Shell Gas Eco-Marathon (ICE)

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Abstract

The Trine University Shell Gas Eco-Marathon team, comprised of 7 ME department students, innovated the existing vehicle in hopes of having the opportunity to complete a run at the competition held at Sonoma Raceway. Vehicle improvements were first designed and then selected based on criteria the team decided to be of importance. Designs for the steering system, frame, driver seat, and shell of the vehicle were then manufactured and tested for driver safety and to ensure the design met the team's expectations. Additional testing was conducted to determine vehicle drag, rolling resistance, and MPG. Dynamometer testing was used to determine the vehicle drivetrain efficiency, or losses, of power being delivered to the system via the engine. Due to the impact of the COVID-19 virus, the team was unable to compete in the annual competition and was forced to halt all manufacturing and testing. The team will detail a report of all modifications and findings from testing for the future iteration of the project.

Customer Needs and Requirements

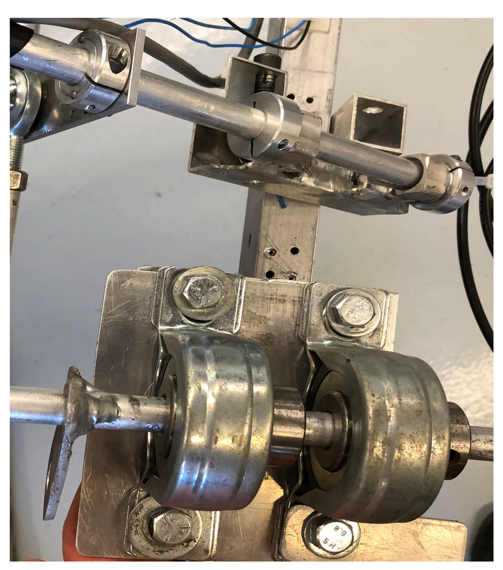
- Complete 6.4 mi run in < 26 min with max MPG
  - Pass Safety/Technical Inspection
- Receive Prize Money from competition
  - 500 MPG or better
  - Place top 6 in Shell Eco-Marathon Prototype Class Competition
- Redesign and improve existing vehicle
  - Steering System structural strength
  - Frame extension/seat modification
  - Test drag, rolling resistance, MPG, dynamometer

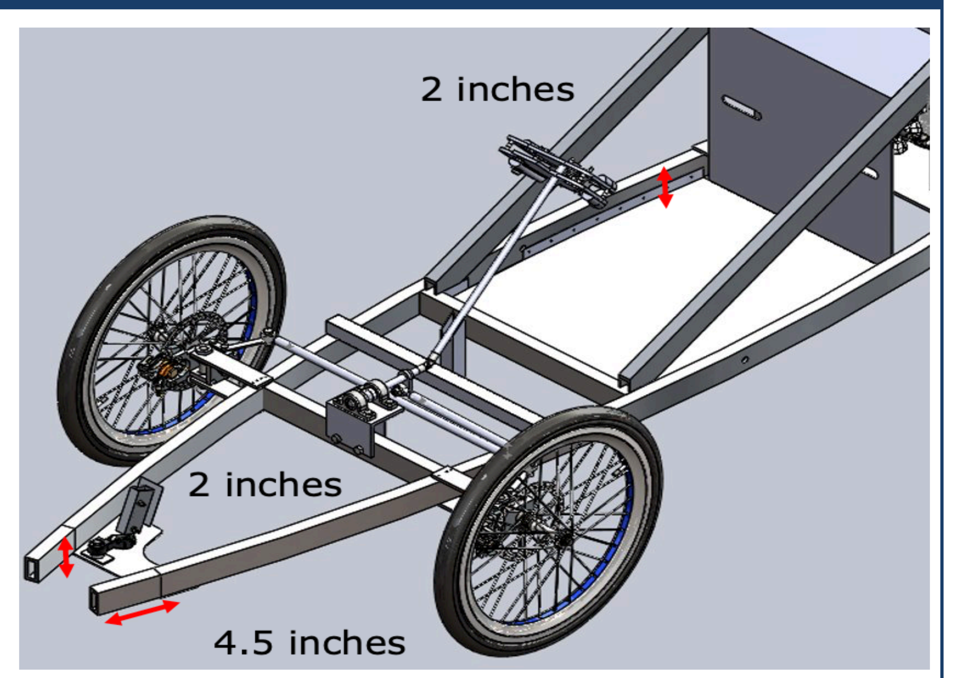
Shell Eco-marathon®

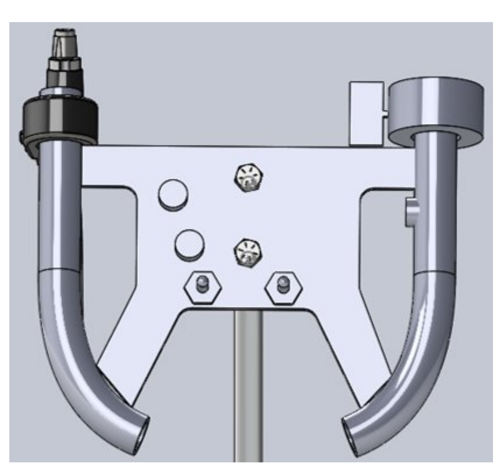
Concept Selection

- Design a Steering System that incorporates structural integrity and passes technical inspection
  - Steering Wheel Butterfly design
  - Rigid aluminum tubing Steering System mount to vehicle frame for structural support and reduced weight
- Provide driver with additional space in order to pass technical inspection at competition
  - Frontal vehicle frame extension (welding) provides additional 4.5"
  - Seat modification provides additional 2"

Design Solution



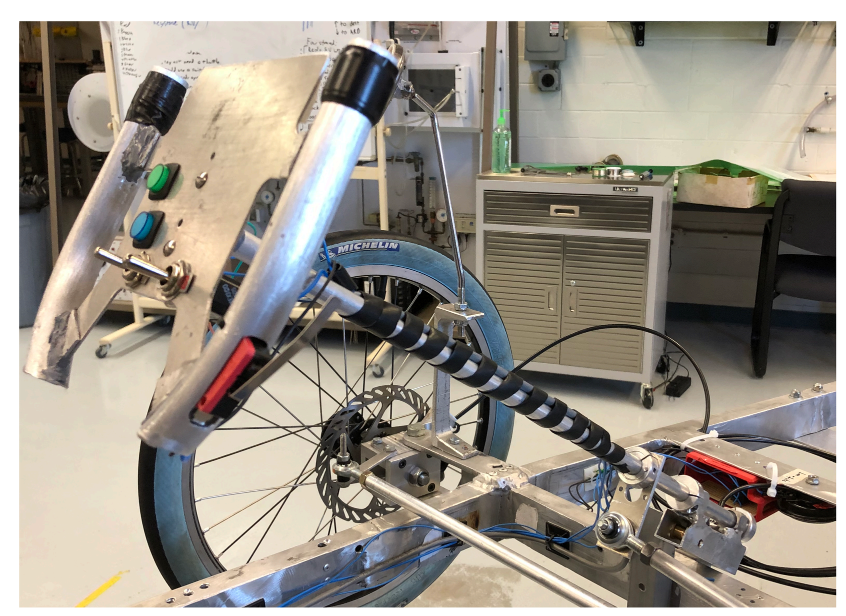




Left: Butterfly Steering Wheel Design with attached brake handle and throttle. The design also includes testing with a prototype the driver used to determine best button/switch layout.
Above: Vehicle frame/seat modifications to allow for the driver and the team to pass technical inspection
Top Left: Comparison of old bearing mount for steering system support versus redesigned steering system bushing mount. Reduced weight and provided better structural support.

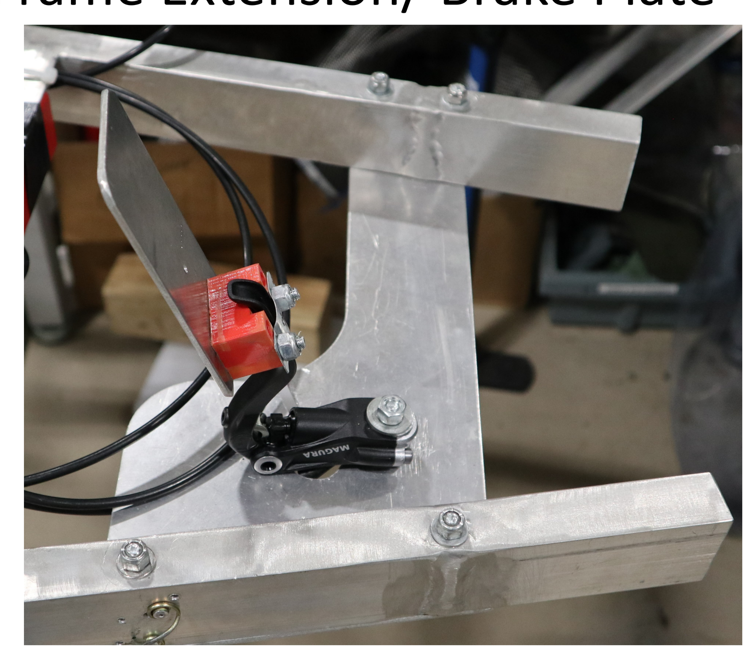
Manufacturing

Steering System



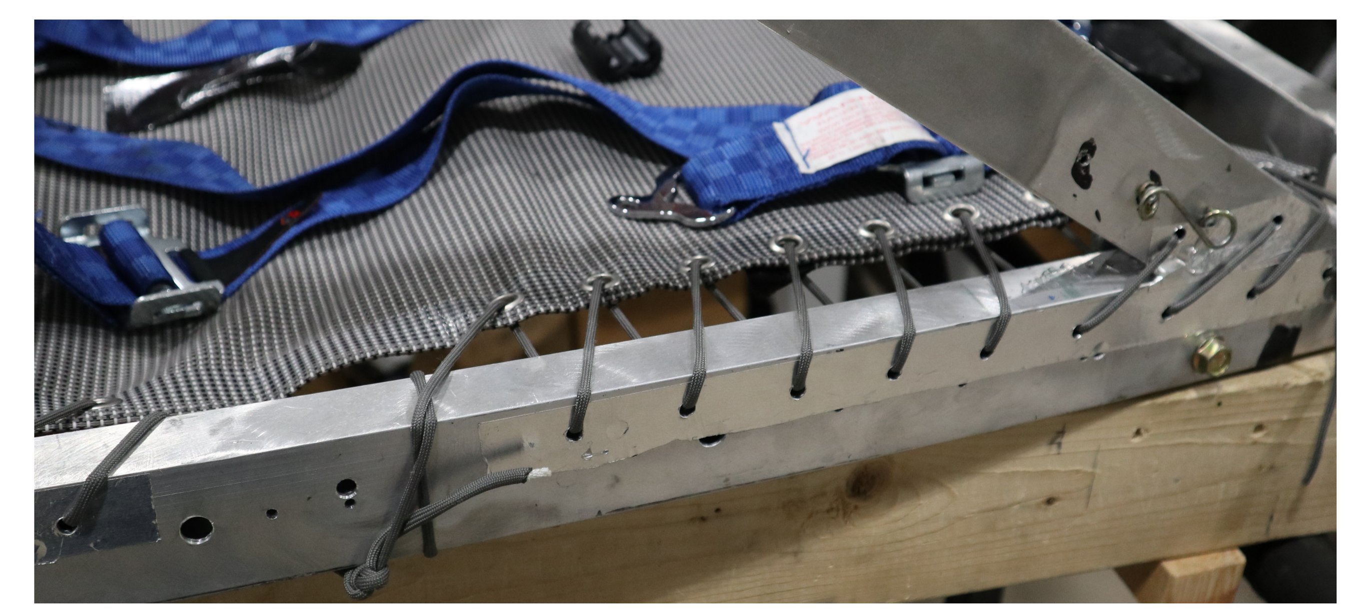
The steering wheel design required some modifications in order to eliminate slop in the system as well as reduce the weight. The entire assembly is made of aluminum and includes bushings to allow the steering column to twist with minimal friction. All cylindrical features are hollow tubes to reduce weight as well as provided rigidity for the technical inspection test. The redesigned system functions properly with the existing Ackerman linkage steering.

Frame Extension/ Brake Plate



- The frame extensions were welded on by an experienced welder and then machined to a smooth surface finish. The strength of the additional rectangular aluminum tubing was put through tests to determine if the frame would meet the expectations of the crumple zone requirement. The brake plate was added to give a place for the front brake foot pedal to rest. Based on the tests, the frame extensions seem to be complaint with the requirements

Seat Modification



- The seat also required multiple iterations of redesign and testing. The redesign including determining the location and method of attachment to the vehicle frame as well as the material the seat should be made of rather than the existing aluminum sheet. Prior to the impact of COVID-19 the team was working to find a solution for the seat, however there was no time to manufacture and complete the changes.

Testing and Validation

MPG Testing

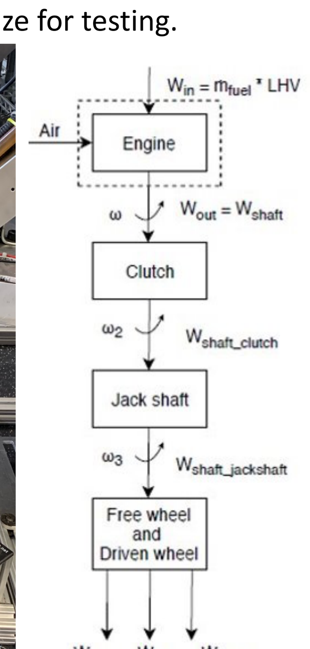
- The team made use of the Trine University baseball park sidewalk in order to conduct multiple MPG tests. In order to properly mock a competition run, the driver needed to average a speed of 15mph, shut off the engine when coasting, minimalize braking, and keep from making sharp turns when possible. iterations

Drag & RR Testing

- In order to better understand the performance of the vehicle, the team conducted rolling resistance testing as well as drag testing. The rolling resistance value of the vehicle found was 0.0016 while sources suggest that competitive values are 0.0015. The drag coefficient would then be found by using analysis of the MPG testing the RR coefficient value.

Dynamometer Testing

- Use of the dynamometer would allow the team to determine the optimal engine operation point as well as determine which components of the drivetrain were causing the most losses of the power being delivered to the system. The team was able to write and finalize a user friendly manual for future iterations to utilize for testing.



Competition Inspection Mock Testing

- The vehicle was inspected by the team in the same way it would be at the competition via the following tests. 20° incline brake test, Windshield deflection, Max/min dimensions, 90° turning radius, Wiring protected, and structural strength

Acknowledgments

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