NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

Final Presentation
The University of Akron
TEAM ADVISOR: Scott Sawyer
4/11/2018

Agenda

- Team Introductions
- Problem Statement
- Objectives
- Vehicle/Fluid Circuit Design
- Hardware Selection
- Drawings
- Manufacturing & Testing
- Cost Analysis
- Lessons Learned / Conclusions

Meet the Team!

Members

- *(Left To Right)* Heath Rohrbaugh, Aaron Ferguson, Drew Lyon, Jacob Pfeifer

About Us

- All seniors graduating in May of 2018
- Have work experience at Technoform, EATON Corportation, Timken, Rockwell Automation and MTD Products.

TECHNOFORM GROUP

TECHNOFORM

EATON

TIMKEN

Rockwell Automation

MTD
For A Growing World.™

Problem Statement

Design and Build a hydraulic vehicle to complete:

1. Sprint race: 600 feet, time trial from stop
2. Efficiency race: Minimum 100 ft travel distance off pressurized accumulation from stop
3. Endurance Race: A 1 mile time trial from stop.

Focusing on utilizing hydraulic components to <u>enhance</u> the features of a mechanical bicycle

Objectives

2017 Bike

- Traditional 2 wheel bike
- Lightweight frame and components
- Simple drive and regeneration circuit

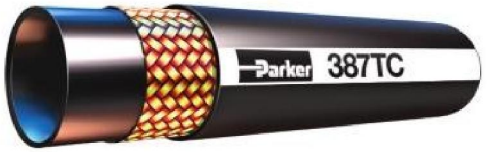
2018 Bike

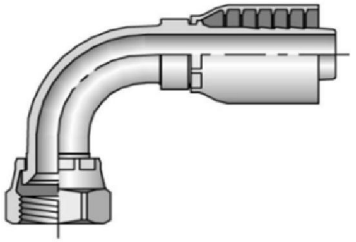
- Increased Efficiency
  - Accumulator Mounting
  - Optimized gear ratio
  - Accumulator pre-charge amount
- Incorporate Chain Design, connecting human input to pump
- Optimize hydraulic pipe length

Vehicle Design

- **Vehicle Frame**
  - **–Surly Karate Monkey Frame**
    - Steel frame for ease of welding and modification
    - Lightweight

- **Connections**
  - **–Parker Custom Fit 387TC-6 3/8” Tubing**
    - Custom fit allows for optimum tubing length and minimalized pressure losses
  - **–Parker size 6 & 8 JIC straights and elbows**



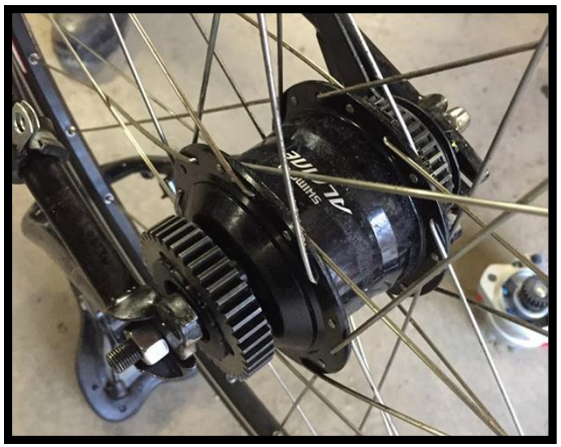


- **Gearing**
  - **–Shimano 8 speed internal gear hub**

Design Continued

Gearing

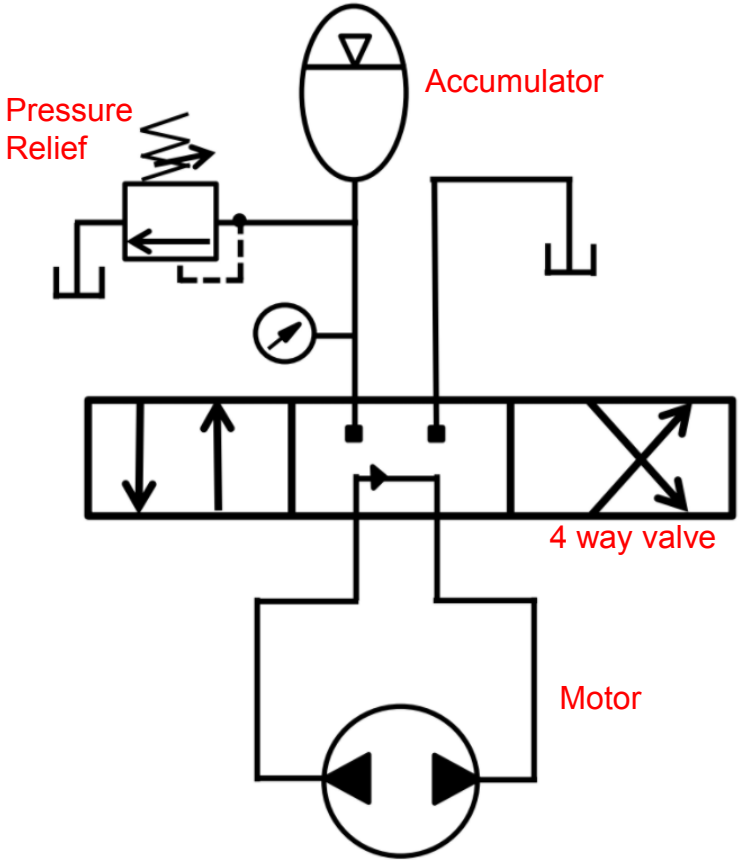
Pedal Input - 80 rev/min
Crank Sprocket - 52 tooth
Pump Sprocket - 11 tooth
Motor Gear - 28 tooth
Hub Gears - 40 tooth
Wheel diameter - 26 in
Gear Ratio (excluding hub)
5:1



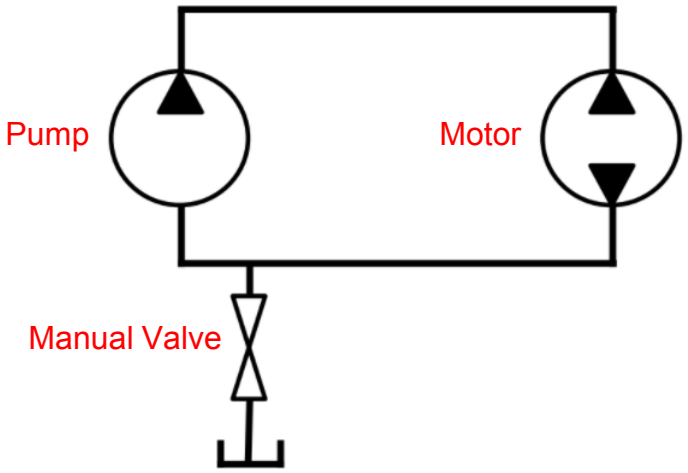
Pump

- Reworked RH Pump

Fluid Circuit Design



Accumulation Circuit



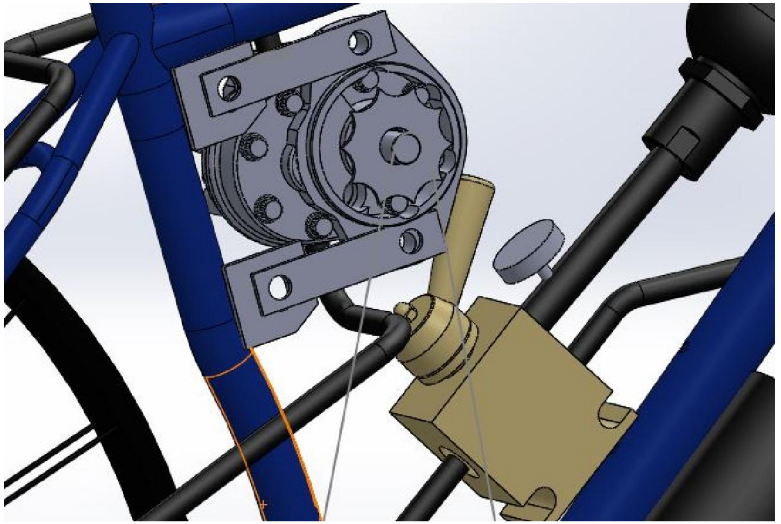
Drive Circuit

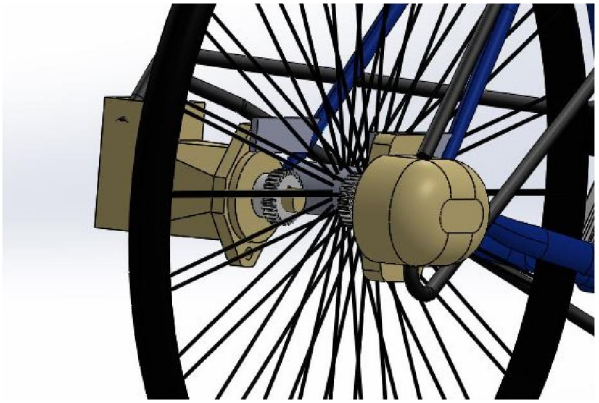
Hardware Selection

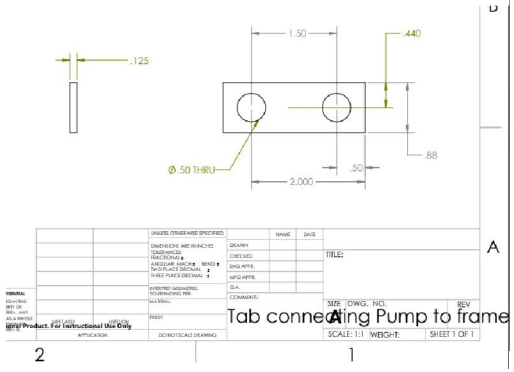
- **Direct Drive Circuit**
  - –***Modified*** **Eaton 26002 RZC Pump**
    - •8.2 cm^3/rev
  - –**Eaton 26 Series Motor**
    - •8.8 cm^3/rev

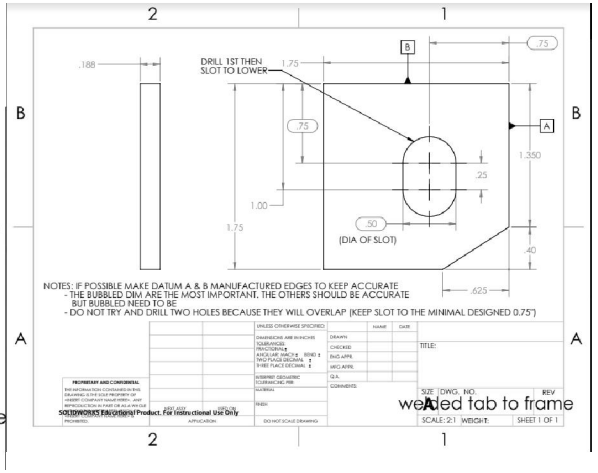
- **Accumulation Circuit**
  - –**Parker F11-5 Motor**
    - •**Low rolling resistance**
  - –**Accumulators Inc 1 Pt. Bladder**
    - •**Pre-charged to 1000 psi, 45 degree mount**
  - –**Eaton 4-way, 3 position rotary valve**
    - •**Allows selection of normal, charge and discharge modes**
  - –**3000 psi Pressure Relief Valve**

Drawings





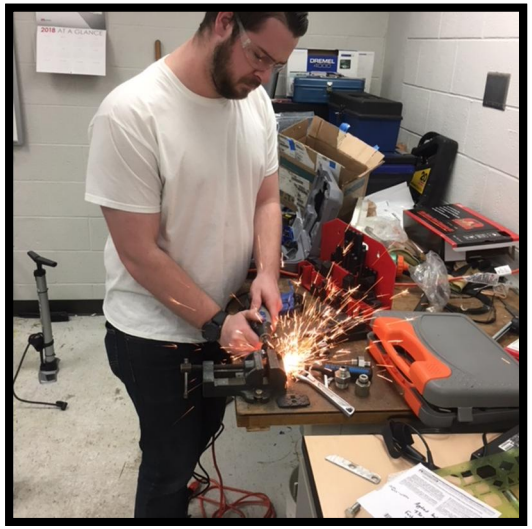

.125
1.50
.440
Ø.50 THRU
.88
2.000
.50
Tab connecting Pump to frame


DRILL 1ST THEN SLOT TO LOWER
.188
1.75
.75
.75
.25
1.350
1.00
1.75
.50
(DIA OF SLOT)
.40
.625
NOTES: IF POSSIBLE MAKE DATUM A & B MANUFACTURED EDGES TO KEEP ACCURATE
- THE BUBBLED DIM ARE THE MOST IMPORTANT. THE OTHERS SHOULD BE ACCURATE BUT BUBBLED NEED TO BE
- DO NOT TRY AND DRILL TWO HOLES BECAUSE THEY WILL OVERLAP (KEEP SLOT TO THE MINIMAL DESIGNED 0.75")
welded tab to frame

Manufacturing

Frame Leveling

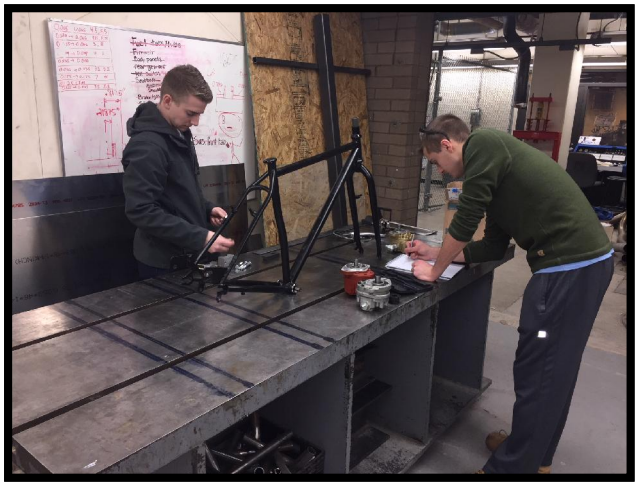
Checking hole locations



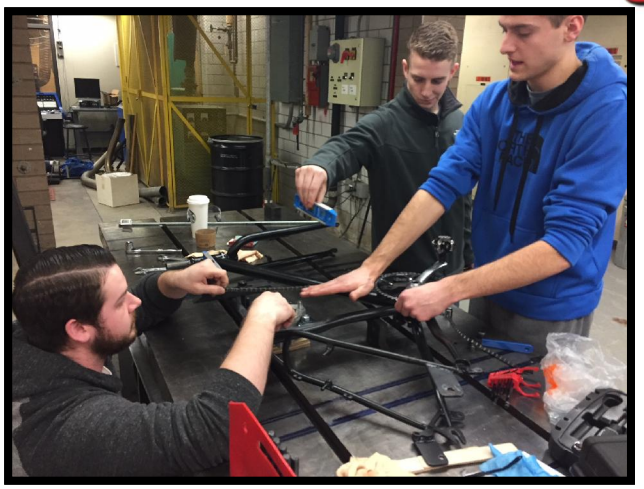
Welding Tab Adjustments

Initial frame leveling w. Pump

Manufacturing (Cont.)



Welding Table Setup



Frame Leveling (pre-weld)

White Primer Painting

First Testing on Campus

Testing / Analysis

- **Determining Optimal Pre-charge**
  - Online calculations w. supplier revealed 1000 psi. The pre-charge amount will provide a 400% increase in pressure force over 2017 bike after testing the 250 psi pre charge.

- **Determining Optimal system charge for Efficiency**
  - Multiple tests revealed that 1500 was minimum charge and 2000 was maximum achievable. 1800-1900 psi is most manageable after testing.

- **Optimizing Starting Gear & Torque**
  - Gear Selection of 7 for starting gear ; this optimized starting torque and pedaling difficulty. (Gear up after start).

- **Weight Savings**
  - 2018 Bike weighed in at 65 pounds (75 pounds in 2017), yielding 15% less. (Gear, hosing,accum.)

Cost Analysis

Item Description	Quantity	Unit Cost	Cost
Bicycle Components			
Surly Karate Monkey Bike Frame	1	$ 400.00	$ 400.00
Handle Bar Assembly	1	$ 85.00	$ 85.00
Shimano Crankset	1	$ 90.00	$ 90.00
Large Shimano Sprocket	1	$ 52.99	$ 52.99
Small Sprocket	1	$ 10.00	$ 10.00
Thompson Bike Seat and Post	1	$ 48.00	$ 48.00
Rear Shimano Alfine 8 SPD Hub	1	$ 235.00	$ 235.00
Brake Assembly	2	$ 14.00	$ 28.00
Brake Levers	1	$ 19.00	$ 19.00
KMC Z51 7-Speed Bike Chain	1	$ 9.99	$ 9.99
Bontrager SS Derailer Cable	1	$ 5.99	$ 5.99
Innova 2304 Tire	2	$ 30.39	$ 60.78
Steel Bike Rim	2	$ 39.99	$ 79.98
8 SPD Shift Kit	1	$ 14.15	$ 14.15
Hydraulic Components			
Eaton 26002-RZC	1	$ 314.50	$ 314.50
Eaton 26 Series Motor	1	$ 480.00	$ 480.00
Parker F11-5 Motor	1	$ 475.00	$ 475.00
Accum Inc. 1pt Bladder (16 oz)	1	$ 667.00	$ 667.00
Eaton Vickers 3 Position 4 Way Valve	1	$ 205.50	$ 205.50
Martin Pump Spur Gear (0.75")	1	$ 47.95	$ 47.95
Martin Pump Spur Gear(0.625")	1	$ 47.95	$ 47.95
Martin Rear Hub Gears	2	$ 43.35	$ 86.70
3000PSI Pressure Relief Valve	1	$ 35.00	$ 35.00
Clear Fluid Resevoir Kit	1	$ 57.75	$ 57.75
Resevoir Container	1	$ 11.99	$ 11.99
Stainless Screws	10	$ 0.59	$ 5.90
Shimano 6 Bolt Disc Brake Adapter	1	$ 15.99	$ 15.99
Parker Custom Fit Hosing w. Adapter	4	$ 40.00	$ 160.00
Hose Clamps	4	$ 3.99	$ 15.96

Other Components			
Rustoleum Satin Pimer	1	$ 5.29	$ 5.29
Rustoleum White Paint	1	$ 5.79	$ 5.79
Rustoleum Metallic Blue Paint	2	$ 5.79	$ 11.58
Rubber Hose Cushion	2	$ 2.99	$ 5.98
3D PLA Printed Accumulator Holder	1	$ 1.62	$ 1.62
Steel Formed Chain Guard	1	$ 5.99	$ 5.99
Speed Tachometer	1	$ 15.99	$ 15.99
Labor Costs			
Machining Tabs/Components (/hr)	5	$ 60.00	$ 300.00
TIG Welding (/hr)	1	$ 60.00	$ 60.00
Engineering Costs	8	$ 30.00	$ 240.00
Total Cost for 2018 UA BR2			**$ 4,418.31**
Total Cost for 2018 UA BR2 (NLAB)			**$ 3,818.31**

Lessons Learned

- Teamwork (#1)
- Working with vendors and suppliers
- Hydraulic applications
- Time Management
  - Dealing with conflicting class and work schedules was a challenge, but it is a lesson in how to proactively manage (calendar invites, structured meetings) team events.

Conclusions

The UA Bike team is thrilled to have had the chance to compete in the NFPA FPVC!

Thank you to Dover Hydraulics, Triad Tech and the rest of the National Fluid Power Association for hosting this competition! Thank you to Parker Hannifin, SunSource, Eaton Corporation, LubeTech, and Danfoss for the great donations!