Design and Analysis of Thermoplastic Metal Detector RC Car with Wireless Charging

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***Abstract*—The RC Car industry is a growing industry that will always be a past time for the older generation. This research is focused on a specific type of RC Car which is a Metal Detecting one. Metal Detectors have been developed for many years. Through research there aren't many metal detecting RC Cars on the market. Currently it's extremely limited in range and depth of detection.**

The goal of this research is to improve, build and test a new RC-metal detector technology. A thermoplastic-ABS used to build the chassis of the RC- metal detector. ABS is easily machined, sanded, glued and painted. Finite element analysis is a powerful tool that allows us to quickly analyze and refine a design. When the Chassis fixed at front Differential (Displacement), the value of the maximum stress and the deflection are higher than when the Chassis Fixed at Rear Differential. The maximum deflection is shown as about 1.339 inches. This value is the resultant of the deflection in all three directions. This research includes, a cost analysis for each piece of the car, group goals for the RC Car and Metal Detector. A working prototype is designed before moving into the final design phase in order to assure that the best possible product can be produced. There is a wireless charging station that ease the process of recharging the battery.

Keywords-Metal Detector; Finite Element; Thermoplastic; RC

I. INTRODUCTION

The challenge for this project is to design and build a remote-controlled car that incorporates two features that no other car possesses. RC Car owners have tedious work to do every time the car needs to be charged. Some components must be taken apart to retrieve the battery to charge it. The wireless charging feature being implemented in the design will eliminate this extra work, while providing a smooth charging operation where no disassembling will take place.

The design and development of remotely operated solar-powered mobile metal detector robot is a rescue robot to autonomously operate in detecting the threat of land mines. During the First and Second World War, military forces deployed many bombs on land filed to fight between soldiers on the battlefield. There were many countries like Libya, Cambodia and Laos had explosive weapons that did not explode when fired or dropped on the ground. In fact, more than twenty thousand people have been killed or injured by unexploded bombs [1]. A remotely solar-powered mobile metal detector robot has been designed and implemented. The system is using RF communication with Atmega32 MCU in embedded system domain. The robot moves in particular direction using the handheld remote. The experimental work has been carried out carefully. The metal detector sensor worked as the required specification for the metal detection sensor. The testing demonstrated that the robot would not pose any performance problem for the installation of the metal detection robot such as the merits and drawbacks of mounting the sensor, cost, support vehicle, handling the cable between the robot and also easiness of the adjustment [2]. Nation et al. [3] demonstrated the accuracy of HHMD in the identification and localization of metallic foreign bodies. They proposed an emergency room foreign body protocol that uses HHMD as an early screening tool in triage in order to expedite the process of obtaining Otolaryngology consultation and potentially shorten the wait time to the operating room or discharge. In instances were outside films are previously performed, HHMD use may be able to minimize the overall radiation exposure to children by obviating the need for repeat radiographs. As the sensitivity is not 100%, a negative HHMD screening does not negate the need for a standard radiograph in order to avoid missed MFBs. HHMD is best suited for detection of coins, which accounts for the majority of the MFB ingestions, and may not be suitable for all metallic objects since the amount of metal may decrease its sensitivity.

Holm, Katja F et. al. [4] evaluated a commercially available metal detector for detecting CIEDs. Design. Observational study including pacemaker patients (n = 70) and a control group without pacemaker (n = 95). The investigational device was a hand-held metal detector for detecting metal or electricity wiring. Results. The metal detector detected the pacemaker in all pacemaker patients and thus exhibited a sensitivity of 100%. The specificity of the metal detector was 86%, and the negative predictive value was 100%. Thirteen individuals without pacemakers were falsely identified as having an implanted device due to implanted prosthetic material or elements of clothing.

The objective of this research is to design a RC car that will provide a smooth wireless charging process and incorporate a metal detector. RC Cars require tedious work in order to charge the battery. It will offer a wireless charging station where no disassembling of the car will be required. Apart from technical innovations, an improved metal detector will be incorporated that will be useful on beaches and in parks to search for lost jewelry. A long-term goal with an unlimited budget is to use this car to detect mines for the army. This car could drive over the field before infantry and passenger vehicles drive over it to protect them from mines or IEDs.

II. MATERIAL AND COST

Acrylonitrile Butadiene Styrene (ABS) is an opaque thermoplastic and amorphous polymer. ABS becomes liquid at a certain temperature, 221 degrees Fahrenheit. They can be heated to their melting point, cooled, and re-heated again without significant degradation. Instead of burning, thermoplastics like ABS liquefy which allows them to be easily injection molded and then subsequently recycled. ABS is easily machined, sanded, glued and painted. This makes it a great material for prototyping. Table 1 shows the required material to build the RC-car metal detector.

TABLE I. THE MATERIAL AND THE COMPONENTS OF RC-CAR METAL DETECTOR

	Cost
Supplies	Battery - $180 Engine - $120 Suspension Kit - $80 Wheels & Tires - $60 Controller & Transmitter - $80 Receiver - $80 Metal Detector - $40 Wireless Charging Components - $100
Prototype	Pre- built RC Car - $80
Equipment	3D Printer - $0 (School Owned) CNC Mill - $0 (School Owned) Welder - $0 (School Owned) Soldering Iron - $0 (School Owned) General Tools - $0 (School Owned)
General Reserves	Possibility of broken components.

A. *Finite Element Analysis of Material*

SOLIDWORKS Simulation uses the displacement formulation of the finite element method to calculate component displacements, strains, and stresses under internal and external loads. The geometry under analysis is discretized using tetrahedral (3D), and solved by iterative solver. SOLIDWORKS Simulation using p adaptive element type, the solution has converged. The material parameters were obtained and the results were simulated. One of the most important inputs to the model is the elastic modulus E of the material. The elastic modulus defines the stiffness (resistance to deflection) of the material. Its value is determined from material tests. A material with a high value of E will deflect less than one with a lower value of E. By applying finite element analysis, we can accurately observe the stress distributions in the various layers of the material as shown in Figures 1, 2, 3 and 4. Figure 1 shows Chassis Fixed at Rear Differential, the highest stress is 4039 psi with mesh size was 0.2. However, the maximum deflection was 0.7 inches as shown in Figure 2. Simulates impact on underside of chassis.

B. *ABS Plastic Material Data*

Elastic Modulus: 290075.4753 psi, Shear Modulus: 46252.53454 psi, and Tensile Strength: 4351.13213 psi

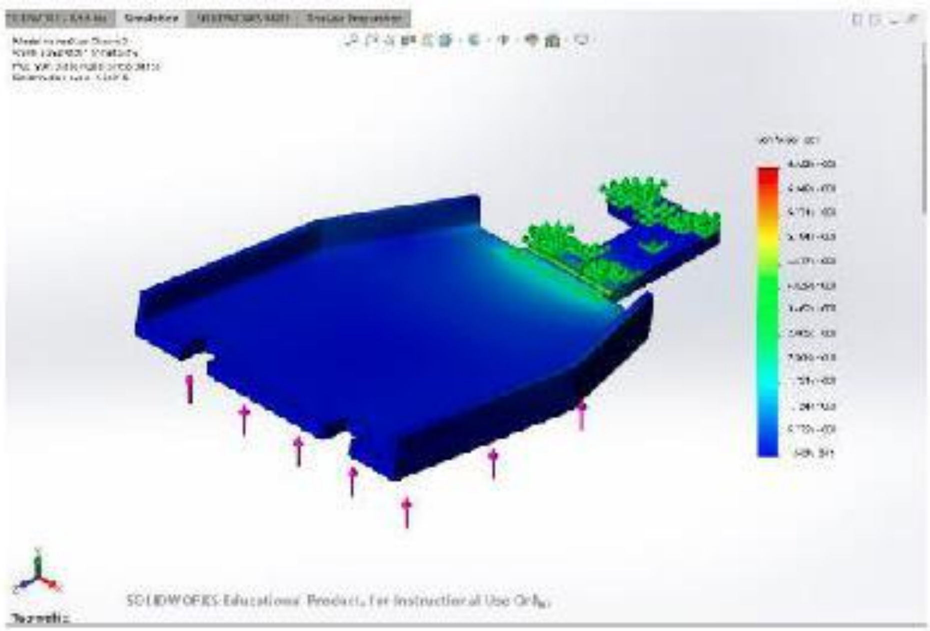

Figure 1. Chassis Fixed at Rear Differential (Von Mises)

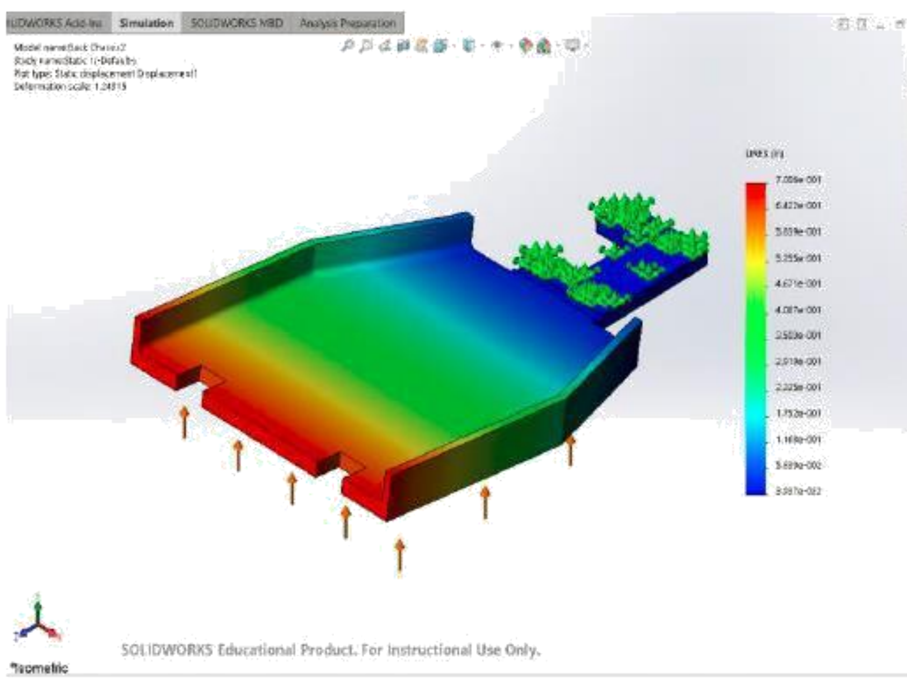

Figure 2. Chassis Fixed at Rear Differential (Displacement)

Figure 3 shows Chassis Fixed at front Differential (Displacement), the highest stress is 8375 psi with mesh size was 0.2. However, the maximum deflection was 1.339 inches as shown in Figure 4, it Simulates impact on underside of chassis

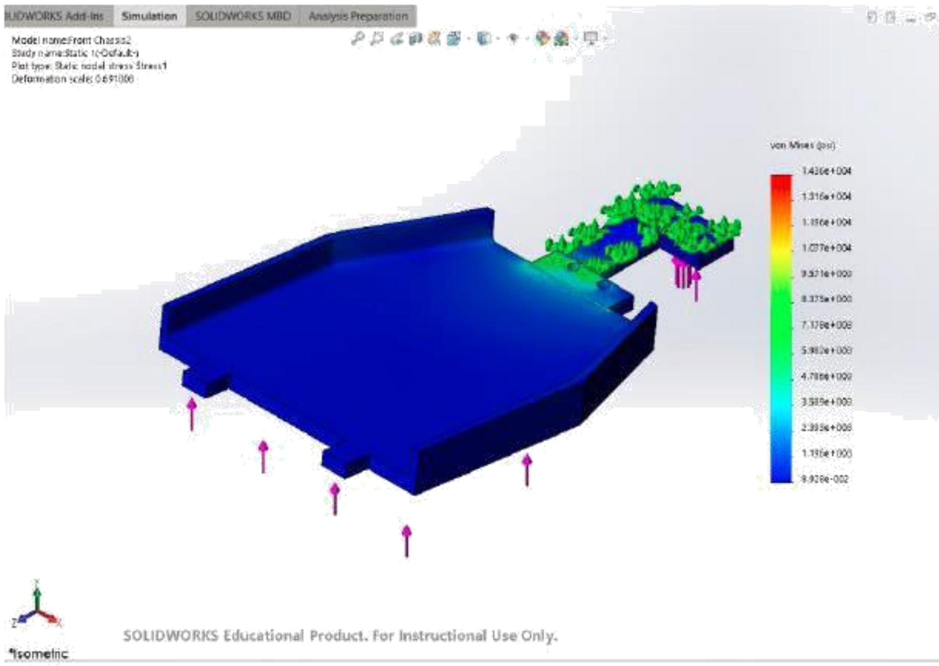

Figure 3. Chassis Fixed at Front Differential (Von Mises)

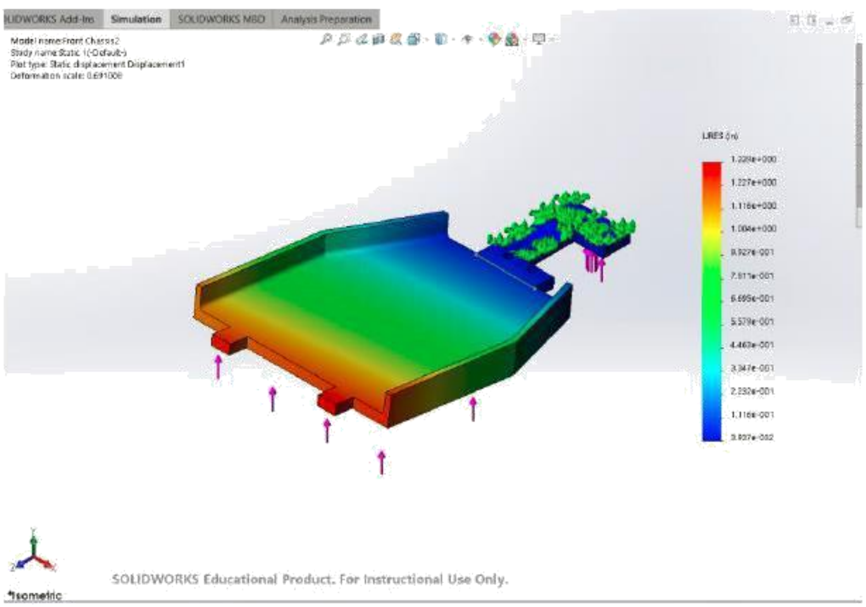

Figure 4. Chassis Fixed at front Differential (Displacement)

III. DESIGN PROTOTYPE AND TESTING

One of the biggest challenges was designing a chassis from scratch that would house all the components necessary to operate a RC Car. The chassis also needed to be strong enough to not only hold the weight of the car and all its components, as shown in Figure 5, but also handle the torque and power that would be outputted from the car. The designed chassis was more than suitable to hold all the components and handle the force of the motor. There was more room than anticipated, which was useful for placing the components and keeping things away from all the moving parts. In the end, the RC Car is programmed and moves as planned. The metal detector detects deeper than expected. Finally, the wireless charging station works better than anticipated. Figure 7 shows the Wireless Charging Ramp Setup.

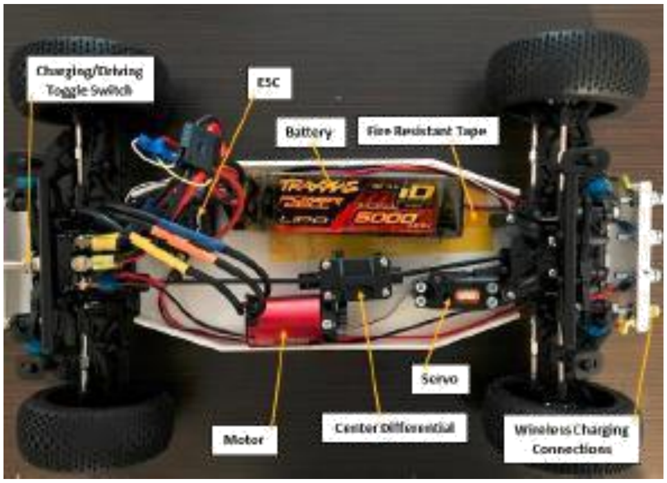

Figure 5. Detailed Picture of all Components

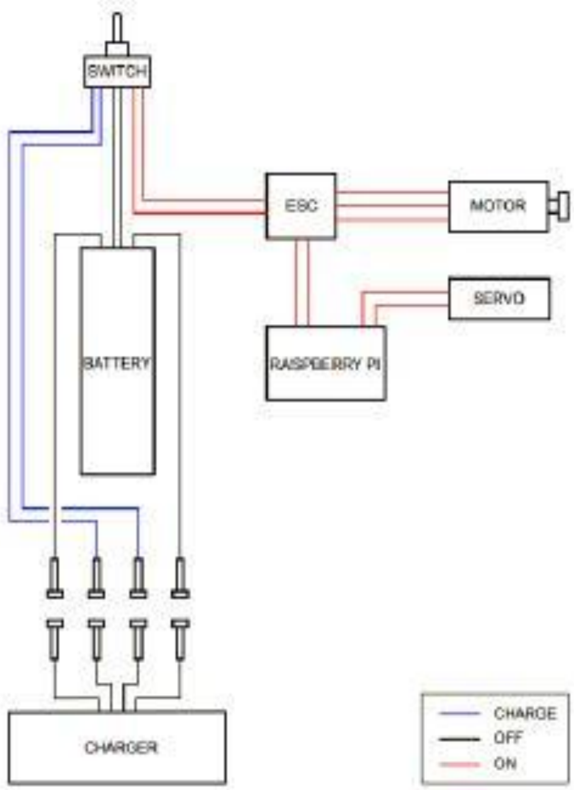

Figure 6. Layout of the Electrical Circuit

Figure 6 shows the layout of the electrical circuit of the RC-car metal detector. The main circuit is powered by a battery through a mechanical switch. If the switch is turned ON, power is supplied to a motor and a servo. The speed of the motor is regulated by an Electronic Speed Control Circuit (ESC). The servo on the hand is controlled by a Raspberry Pi computer board. The circuit also has four terminals that are used to connect to an external charger once the battery has depleted.

Figure 7. Wireless Charging Ramp Setup

Figure 8. Final prototype

IV. CONCLUSION

This project aimed at creating a thermoplastic RC Car designed with a purpose, more than just an average recreational toy. This was bringing up the reality of a much greater idea. The wireless charging aspect of the RC Car will mostly be aimed towards small scale vehicles. However, the metal detection can be a very realistic and useful application for much bigger vehicles. The idea that an unmanned vehicle can be used for detecting not only metals, but harmful objects could potentially be a breakthrough for something like the military. IED's are a very serious issue for the military, being able to sniff these out without having to risk the lives of anyone would be huge. Completing this project with a limited budget would show a lot, especially when someone like the military could spend endless amounts of money in order to perfect the system for more dangerous and life like scenarios. FEA analysis was used to test the chassis, When the Chassis Fixed at front Differential (Displacement), the value of the maximum stress and the deflection are higher than when the Chassis Fixed at Rear Differential.

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