SENIOR CAPSTONE/
SENIOR DESIGN EXPERIENCE
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PUP Electric Driveline

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Executive Summary

The Tumaini Innovation Center (TIC) and Purdue University have a long-standing relationship centered on the collaborative design of Public Utility Vehicles called PUPs. The development of a method for electrification of the traditionally ICE vehicles was a project initially requested by the TIC, in an effort to reduce noise, address rising fuel costs, and better serve the rural community around the TIC in Eldoret, Kenya.

Research and Context

The Team carried out considerable research in the positive public health, safety, welfare, global, social, environmental, and economic impacts of introducing inexpensive electric vehicles to rural areas of Kenya. The team also carried out research in available battery technology to get a gauge on feasible options, existing electric drivetrains to model the PUP after, and mobile frame optimization to best determine the configuration of vehicle components. These three laid the groundwork for the final design.

Project Characteristics

Criteria

- >40 km/hr max speed
- 50 km per charge
- 500 kg Allowable Load
- Versatile & Serviceable

Constraints

- Low Cost
- Uses existing PUP frame
- Road Legality
- Uses Available Material
- Safe

Relevant Codes and Standards

- KS ISO 12405-4: Battery Performance Criteria
- KS ISO 6469-1, 2, 3: Electric Vehicle Operational Safety

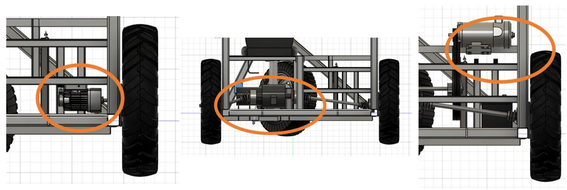

Figure 1: Three Solutions in Order defined below

Solution Ideas and Alternatives

Three solutions were explored:

- Rear Wheel In Hub Motors
- **Electric Rear Axle & Gearbox**
- Electric Motor Attached to existing Driveline

Ultimately, the electric rear axle was selected by the TIC as the best solution given its versatility, expected longevity, and its ease of installation when compared to other solutions.

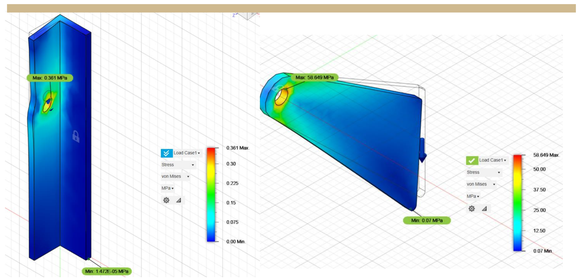

Figure 2: FEA Member Analysis

Design Process

The overall frame and model were first modeled in Fusion 360. FEA analysis through Fusion 360 shows that stress in new members used for support of the motor and gearbox for the conversion were acceptable and unlikely to be damaged. Aside from modeling, motor selection was a huge factor in design. Motor selected to meet project criteria values. A key influence on the design process was communication with vendors in China. Potential options were introduced and eliminated based on on-going global economic climate.

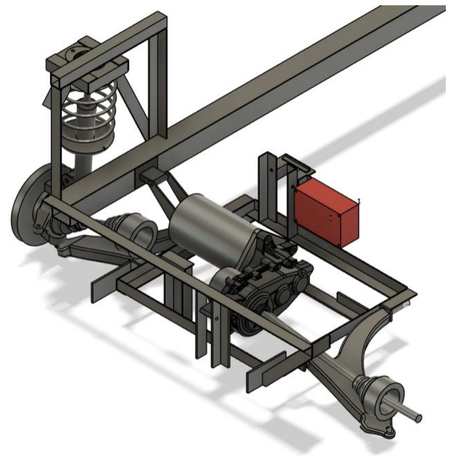

Figure 3: Final Model of Driveline Assembly

Final Design & Test Results

The final design of the vehicle consists of a redesigned drivetrain, steering column, and a bench seat.

The electric motor and single speed gearbox was mounted below the proposed floor of the mini-PUP to allow a better COG as well as a flat loading floor. The steering column was shifted towards the front of the vehicle. The column now uses a linkage system that amplifies steering advantage while providing the same turning radius. This was accomplished using an "L" bracket to translate motion and force from the steering column to the front wheel. The seat was moved forward to accommodate the new steering column and optimize loading. Placing the primary load under the rear axle allows for optimal riding. The seat was converted into a bench seat to seat more and provide a confined area for battery storage while allowing easy access.

Due to supply chain circumstances regarding the United States current economic policies, vehicle testing will be done between poster completion and capstone presentations.

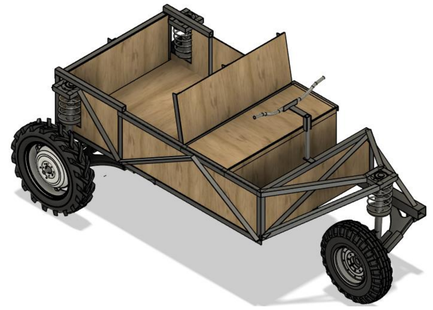

Figure 4: Final CAD Model of Electric mini-PUP

Project Value Proposition

The goal of the project is to produce a replicable process for electrifying the mini-PUP. The TIC and the rural Kenyan community around it will see major economic benefit in having 4 working electric mini-PUPs. The TIC can lease out the vehicles to the community to use, thereby also spurring economic growth by providing agricultural transportation.

Maximizing Project Impact

The Team has great pride in playing a role in introducing electric vehicles to rural African towns, and to supplement and grow the agricultural economy in those areas. The plan to maximize impact by the project is to develop a manual to send to the TIC explaining a step-by-step process for electrifying the existing mini-PUPs.

Conclusions

The electrification of the mini-PUP is one of the most complex and deep projects carried out by the team. All aspects of the project, such as communicating internationally both with the sponsor and the Chinese parts suppliers, stripping the frame, and designing a cost analysis played a large role in reinforcing and growing a firm engineering skillset and foundation. One that no doubt will be utilized heavily in the careers ahead.

The Team is appreciative of the sponsor of this project, the Tumaini Innovation Center, for giving the Team the opportunity to work on a project with such global reach and impact as this.

The Team shows profound gratitude to the instructors of this project, Dr. Lumkes and Logan Heusinger for their impeccable guidance and knowledge. Without them this project would be impossible.