A Study on The Development Of A Robot Chassis For Mini Project In Embedded Robotics (DEC50122)

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Abstract: The development of a robot chassis is an important component of robotics engineering, requiring careful material selection and design methods to optimize performance, durability, and cost-effectiveness. This study compares aluminum and acrylic as key materials for chassis construction, analyzing their respective advantages and limits. This research intends to create a practical chassis without overlooking some critical characteristics. This production must include all five categories of the mini project for the Embedded Robotics course (DEC50122). The three methods used involved designing a chassis prototype from aluminum alloy and acrylic sheets, fabricating the prototype with precision machining techniques for aluminum and laser cutting for acrylic, and conducting a series of tests, such as load tests, terrain adaptability evaluation, speed and acceleration evaluation and battery life analysis. The findings demonstrate that aluminum has the greatest improvement in terms of strength, durability, weight, precise manufacturability, and thermal conductivity. When combined with dynamic design and load testing, this demonstrates that aluminum is a sustainable chassis. Finally, the strategic development of chassis robots with aluminum and acrylic demonstrates the necessity of specialized material selection and design optimization to fulfill specific application needs. This study compares aluminum and acrylic for robot chassis, optimizing performance and durability through design. Continued innovation and research will drive further progress, boosting the capabilities and uses of chassis robots in various industries.
Keywords: Chassis, Aluminum, Acrylic, Robot

1. INTRODUCTION

The integration of robots in education is revolutionizing the way students learn and engage with various subjects. This development encompasses several aspects, including interactive learning, personalized education, and the enhancement of STEM (Science, Technology, Engineering, and Mathematics) skills. Robots provide a dynamic and interactive platform for students to engage with educational content. Unlike traditional teaching methods, robots can offer real-time feedback and adapt to the learning pace of individual students. This interaction makes learning more engaging and helps in retaining information better. One of the significant advantages of using robots in education is the ability to offer personalized learning experiences. Robots can be programmed to cater to the unique needs of each student, providing customized lessons that address their strengths and weaknesses. This individualized approach helps in accommodating diverse learning styles and paces, ensuring that no student is left behind.

Robots are essential in advancing STEM education because they give abstract ideas a concrete form. Students practice computational thinking, problem-solving, and critical thinking using robotic kits and programming activities. In addition to making studying enjoyable, these activities help students get ready for professions in engineering and technology. Robotics contests, like ROBOTO (Robotic Tournament), further inspire students to develop and use their STEM expertise in real-world circumstances. A teaching aid (ABBM) tool called ROBOTO, a robot competition platform, is intended to assess students' mastery of general skills and CLO achievement through mini-projects (Yusmahaida et al.2020). Additionally, collaborative learning environments where students work together to solve problems and finish projects can be facilitated by robots.

This collaborative aspect promotes collaboration and communication skills. Educational robots frequently serve as tools for group activities, allowing students to cooperate and exchange ideas, cultivating a feeling of community and collective learning. The use of robots in education marks a substantial move toward a more interactive, individualized, and engaging learning experience. Robots help kids prepare for the future by improving STEM abilities, encouraging collaborative learning, and making education more accessible. As technology advances, the use of robots in education is projected to expand, providing even more innovative approaches to improve learning and teaching methods.

Stem is still being used in higher education, whether through diplomas or degrees. The polytechnic education system is also responsible for guaranteeing the sustainability of stem subjects such as embedded robotics.

2. PROBLEM STATEMENT

The subject DEC50122 Embedded Robotics must include CLO1, CLO2, CLO3, and CLO4. Following the complex calculation of CLO4 scoring, ROBOTO was developed to facilitate score calculation as well as the implementation of micro projects. In the small project, five categories are contested: Sumo robot, Line Follower robot, dancing robot, speech robot, and robot racer. All these categories must use the same robot. Some issues develop during and during the competition. The robot chassis is constructed of plastic, which is brittle, lightweight, and thin. A training occurrence caused significant damage to the robot's chassis. Students must pay the cost of obtaining a new chassis.

The second issue is that the cost is not comparable with the robot body, which has a lot of extra space and an excessive number of holes that aren't used. The final one is the inflexible body with components used in terms of size and space.

3. LITERATURE REVIEW

The development of robot chassis is a pivotal area of focus in robotics, as the chassis forms the foundation upon which all other components are mounted and integrated. This literature review examines recent advancements and critical developments in robot chassis design and manufacturing, particularly since 2020, emphasizing their impact on the overall performance, durability, and adaptability of robots.

The performance of a robot is greatly influenced by the materials used for its chassis. The utilization of cutting-edge materials that provide balance between strength, weight, and cost is emphasized by recent studies. Because of their excellent strength-to-weight ratios, composite materials such as carbon fiber and fiberglass are becoming more and more popular. Carbon fiber composites, according to Chen et al. (2021), offer superior structural integrity while lowering the robot's total weight, which is essential for mobile and airborne robots. Robot chassis are still frequently made of aluminum and titanium alloys because of their strength and simplicity of machining. Aluminum alloys are used in industrial robots to ensure robustness while retaining a tolerable weight, according to a study by Kim et al. (2020).

Design considerations and versatility must be evaluated while developing this chassis design. The design of the robot chassis is crucial to ensure that all components are properly integrated and that the robot can execute its intended activities. Modular chassis designs enable simple upgrades and maintenance, which is critical in both research and commercial applications. Jones et al. (2020) explain the benefits of modularity, such as the ability to swiftly reconfigure the robot for new duties or repair broken sections.

The chassis is crucial to the robot's overall performance, influencing elements like stability, mobility, and energy efficiency. A well-designed chassis improves the robot's stability and mobility, which are essential for activities ranging from basic navigation to complicated operations. Liu et al. (2020) investigate how the chassis design influences a robot's ability to navigate uneven terrain and maintain equilibrium while operating. The weight and distribution of chassis components have a considerable impact on the robot's energy consumption. According to Park and Lee (2021), lighter materials and efficient designs lead to longer operational durations and lower energy consumption.

Recent advances in robot chassis development demonstrate continuous innovation and the incorporation of new technologies. The use of smart materials, which may change properties in response to external stimuli, is an emerging trend. According to Hwang et al. (2021), these materials can improve the robot chassis' adaptability and functionality.

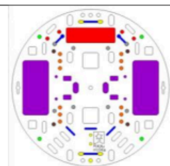
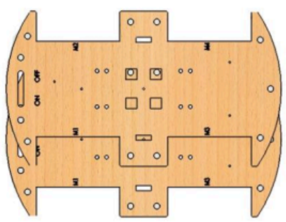
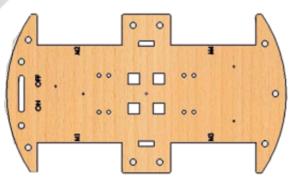
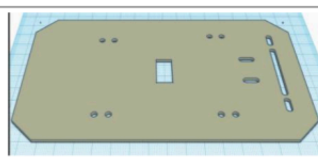
4. METHODOLOGY

This product was developed in numerous phases, including robot body design, body fabrication, and testing.

4.1 Design

Several sketches were created during the design phase of the robot chassis, as illustrated in Table 1. As may be seen, six chassis types have been identified. Each design emphasizes the robot's balance as well as its size, design, and material weight.

Table 1: Design And Materials Used In The Development Of The Robot Chassis

	Design	Material	Dimension (D) Weight (W)
Design 1		Acrylic	D: 15.9 x 9 x 3.3 cm; W: 71.99 g
Design 2		Acrylic	D: 22/86 x 12.7 x 5.8 cm W: 480 g
Design 3		Acrylic	D: 22/86 x 12.7 x 5.8 cm W: 480 g
Design 4		Acrylic	D: 15 x 10 cm W: 425g

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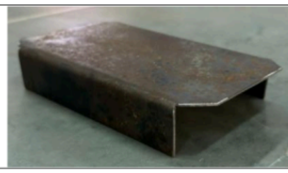
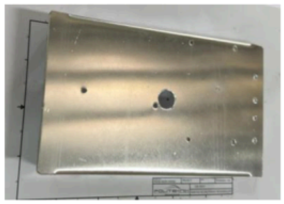
Design 5		Iron	D: 15 x 10 cm W: 800g
Design 6		Aluminium	D: 15 x 10 cm W: 550g

4.2 Chassis fabrication

Once the design is complete, the robot will be assembled. The completed robot's result is shown as in Figure 1. The diagram above shows the robot's evolution from using two to four tires. This revision also addresses the transition from two to one layer. Next, the materials used have changed from acrylic, iron, and aluminum.

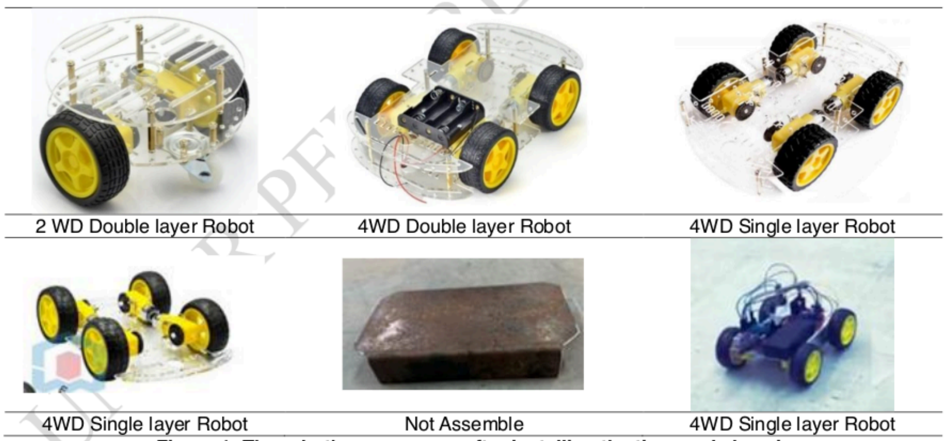


Figure 1: The robot's appearance after installing the tires and chassis

4.3 Testing

The testing phase focuses on assessing the robot's strength and endurance, especially for Sumo robots. Observations and questionnaires are approaches to acquiring data and research results. The questionnaire was given to 265 semester 4 and 5 students to complete. Observations during training and in the field are also recorded.

5. RESULT AND ANALYSIS

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The questionnaire was distributed to 265 students in semesters 4 and 5. At the same time, ten lecturers who teach Embedded Robotics documented observations made during training and in the field. Observation result can be displayed as Table 2.

Table 2: Observation result by lecturers

DESIGN	OBSERVATIONS
Design 1	Small, No stability and enough space, easy damage
Design 2	Big and heavy. many unused space, need a lot of screws, easy damage
Design 3	Big, Bending chassis due to cannot support battery holder, many unused space, easy damage
Design 4	No unused space, thin, easy to damage since it's made from acrylic
Design 5	Heavy, rusty and sharp edge, Safety issue
Design 6	Heavy, smart

Weight, strength, and manufacturability are among the characteristics evaluated when analyzing the performance of aluminum and acrylic in the construction of robot chassis. Figure 2 compares the performance of aluminum and acrylic. Aluminum has exceptional structural integrity, withstanding high mechanical stress and load. Its high tensile strength makes it excellent for applications that demand strong and long-lasting construction. However, unlike metal, acrylic cracks and breaks more easily under intense pressure. It is also less suitable for applications that need strong weights or impacts.

Aluminum offered a good balance between strength and weight, making the chassis relatively lightweight without compromising on durability. Result shows Acrylic was lighter than aluminum, contributing to a lower overall weight of the chassis. In terms of manufacturability, Aluminum was easy to machine, allowing for precise and complex designs. Techniques like CNC machining, laser cutting, and bending were effectively used. Although Acrylic was easy to cut and shape using laser cutting and other methods but it still required careful handling to avoid cracking.

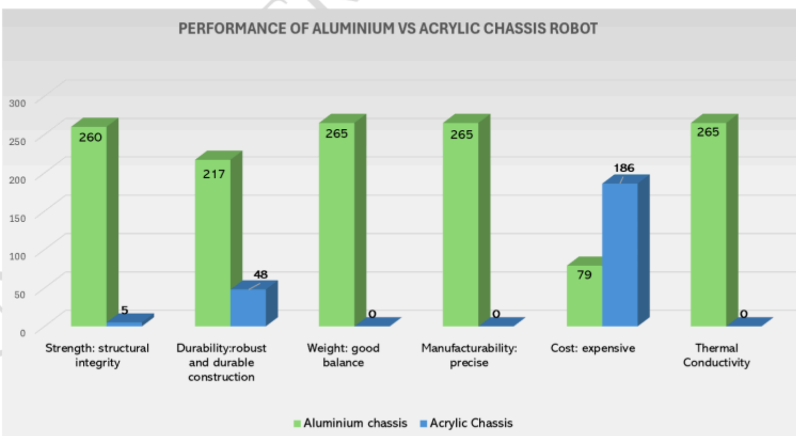

Figure 2: Performance of aluminum vs acrylic chassis robot

When it comes to cost, the graph shows that 79 respondents felt that aluminum was more expensive than acrylic but had higher strength and longevity. It was less expensive than acrylic and aluminum, making it a

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good choice for low-budget applications. All responders agreed that aluminum's excellent thermal conductivity helps dissipate heat generated by motors and electronics, lowering the risk of overheating.

Figure 3 demonstrates that almost all responders selected metal for load testing, adaptability, speed and dynamic design. Aluminum successfully handled higher loads with minimal deformation. It proofs that aluminum is suitable for applications requiring the transport of heavy components or equipment while acrylic performed well under moderate loads but exhibited signs of stress and potential cracking under higher loads. It is best suited for lighter applications or prototypes.

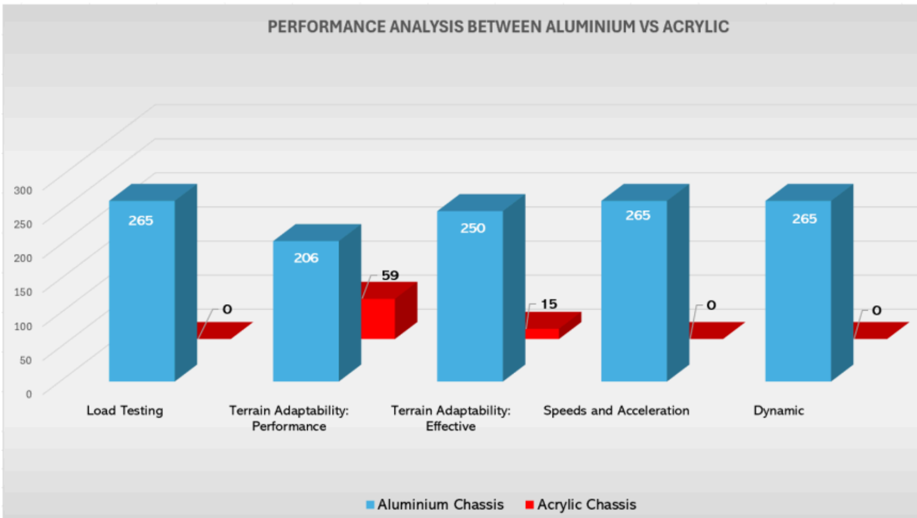

Figure 3: performance Analysis between Aluminum and Acrylic

Figure 4 indicates that aluminum has a 100% share of the three study insights because it provides superior strength, durability, and thermal management at a higher cost and weight. It is suited for applications that require both durability and performance. On the other hand, acrylic necessitates cautious handling and heat management. The respondent additionally chose aluminum because of its application applicability and design concerns.

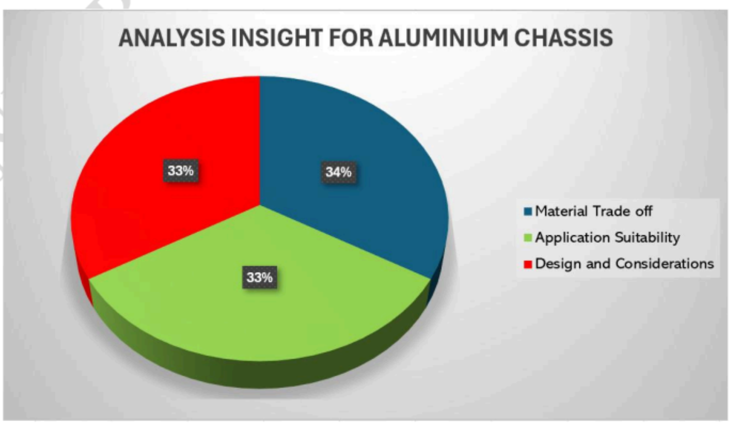

Figure 4: Analysis insight for Aluminum Chassis

6. CONCLUSION

The development of a robot chassis for a mini project in Embedded Robotics (DEC50122) successfully illustrated key mechanical design and integration principles relevant to robotics applications. The design process was centered on constructing a strong and adaptable chassis capable of fitting various components while maintaining stability and longevity. The study's findings demonstrate that aluminum offers several advantages over plastic chassis in a variety of areas.

Although the project's primary goals have been met, there is still room for improvement. Future enhancements could include investigating innovative materials to improve performance, incorporating additional sensors for enhanced functionality, and adopting more sophisticated control algorithms to expand the robot's capabilities.
Finally, the successful construction of the robot chassis has laid a solid foundation for the following robotics.

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