PURDUE UNIVERSITY | Agricultural and Biological Engineering

CAPSTONE/SENIOR DESIGN EXPERIENCE 2020

NFPA-1 Fluid Powered Vehicle

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Problem Statement:

Design and build a human-powered vehicle which uses fluid power as the mode of power transmission and energy storage, while outperforming other colleges' and past year's designs.

Background & Impact:

- The competition has different portions to compete in: sprint challenge, pneumatic challenge, endurance challenge, and overall design.
- Gain practical experience working with hydraulic systems, while building project and team management skills.

Constraints / Criteria:

- Max system pressure of 3000 psi
- 1-gallon accumulator
- Follow NFPA safety standards
- Win the competition

Factors Considered:

- Stick with imperial units of measurement --- *Global*
- Adjustability based on rider height --- *Social*
- Bio-degradable hydraulic fluid and lubricant --- *Environmental*
- Low maintenance build with durable, high precision, readily available materials --- *Economical*

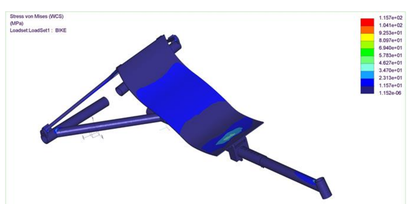
Alternate Solutions:

- A decision matrix was used to evaluate the overall performance of different designs.

	Ib	HD	Cost	Built	STR	Style	SFT	Sum
2-W	0.45	0.1	0.15	0.4	0.4	0.2	0.5	2.2
3-W	0.3	0.15	0.1	0.8	0.8	0.3	1	3.45
4-W	0.15	0.2	0.05	0.6	0.6	0.1	0.75	2.45
E.Go	0.6	0.05	0.2	0.2	0.2	0.4	0.25	1

Finite Element Analysis:

- FEA conducted on original design. Critical region identified as the seat clamp.
- Decided to use steel U-bolts to overcome fatigue.
- For a rider of 100 kg we get a static FOS of 5 and fatigue FOS for 300 km of 2.4.

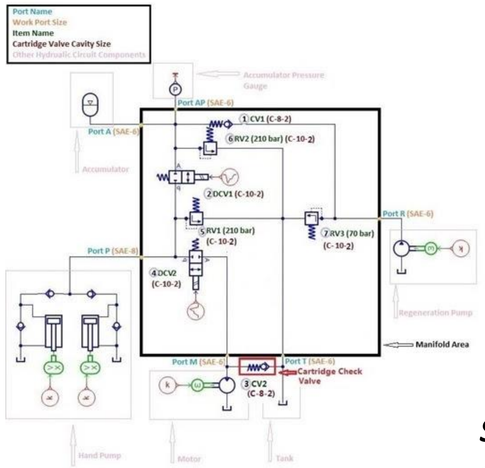


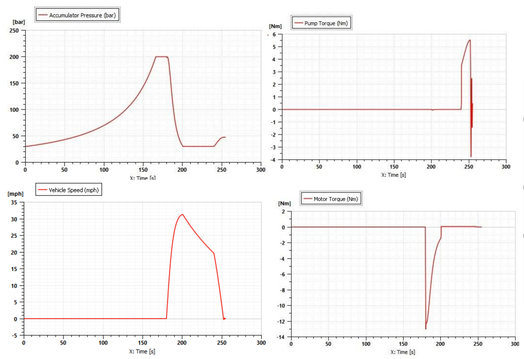
Economic Analysis:

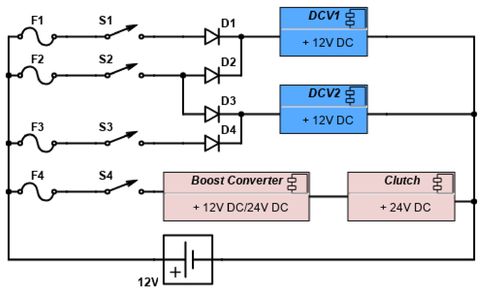
Components	Price ($)	Sp. Don.	Cost
Mechanical/Structural	5228.05	2366.89	2861.17
Electrical	604.05		604.05
Hydraulic	1874.01	1194.00	680.01
Pneumatic	236.62	236.62	0.00
Miscellaneous	53.77		53.77
Total	7996.5	3797.51	**4199.00**

Hydraulics & Electronics:

- Four different modes available (charge, pedal, boost, regenerate) using two DCVs.
- Components sized using competition constraints and component availability.
- 2 km distance with a full accumulator.
- Max. simulated speed of 30 mph.
- 12V battery switch activate DCVs
- 12/24V DC step-up converter for electrical clutch activation

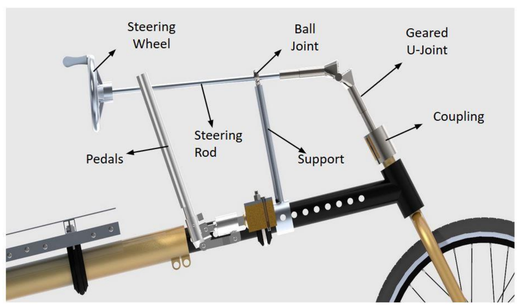






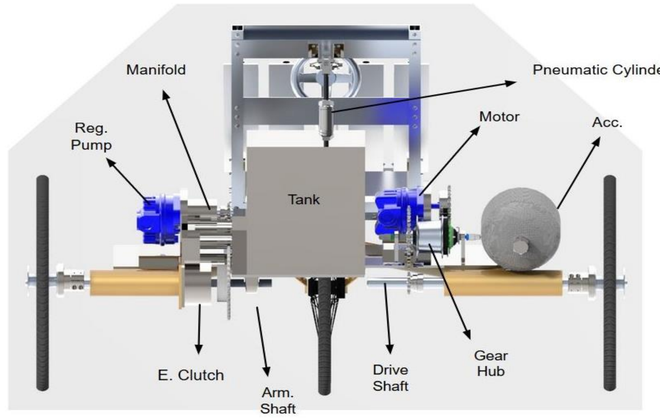
Steering System:

- Steering rod is supported by a support with a ball joint rod end.
- An extreme angle geared u-joint is used to allow 1:1 ratio for the rotation of the steering wheel and the fork.



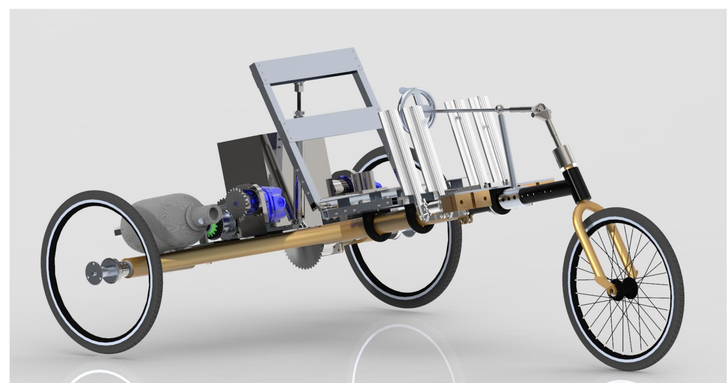
Custom Main Frame:

- Five aluminum 6061 tubing welded together
- Flange to mount electric clutch for regeneration purposes.
- Has pin holes and tighteners for the telescopic extension.
- Provides just enough space for hydraulic components.



Specifications:

- 20'' wheel size
- Weighs around 40 kg (90 lbs)
- Total vehicle length adjustable from 4 - 7.5 ft
- Two shafts, one for driving, one for regeneration, allows very tight turning radius and increased safety compared to a live axle
- "Delta" design offers higher ground clearance and increased maneuverability compared to standard tadpole
- Vibration damping U-bolts to connect the seat and foot pumps
- 5 gear reduction from motor to drive shaft, 6 gear reduction from regen shaft to regen pump
- Electronic gear shift
- Memory foam padding on the seat
- Pneumatic seat adjustment



COVID-19 Effect on Completion & Testing:

- The only components to be mounted are the steering wheel, the electrical system, and miscellaneous safety features.
- Painting and improvement of aesthetics to be completed.
- Testing will be done by acquiring the actual accumulator pressure and acceleration data for analysis of performance.

Sponsors:
National Fluid Power Association
SunSource
Bimba Manufacturing Company

Technical Advisor:
Jose Garcia-Bravo

Instructors:
John Lumkes

Acknowledgements:
Alec Watkins, Nicholas Moss, Neil Oberley, Joel Thompson, Eric Kong