CNC machine, or creating an RC vehicle, the LDX 218 offers the accuracy and durability required for demanding tasks.
 **Fig.12.Screwdriver**	1-pcs : A screwdriver is a tool used to turn screws, typically to either insert or remove them. The tool consists of a handle and a shaft, with the end of the shaft (called the blade or tip) designed to fit into the slot or drive of a screw. The primary function of a screwdriver is to exert torque or rotational force on the screw.
 **Fig.13. USB 16-Servo Controller Board (RKI-1005)**	The center of this circuit board is a microcontroller unit (MCU), the large black integrated circuit, the brain, which executes instructions and drives the servo motors. To serve servo motor purposes, the top-right region has 16 servo connectors, labeled S1 to S16. 12MHz and 16MHz crystal oscillators give accurate timing to both the USB interface and microcontroller. A USB connector at the bottom-left is available to be used to communicate with a PC or other microcontroller, and possibly for serial communication to provide servo commands. Power is supplied through a bottom-right red screw terminal, having an input voltage of 5-7V DC, and a reverse polarity protection using a black diode.

IV. MODIFICATION PLAN

Material Replacement:

- Arm Links and Joints: Replace with aluminium sheets of 1-1.5 mm thickness, ensuring lightweight while maintaining strength.
- Gripper Housing: Replace plastic housing with machined cutting aluminium for better grip and durability

Weight Analysis:

Plastic Weight Estimate: ~800g

Aluminium Weight Estimate: ~2-3x more, approximately 1.5 kg.

V. ESTIMATED BUDGET AND TIMELINE

- Material Cost : 1500 rs for aluminium sheets
- Fabrication Time : 1 week depending on complexity
- Assembly and Calibration : 3-4 days post-manufacturing

VI. CONCLUSION

Converting the robotic arm's body to aluminium will enhance its performance, making it suitable for industrial and research applications requiring higher durability and precision.

The modification is feasible with minimal adjustments to the existing setup, ensuring seamless integration and improved functionality.

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