Department of
MECHANICAL ENGINEERING
COLLEGE OF ENGINEERING | THE UNIVERSITY OF UTAH

AR MEDL
SCIF Sustainable Campus Initiative Fund

Useful Robot Team 1: Chassis Assembly

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INTRODUCTION

The construction industry accounts for 37% of greenhouse gas emissions. To reduce this, electric-powered machinery is being adopted. However, current models support only one attachment and are limited to construction sites due to their large size. Our goal was to design and build a chassis compatible with a forklift and excavator attachment. The robot is electrically powered and hydraulically actuated.

PROJECT SCOPE

The scope of this project is to design and manufacture the chassis of a modular electric construction machine. This includes the frame, front-wheel steering, and turning about its center axis. Key requirements include supporting a 2,500 lb forklift load and 1,000 lb digging load, handling 15° slopes, and operating on dirt, grass, and concrete.

INITIAL CONCEPT TESTING

We began with a detailed CAD model to define geometry, layout, kinematics and component placement. Finite Element Analysis (FEA) was then used to evaluate structural performance and guide frame optimization. A simplified prototype was built to test mechanical function, including the range of motion of steering.

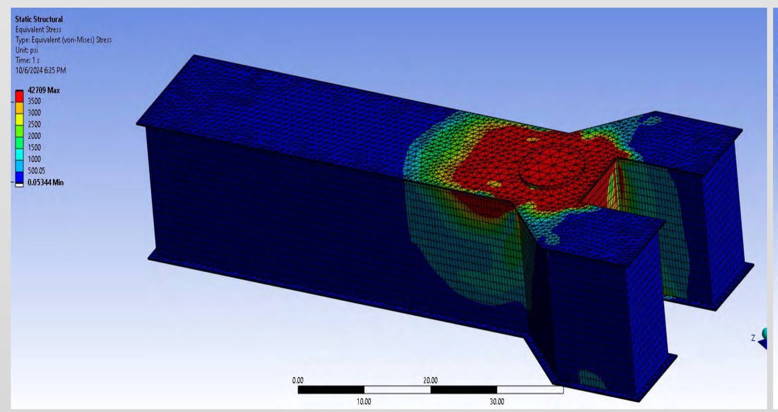
Figure 1: Initial Chassis FEA Results

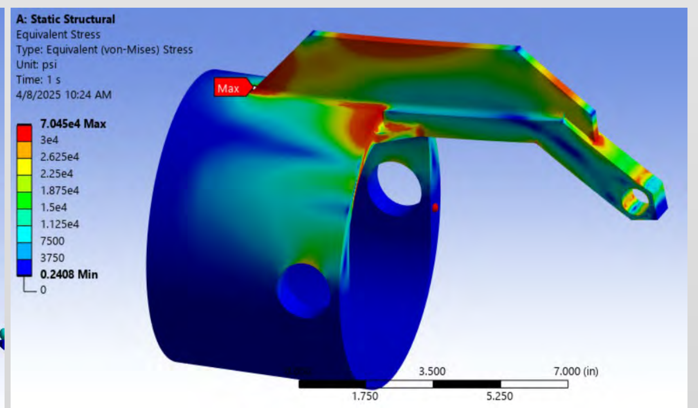
Figure 2: Initial Steering Knuckle FEA Results

FINITE ELEMENT ANALYSIS

A Static Structural analysis was developed in Ansys to test the structural integrity of the chassis, which empowered us to strengthen our design to meet design criteria. The images below depict the stress that the chassis would undergo in the highest stress situations: digging operation at full length (6 ft), forklift load tilted to the wheels

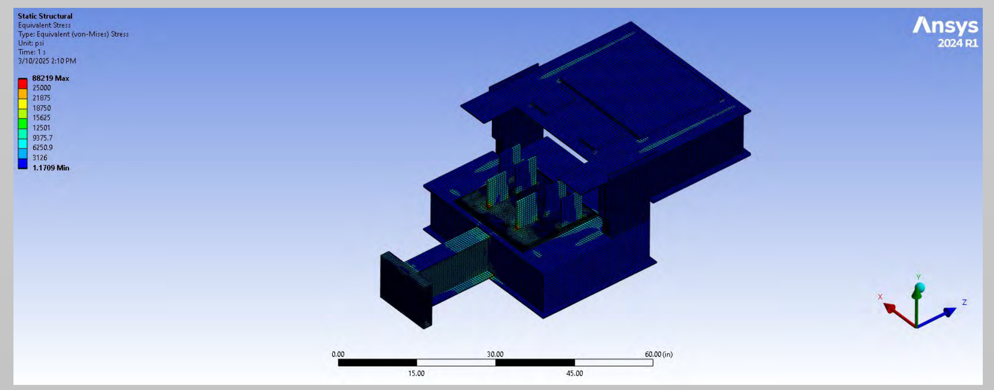

Figure 3: Final Chassis FEA Results

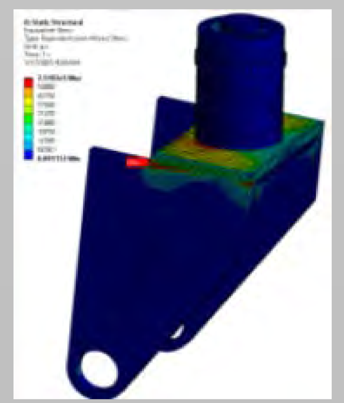
Figure 4: Final Rear Wheel Castor FEA Results

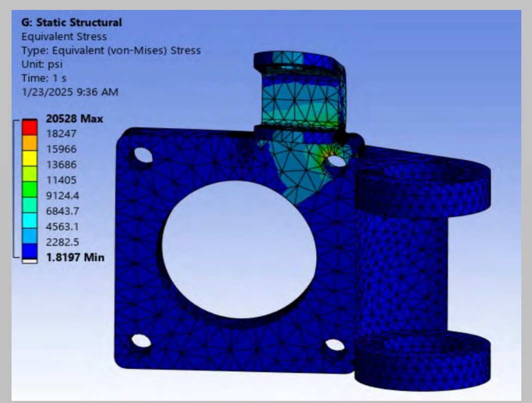
Figure 5: Final Steering Knuckle FEA Results

CHASSIS ASSEMBLY DESIGN

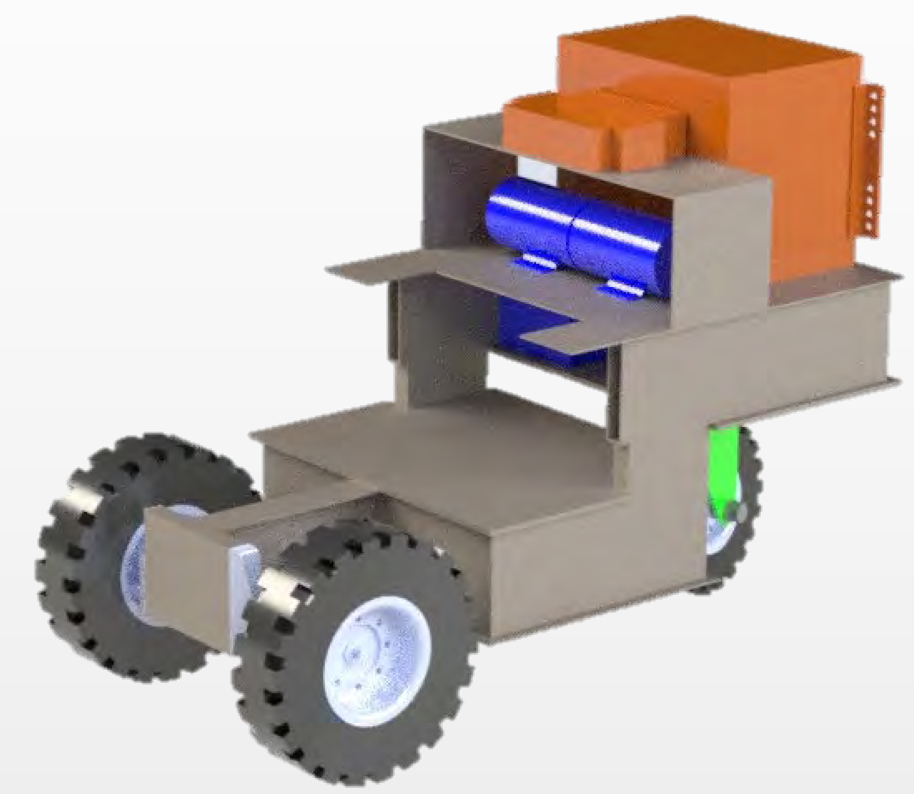
Figure 6: Chassis Visualization. Colors represent the sections that team members worked on. Frame is coarse grey. Electronics are deep blue. Hydraulics are deep orange.

The chassis is designed to properly connect attachments and auxiliary systems within the size constraints. The chassis frame consists of a steel beam skeleton sandwiched between steel plates. The steering system consists of machined steering knuckles/fists that connect to wheels and hydraulic motors, which steer through hydraulic actuators. The rear wheel is designed to operate like a castor wheel, allowing for zero-point turn. It consists of welded steel plates, channel, and solid shaft that connect a swivel to the wheel.

ELECTRIC/HYDRAULIC SYSTEM DESIGN

The hydraulic system is designed to fit into a limited space and deliver sufficient power and torque. Additionally, the system is designed to endure pressures of around 2900 psi for the operation of motors and cylinders. A 9-valve manifold uses electronic solenoids to control the speed and direction of the motors.

The electronics system is designed to pump the hydraulic fluid. The fluid can only flow while the pumps are moving. The vehicle will stop moving if the motors are shut off. The motor speed is controlled using an XBOX controller so that users need to be within line of sight of the vehicle to operate the vehicle.

RESULTS

Req #	Requirement	Target Value	Achieved Value
1	Chassis weight	2500 lbs	1500 lbs
2	Stress Safety Factor	2	2.2
3	Maximum chassis width	3 ft	3 ft
4	Maximum chassis length	7 ft	7 ft
5	Maximum height (with attachment)	8 ft	6 ft

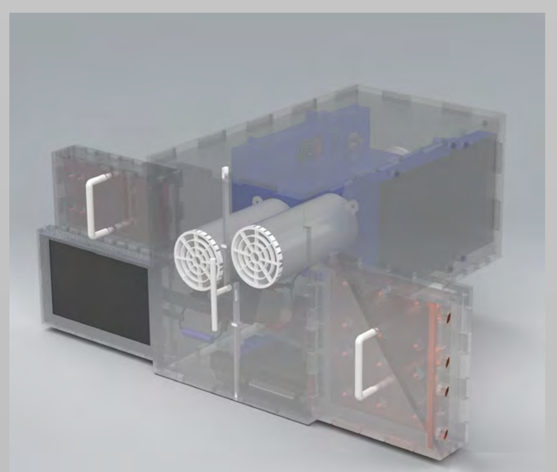
Figure 7: Final Electronics Box Design

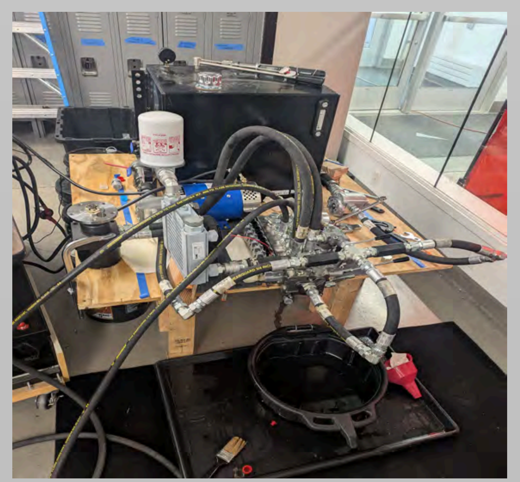
Figure 8: Final Hydraulics Testing Setup


Figure 9: Welded X-brace for chassis

MANUFACTURING PROCESS

Our manufacturing consisted of assembling chosen commercial products for electrical and hydraulic systems, angle griding, CNC machining, welding, cutting/trimming, and sanding.

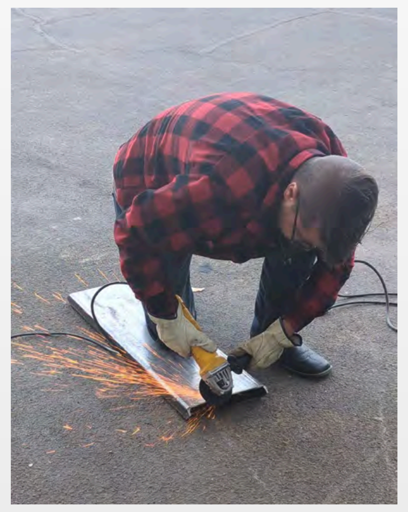
Figure 10: Angle griding


Figure 11: CNC machining


Figure 12: Welding


Figure 13: Cutting


Figure 14: Hydraulics assembly

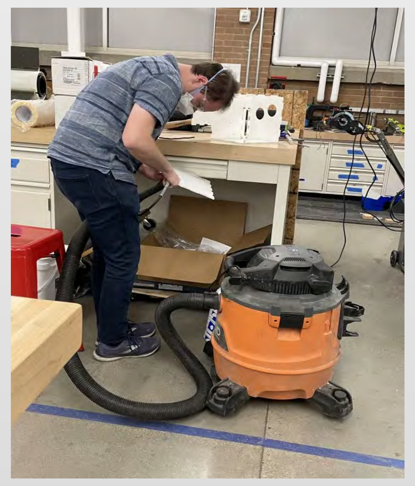
Figure 15: Sanding

NEXT STEPS

Next steps for the Useful Robot project is to interface the arm with the chassis and integrate more batteries to extend the time the robot can be used. Future design teams will be tasked with completing the integration, improving the design for usability and repairability, and automating the machine so that it can operate without human intervention.

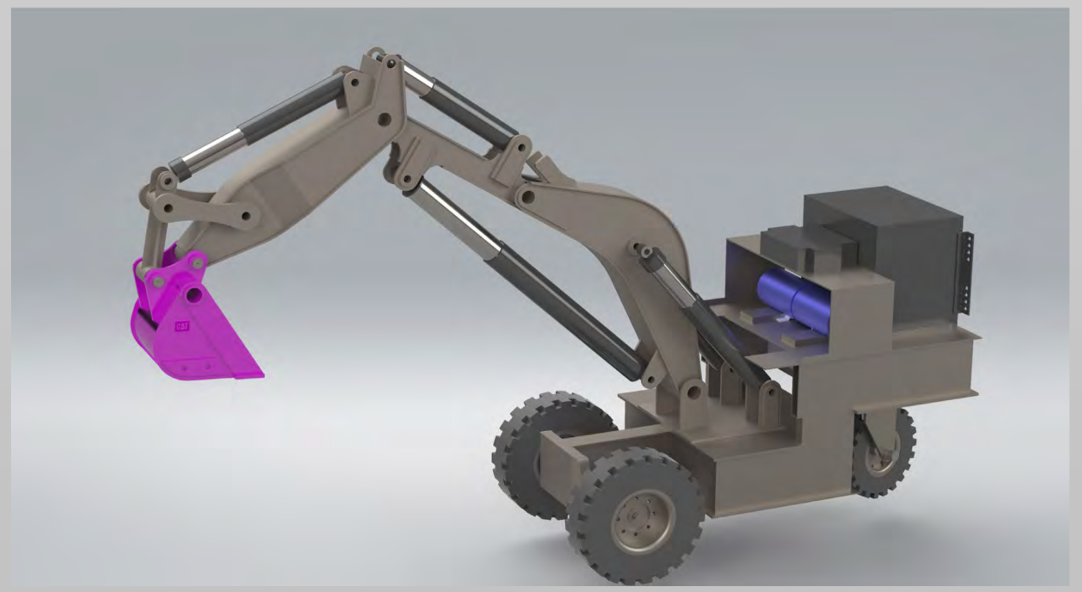
Figure 16: Integrated project visualization

CONCLUSION

The final chassis design is capable of withstanding forklift and digging operations while performing a zero-point turn. The chassis and attachments connect without interference and fit within size constraints. The electric/hydraulic system operate steering and attachments without failure. Overall, the chassis meets most of the design requirements.