Industry Sponsor: National Fluid Power Association **Team 13 & 14**

Design and Optimization of a Human-Powered Hydraulic Bike

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OBJECTIVE

The goal of this project is to design, build, and test a fully original human-powered hydraulic bicycle for the NFPA Fluid Power Vehicle Challenge. The team aims to explore the potential of fluid power in small-scale transportation by developing a bike that uses hydraulic systems for propulsion and braking, supported by electronic monitoring. This project provides hands-on experience and promotes innovation in fluid power applications.

CUSTOMER PROBLEM AND BACKGROUND

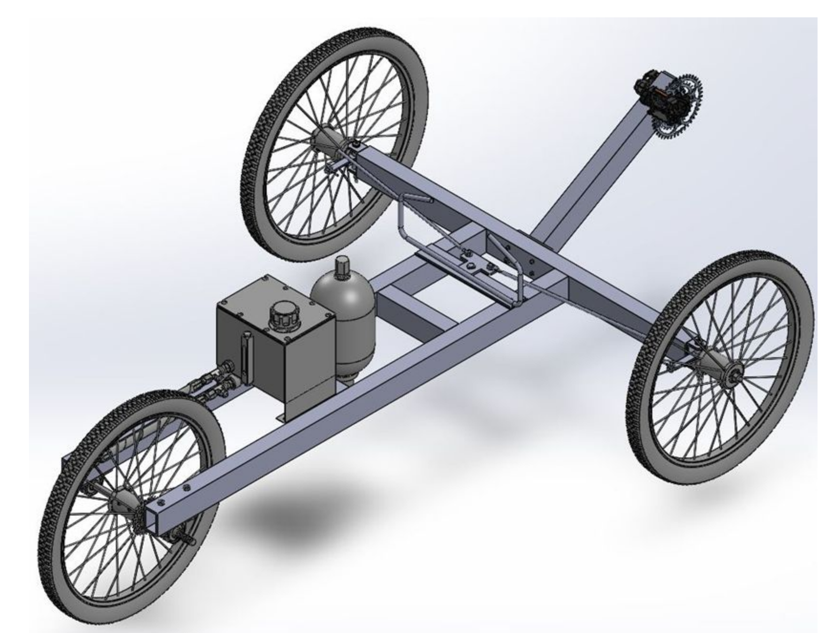
The NFPA Fluid Power Vehicle Challenge promotes innovation by merging two very different technologies: human-powered vehicles and fluid power systems. While bicycles are known for their efficiency and simplicity, fluid power presents greater challenges in energy transfer and control, especially at low speeds. This competition provides engineering students with a platform to explore how fluid power can be adapted for small, lightweight vehicles in creative and effective ways.

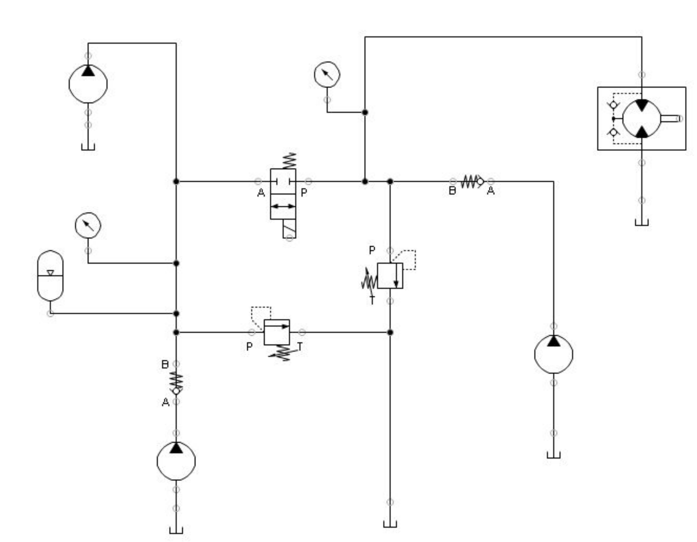
Our project addresses the core challenge of making fluid power more practical and efficient in human-powered transportation. The team was tasked with developing a fully functional bicycle that integrates hydraulic propulsion, a regenerative braking system, an energy-storing accumulator, and an electronic control system to monitor and manage key performance data. This effort not only demonstrates how fluid power can be applied in nontraditional ways, but also contributes to broader industry goals of increasing awareness, understanding, and skilled use of hydraulics and pneumatics.

CONCEPTS AND EXPERIMENTATION

In the early stages of development, the team explored various design concepts to optimize performance, efficiency, and manufacturability. A recumbent trike configuration with a ladder-style frame was considered for its structural simplicity and compatibility with available fabrication resources. Constructed from lightweight aluminum tubing, this design offers ample space for integrating hydraulic and electronic components while ensuring rider stability and comfort.

A key area of exploration was the hydraulic system, specifically the integration of a variable displacement pump. Unlike fixed displacement pumps, this system allows for real-time adjustment of fluid flow based on rider input. This feature functions similarly to a gear system, facilitating easier pedaling at startup and increased resistance as speed builds, thereby enhancing ride efficiency and comfort. To address torque challenges at the hydraulic motor, the concept of incorporating a front-mounted cassette gear system was evaluated. This setup aims to reduce the torque load on the motor, improving overall drivetrain performance and responsiveness.





REQUIREMENTS AND FINAL DESIGN

- Frame: Develop a Robust frame capable of accommodating hydraulic components, electronic systems, and the rider, ensuring structural integrity and stability.
- Hydraulic System: Implement a closed-loop hydraulic circuit incorporating an accumulator for energy storage and regenerative braking, optimizing energy efficiency.
- Electronics: Use a Programmable Logic Controller (PLC) and Human-Machine Interface (HMI) to monitor parameters like speed, pressure, and RPM. The HMI also allows the rider to activate systems such as boost and regenerative braking, providing real-time feedback and control.
- Pneumatics: Employ a pneumatic clutch system activated by an electronic pressure regulator to engage the regenerative braking mechanism efficiently.

This project was completed with support from DTS Fluid Power mentors, Consultant from HYDAC, and industry specialists who assisted with part sourcing and technical guidance. We also collaborated with the National Fluid Power Association, which organized the competition. Their involvement provided valuable insight into hydraulic and mechanical system integration throughout the design process.

TESTING RESULTS

CONCLUSION AND RECOMMENDATIONS

This project provided valuable hands-on experience in the design and construction of a human-powered hydraulic bicycle. Through the integration of hydraulic, pneumatic, and electronic systems, the team was able to explore innovative applications of fluid power in a small-scale vehicle. The project emphasized the importance of system compatibility, efficient power transmission, and reliable control mechanisms.

Several lessons emerged during the process that will guide future efforts. Starting bike assembly earlier would allow more time for testing and troubleshooting, especially for critical systems like hydraulics. More careful selection and sizing of the motor, pump, and gear ratios are essential to optimize performance. Material strength must also be reevaluated, as components like the steering pipe and prototype spindles experienced failure under load. Additionally, the total vehicle weight exceeded expectations, suggesting the need for improved planning and weight estimation during the design phase. Lastly, modularity should be prioritized in the frame design to allow for easier adjustments and system integration.