Human Powered Vehicle Challenge

Anuththara Alujjage, Allison Bedrin, Ryan Podell, Paolo Quattrociocchi, Samantha Robbins, Sebastian Ruvalcaba

College of Engineering, Informatics, and Applied Sciences, Northern Arizona University, Flagstaff, AZ 86011

Abstract

Human powered transportation is one of the most sustainable, inexpensive, and efficient modes of transportation available and is currently developing. This mode of transportation can help those in third-world countries or over-populated areas. The Human Powered Vehicle Competition (HPVC) team's primary goal is to build a sound design that abides to rules and regulations provided by the American Society of Mechanical Engineers (ASME).

Problem Formulation

Project Goal: To design a human powered vehicle that can be used as an alternative mode of transportation.

Competition Eligibility Requirements (provided by ASME):

- Rollover Protection System
- 8 meter turning radius
- 30-meter stability at 5-6 km/hr
- 6 meter stopping distance at 25 km/hr

Table 1 discusses the engineering requirements derived by the team to meet customer and competition requirements.

Table 1: Engineering Requirements

Requirement	Target Value
Top Speed	>45 mph
Weight	<50 lb
Turning Radius	< 15ft (+/-3ft)
Frame Strength	1.5<Yield FOS<4
Innovation	Max points
Cost	<$3000
Mount/Dismount Time	< 30 seconds (+/- 5s)
Ergonomics	Comfort for 2hrs (+/-15 mins)
Frontal Area	≤ 5 square feet
Drag Coefficient	CD <0.2 (+/- 0.1)

Budget

Table 2: Cost of Materials

Component/ Sub-system	Price
Frame	Donated material + $75
Seat	$250
Harness	$115
Brakes	$250
Wheels	$155
Drive Train	$435
Handlebars	$15
Total	**$1295**

Final Design

The final product was designed by taking project goals, ASME rules and regulations, and customer and engineering requirements into account. The final product included the five primary components; frame with roll cage, drive train, steering, braking system, and ergonomics. After analyzing each component by conducting literature reviews and software simulations (primarily FEA simulations), the final proposed design was created as a single rider, two-wheel recumbent bicycle as shown in below in **Figure 1**.

Figure 1: NAU 2020 Human Powered Vehicle

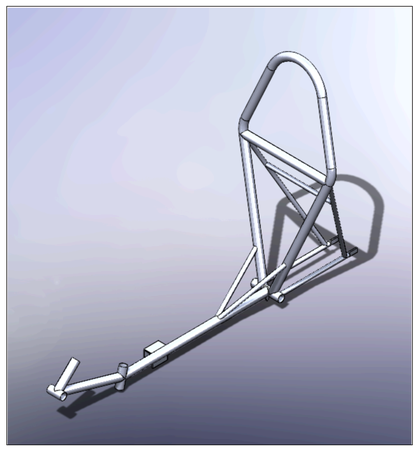

Figure 2: Final Frame Iteration CAD Model

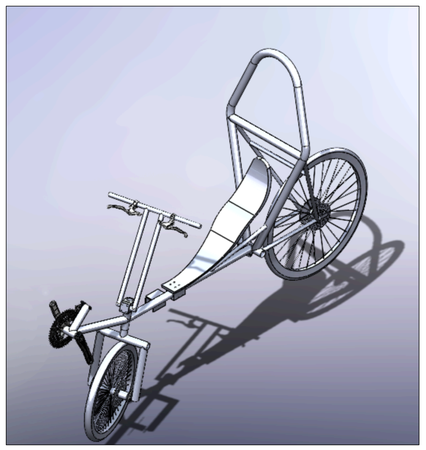

Figure 3: Complete Human Powered Vehicle Design CAD Model

Frame Analysis

Completing a comprehensive FEA analysis was paramount to ensuring that the vehicle was safe. The applied loads are detailed in the ASME E-Fest roll protection system criteria. These included a side impact to the cage at shoulder height and a top load to the cage directed 12 degrees to the aft of the vehicle. Simulations showed the minimum YFOS for 1018 frame to be 1.5.

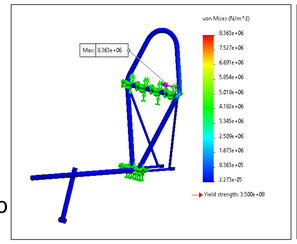

Figure 4: Side Load Case

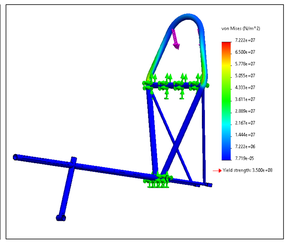

Figure 5: Top Load Case

Testing

Testing was broken down into 3 main categories: functionality, performance, and safety. Functionality testing was conducted to check the overall performance of the design and its' ability to behave as intended. This included the overall drivability of the vehicle and proper services of the controls such as steering, brakes, and drivetrain. Performance testing was able to ensure that the HPV was capable of meeting competition requirements such as maneuverability through obstacles, slow speed stability, and braking within the specified limits. Safety testing composed of crash safety and rider ergonomic strain safety trials. The HPV features a roll cage and safety harness which, through FEA analysis, was intended to prevent rider contact with the ground in the case of a roll over accident. Lastly, the overall ergonomics were optimized to position the rider in a natural seating position that maximizes pedaling power with little strain imposed on the rider.

Future Work

The primary goal for future work is to implement a fairing to the final design. In order to achieve this task, the team would like to conduct wind tunnel testing to the proposed fairing designs shown below and choose the fairing that has the lowest coefficient of drag.

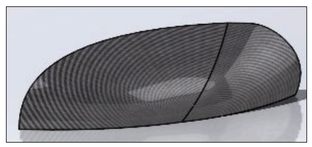

Figure 6: Proposed Design 1

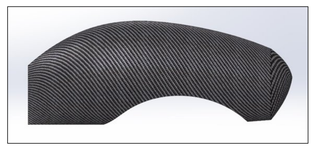

Figure 7: Proposed Design 2

References

[1]"Human Powered Vehicle Challenge (HPVC) | ASME E-Fests®", *Efests.asme.org*, 2020.

[2]" Final Report",20Su1_ASME_HPVC,CEIAS,capstone, 2020

[3]"Bill of Materials", 20Su1_ASME_HPVC,CEIAS,capstone,2020

Acknowledgements

Faculty: Dr. Sarah Oman, Dr. David Trevas
Client: Mr. Perry Wood
Sponsors: ASME, Absolute Bikes, Copper State Bolts & Nuts, Yavapai Steel and Gore
Team: Icarus 2020