NFPA Fluid Power Vehicle Challenge

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Competition Description

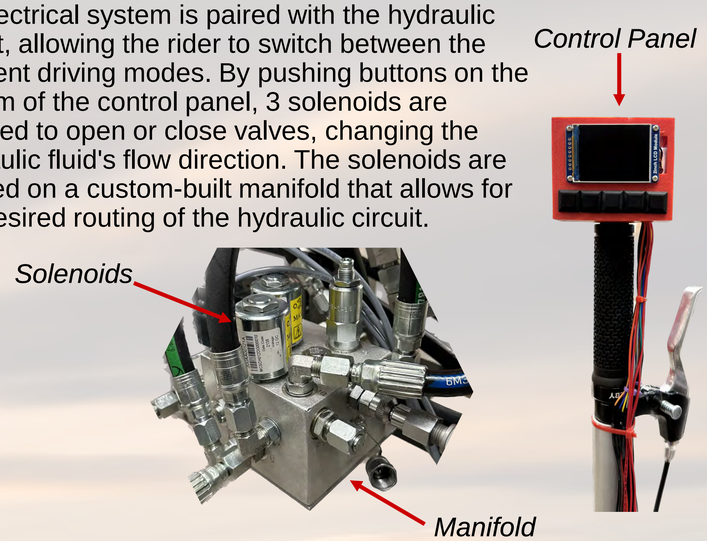
Every year the National Fluid Power Association (NFPA) hosts a competition that focuses on introducing students to the engineering behind hydraulics through the process of designing and building a fluid powered vehicle. Using certain hydraulic components such as a hydraulic motor, hydraulic pump, and an accumulator, the participating teams design a vehicle aimed at competing in 4 difference races: a sprint race, efficiency race, endurance race, and a regen race.

4 Drive Modes

- Direct Drive
- Regenerative Braking
- Boost (Accumulator Discharge)
- Direct Accumulator Charge

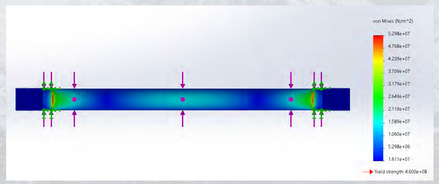
Electrical system

An electrical system is paired with the hydraulic circuit, allowing the rider to switch between the different driving modes. By pushing buttons on the bottom of the control panel, 3 solenoids are directed to open or close valves, changing the hydraulic fluid's flow direction. The solenoids are located on a custom-built manifold that allows for the desired routing of the hydraulic circuit.

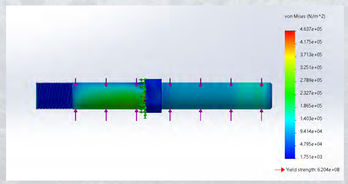


Vehicle Frame Upgrades

Front and back wheel mounting systems were redesigned from the previous bike. Issues related to fatigue on wheel axles proved to be a major focus point. Finite Element Analysis was performed for newly implemented parts, such as the front and rear axles illustrated below:

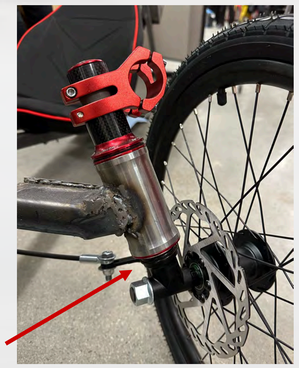


Rear axle minimum safety factor of 8.7



Front axle maximum stress of $3.2x10^7$ N/m^2

The frame makes use of spindles which are widely used steering components for recumbent trikes. Spindles use a non vertical geometry which minimizes the loads on the rotating components, allowing for a smoother steering experience.



Spindle Inside Head Tube

Hydraulic Circuit

The hydraulic circuit converts the pedaling motion into kinetic energy. The pedals in the front turn a hydraulic pump which creates pressure inside the hoses and generates a fluid flow. A hydraulic motor at the other end of the circuit converts this fluid pressure into a rotary motion that ultimately spins the back wheel of the vehicle.

The hydraulic system also includes an accumulator that can be precharged and pressurizes fluid using Nitrogen gas. This creates stored energy based on the chosen driving mode.

After a thorough analysis of the previous team's hydraulic system, it was determined that a new pump was needed for the circuit to provide greater torque and allow for the rider to comfortably start moving from a resting position.

Radial piston pump →

Metrics

The competition is scheduled to take place in Denver, Colorado, from April 12 to the 14th, 2023. This poster was created before those dates, therefore while we do not have results from our performance, a few important metrics of the current vehicle are presented below:

Circuit Theoretical Pressure	3,000 psi
Accumulator Precharge	1,000 psi
Pedals to Pump Gear Ratio	Range from 4:13 to 4:86
Motor to Wheel Gear Ratio	13:16
Theoretical Maximum Speed	12 mph

Performance

This vehicle presents a significant upgrade from last year's team's design. With better wheel mounting systems and improvements to the hydraulic circuit, the bike is expected to provide better torque which should help the rider with acceleration. This new circuit should also ensure that the bike will reach a new higher maximum speed. The new electrical system will ease the ability of switching between the different operating modes, as well as provide the rider with better input of the vehicle's performance. While these are all expectations for now, we have high hopes that we will be able to succeed in the competition.