PURDUE UNIVERSITY

CAPSTONE/DESIGN EXPERIENCE 2017

NFPA Fluid Power Vehicle Challenge

PurdueTracer

Agricultural & Biological ENGINEERING

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Problem Statement

Fluid Power Vehicle Challenge (FPVC) is a competition between universities to develop high-performance fluid power vehicles without the use of chains or belts. The main problem, of course, is to stand out among other universities in both speed and efficiency. The team will have to first design with the help of computer software, then build the vehicle according to their best design. The design quality will be eventually evaluated and indicated by the final competition score.

Background

Purdue ABE has attended FPVC for multiple years. The previous experience is the team's best resource. Should the team this year do well or not, at least, team members will have valuable experience, and also give advice to next year.

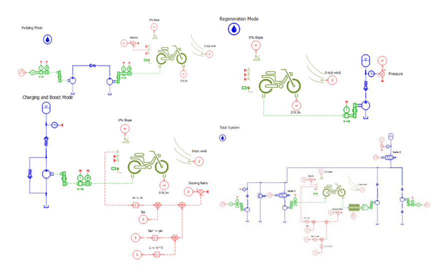
Hydraulic System Design

Hydraulic Circuit Layout

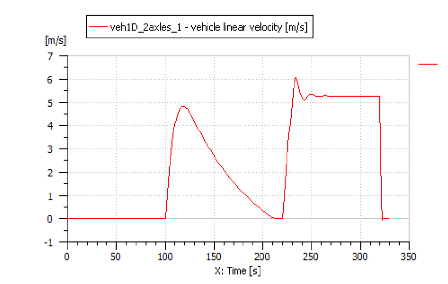
- A hydraulic circuit layout was developed to describes the working principle of the hydraulic system

AMESim Simulation Process

- Basic Calculation Estimation
- Simulation Models
  - Model 1: Optimization Test
  - Model 2: Performance Estimation
- Simulation Result



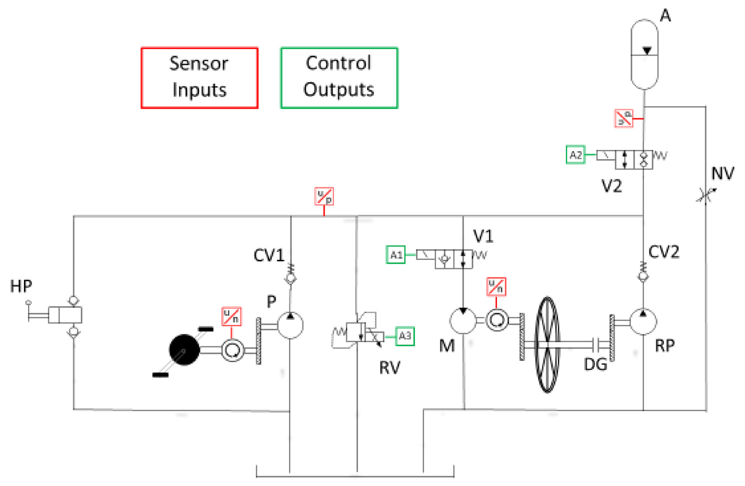
Simulation Models



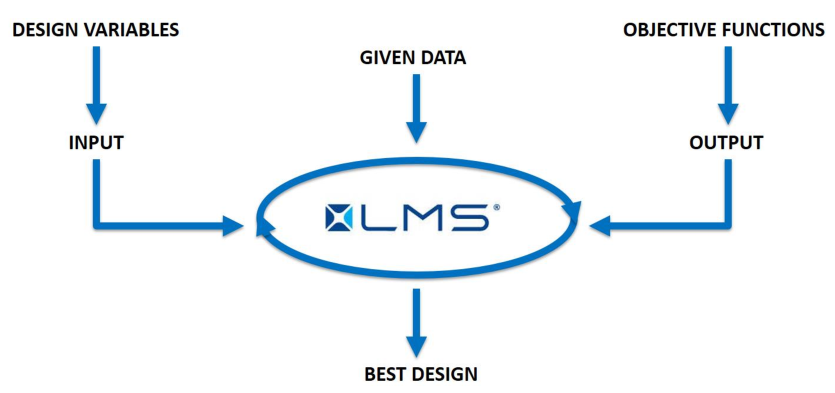
Performance Estimation

Components Selection

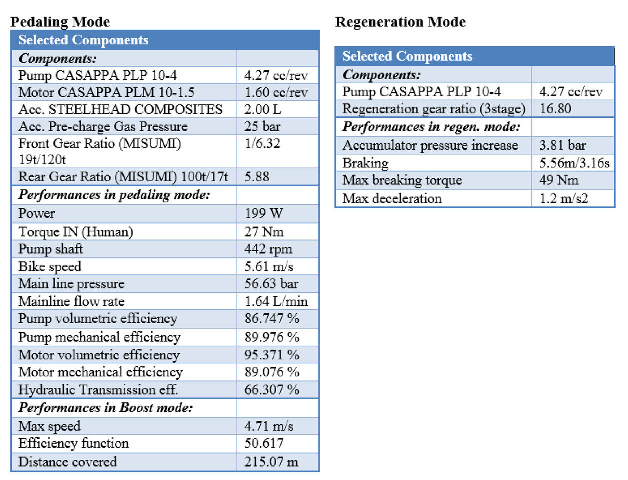
- The components of the hydraulic system are selected base on the simulation result



Layout of Hydraulic Circuit



Optimization Process



Hydraulic Components Selection and Corresponding Performance

Performance

- Maximum Speed – 25 km/h
- Boosting Distance – 300 m

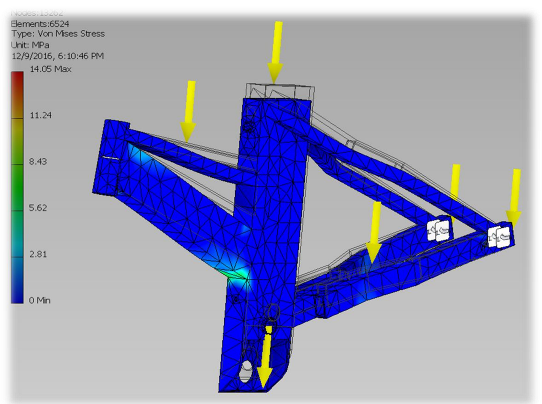
Key Features

- Internal Oil Reservoir
- Carbon Fiber Accumulator
- Energy Storage and Regeneration System
- Electronic Control System

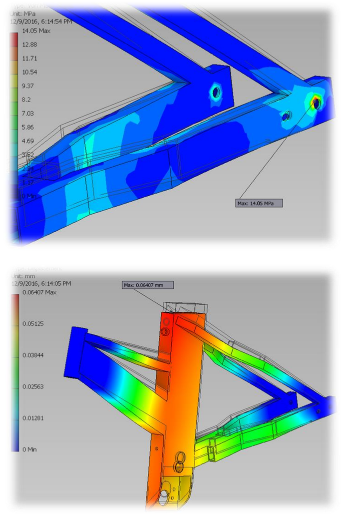
Mechanical System Design

Frame FEA

- Max. Stress 14.05 MPa
- Yield Stress 55 MPa (Al 6061 weld)
- Safety Factor 3.9



FEA Set-up



Max. Stress & Disp.

Frame Features

- Self Designed & Built
- Internal Oil Reservoir
- Triangular Structures
- Made of Aluminum

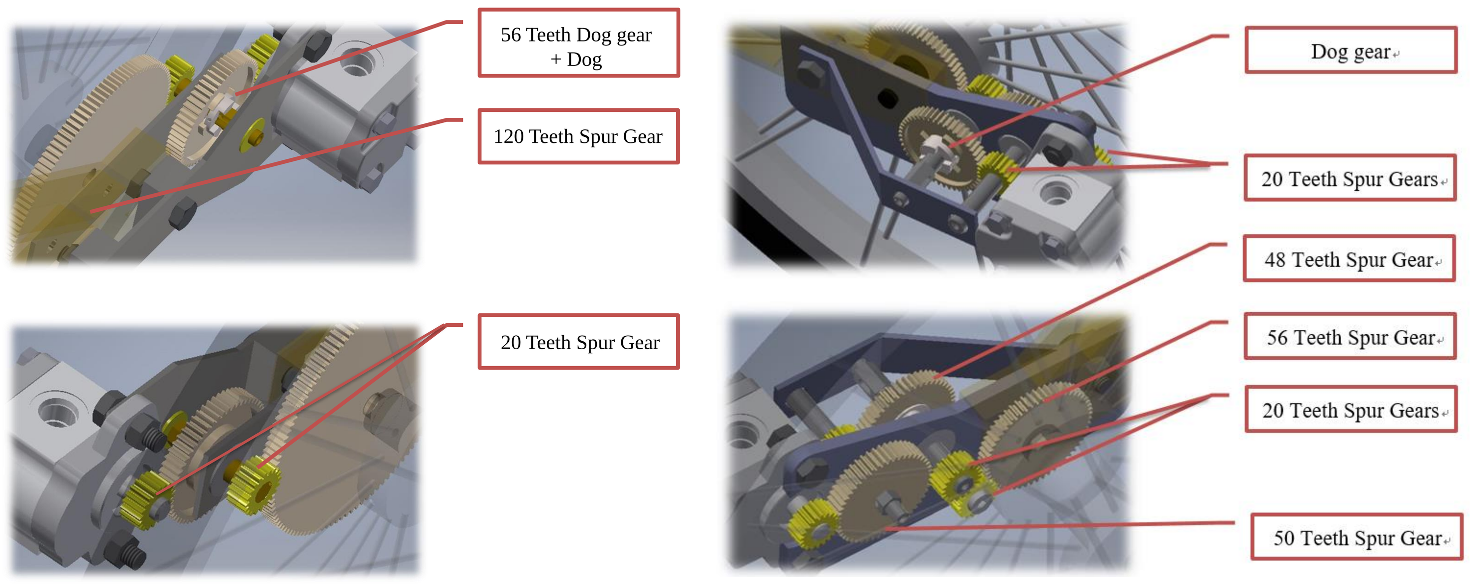
Processing the Tubes

Frame Processing

- Order Varies-sized Tubes
- Create Drawings
- Cut & Weld

Finished Frame

Regeneration System (Example of **Alternative Design & Evaluation**)



Selected Design	Old Version
✓ 2-Stage transmission	4-Stage transmission
✓ Giving less friction to normal pedaling	Giving more friction to normal pedaling
✓ More compact	Less compact

Cost Analysis

- The components of the prototype vehicle are grouped into seven subsystems

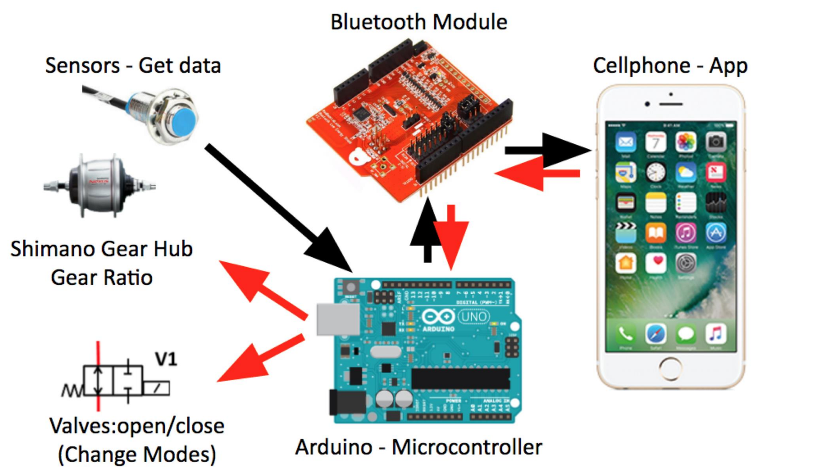
Subsystem	Cost [$]
Frame	703.00
Front Gear box	393.96
Motor Gear Box	518.87
Regeneration Gear Box	542.35
Hydraulic Circuit	2299.44
Electronics	1355.21
Bicycle Parts	478.17
Total	6314.79

Cost Analysis without Donation from Sponsors

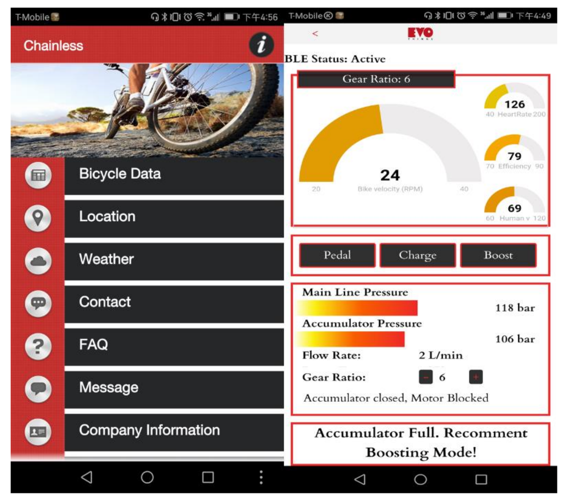
- Thanks to the generous donations from Casappa, Steelhead, Eaton and MiSUMi, which greatly reduce the cost of the vehicle.
- The total cost of the prototype vehicle included the donation is calculated as $4237.14
- The total cost without the donations from the sponsors is $6314.79

Electronic Control Features

- Arduino Control
- Bluetooth Connection
- Phone App Interface
  - Vehicle Data Display
  - Gear Shifting
  - Valve Control
  - Heart Rate Monitored



General Connection between Devices



Phone App Homepage

Societal Impact & Conclusion

- The FPVC provides college students a chance to go deeper in fluid power. After this challenge, we gained progress both in theoretical knowledge and industrial designs
- Our aim to design a product that could be successful in the free market is achieved. We believe PurdueTracer is very competitive for its weight, speed, and efficiency

Sponsor:
National Fluid Power Association
Steelhead Composites
Parker
EATON
SUNSOURCE
LUBE TECH
Danfoss
MiSUMi
Casappa

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