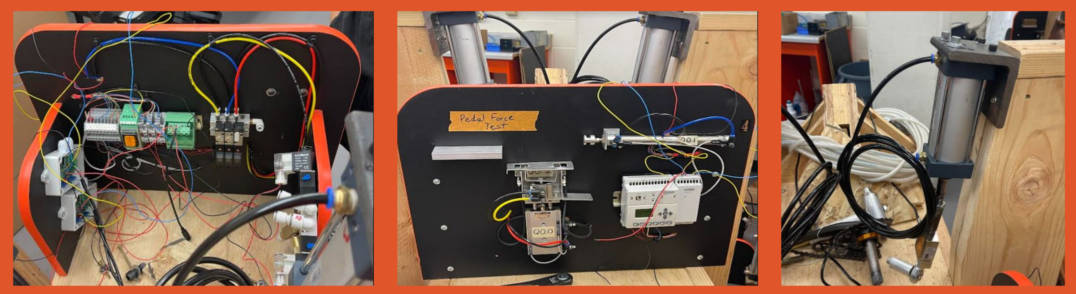


PREVIOUS MACHINE COMPONENTS

BACKGROUND & PROJECT INFORMATION

- Celio Cycles is small company that designs and manufactures bike frames made out of wood.
- Bicycle frames undergo many different loads while they are being ridden, it is difficult to calculate these forces because they change throughout the cycle of the pedal.
- It is important for the bicycle frames to be tested to International Organization for Standardization (ISO) guidelines. Meeting these standards will ensure safety for customers when they are riding these bicycles.
- There are several tests involved in meeting the ISO standards for bike frames, these tests include the Impact, Frame and Fork, Pedaling Forces, Horizontal Forces, and Vertical Forces.
- Designing a machine that would meet all the requirements for the ISO standard is much more complicated than can be designed and produced in one capstone project so the team was tasked with the Pedaling Force Test.
- The Pedaling Force Test requires that each pedal on the bicycle has a specific load applied to it 50,000 times. These loads can not be applied at a rate higher than 4 Hz, and the loads vary between 1000 N and 1200 N based on the type of bicycle begin tested.
- Team 108 was originally tasked with making improvements to the previous years team's attempt at the bike frame load testing machine. Specifically, "improving the PLC control interface and functionality, verifying that the test forces are within ISO standards, improving the durability of the test frame, and ensuring the ability to accommodate various frame sizes"
- However, project scope quickly changed under direction of project mentor/sponsor, Scott Campbell, who was open to moving away from the pneumatic and PLC controlled system because last year's machine failed to perform effectively.
- After research on existing pedal testing machines, the team found a promising direction with an electrical motor driven system to apply the necessary forces on the pedals. Inspiration from a similar machine designed by graduate students at University of Connecticut in 2014. After presenting a video of the machine to Campbell and a discussion on how a hydraulic system could be expensive and messy, the team was instructed to move forward with the electric motor system.

CUSTOMER REQUIREMENTS & ENGINEERING SPECIFICATIONS

Customer Requirements	Engineering Specifications
Accurately Apply Forces	Apply a Maximum Force of 180 lbs
Run Cycles Quickly	Run Motor at 4 RPS (4 Hz)
Verify Applied Forces	Accuracy of Applied Force -0% +5%
Count Number of Cycles	Achieving 100,000 cycles (50,000 cycles per pedal)
Functioning Proof of Motor-Driven Machine	Weight of Machine <200 lbs
Under Budget	Overall cost is $1000
Test Pedals	Using Instron to calibrate the forces to the pistons of a maximum 300 lbs.
Rigidity of Frame	Machine Frame deflection less than 10 mm
Adjustability	Applied Force is adjustable to 300 lbs for later iterations
Durable	Lifespan of 100 (# of tests)

- Important customer requirements (CRs) for this project are to test the bike pedal joint, build a functioning machine that proves the electric motor system will work, and be under budget.
- The Engineering specifications stated that the testing is done for the design and drive system of the Bike Frame Load Test machine
- The satisfied engineering specifications are Run Motor at 4 RPS (4 Hz), Accuracy of Applied Force -0% +5%, Overall cost is under $1000 and using Instron to calibrate the forces to the pistons of a maximum of 300 lbs.

Oregon State University

Bike Frame Load Test Machine

Sponsors: Sports Product Development Club (SPD), Scott Campbell

Advisors: Dr. Sarah Oman, Scott Campbell

MIME Team 108 Members:

Brett A. Haines, Kruthik N. Kesari, Emmett L. Lawson

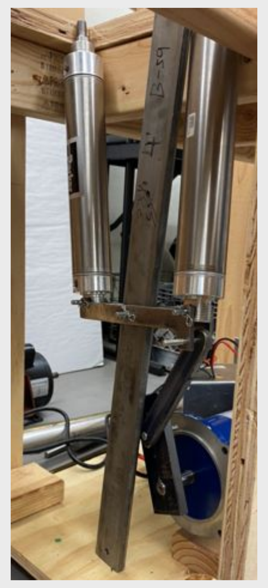
FINAL MACHINE

Machine Functionality

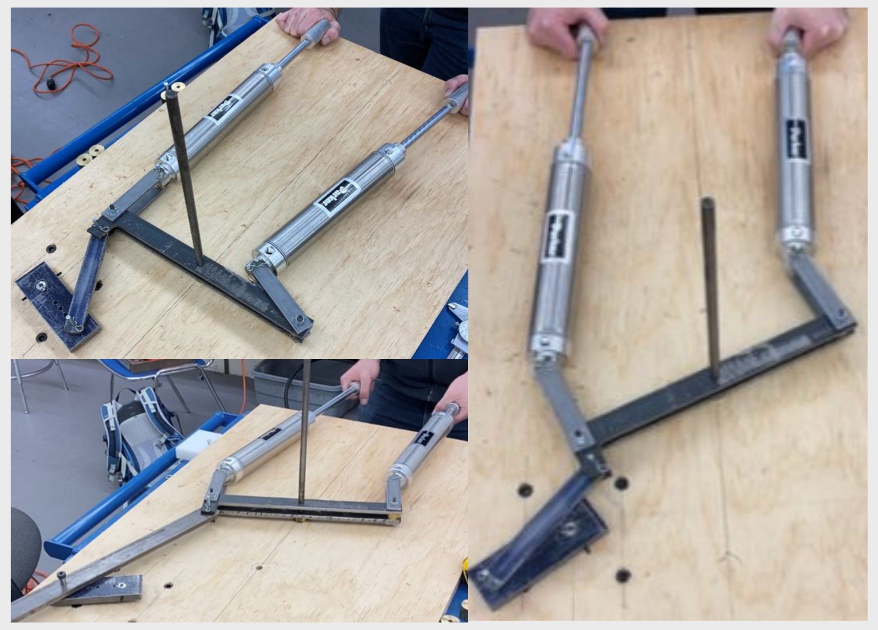
- The electric motor driven system turns rotational motion into linear motion using a four-bar-linkage to actuate pneumatic pistons. Cables are attached to the ends of the pistons and run to pulleys which then run back and around a steel bar to redirect the cables upward. The cables are then attached to the pedals to deliver the force. (Images shown above)
- The pneumatic cylinders are double acting and have blow off valves screwed into the top end so that pressure builds as they extend, which pulls on the cables to pull on the pedals.
- Check valves are also attached which allow air to refill the cylinders on the compression stroke to repeat the cycle.
- The pneumatic cylinders are 2 inch bore, 8 inch stroke that are capable of outputting 300 lbs using about 7 inches of stroke (Found using an Instron Compression machine).
- Using the Instron machine, the team set the blow off valves to release at 180 lbs.
- The motor is a ¾ horsepower dc, 90 volt motor.
- However, after cycle testing, the team believes a more capable motor is needed to run the machine better. (See Moving Forward section for methods to improve the bike frame load test machine.)

LINKAGE ITERATIONS

- This is the very first prototype designed with plywood and the first pistons the team found in a supply closet.
- During this iteration, the team found that increasing the flywheel would increase the stroke used in the pistons.

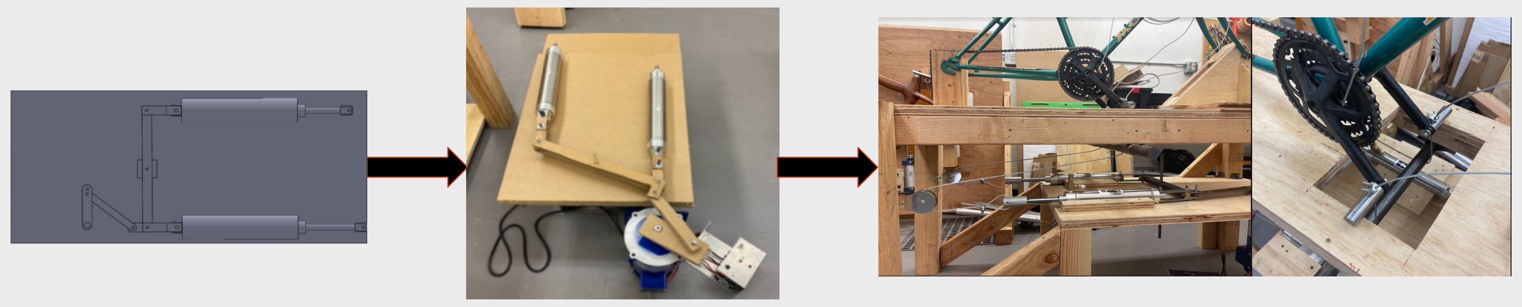


- This is the first prototype built with steel material and the new pneumatic cylinders.
- We wanted to make the support beam vertical to avoid axial loading.
- However, the new, larger pistons, would crash into the vertical support beam before reaching the stroke necessary to create the appropriate force.
- Design changes were then implemented and shown below.



- The team decided that in order to make the system work, it would need to be laid on its side and use cables to redirect the forces to the pedals.
- The team also increased the length of the cantilever in order to achieve the stroke needed using the new eight inch pistons.

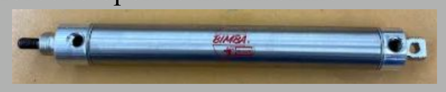
- The upper left hand image showcases a small transfer bar but the piston extenders were not hard linked at both joints.
- The right hand side image shows the piston extension bars were hard linked to mitigate the end of the piston from clashing with the linkage.
- The bottom left hand image shows the final linkage design with a larger transfer bar to prevent steep angle binding in the system.
- After testing, there was still some binding and odd rotation, so the team added guiders to keep the pistons in line.



Overall Design Concept

DESIGN CHANGES & ITERATIONS

- There were quite a few changes to the pneumatic cylinders, and each time a new set had to be adopted changes had to be made to the entire linkage system.
- The team found a set of pistons that had a stroke of four inches and a diameter of one inch. it quickly became apparent that these would not produce enough force to operate the machine.



- The second set of pistons that were tried had a diameter of two inches and a stroke of 4 inches. changing to these pistons required redesigning the cantilever beam, and the support bars. When this change was made Scott Campbell also told us that he planned to use the machine to give him confidence that his frames could pass the test and then he would send the frame to a lab that would certify the it. Campbell allowed us to relax some of the standards because of this.

- As a bike frame fails the point where it can handle a given load changes, this means that the piston needs to have extra stroke to continue exerting the required force on the frame, the team was worried that the four inch pistons would not be able to continue applying the force as the bike frame failed. A change was made to pistons with two inch diameter and eight inch stroke was made. This required the redesign of the cantilever beam, the flywheel, the transfer bar, the way that the pistons are attached to the cantilever bar and finally the system had to be laid vertically and attached to the bike frame with cables because the new pistons were too tall to sit under the bike frame.

- The pistons were designed to attach to the cantilever bar via spacers. These spacers were originally designed to float, however this caused the system to lose a large amount of stroke distance, and this in turn lowered the forces generated by the machine. This was rectified by mounting the spacers to the cantilever so they could not rotate, and they were still allowed to rotate at the piston mount.
- The change to fixed spacers caused large amounts of friction to develop in the system. This was remedied by mounting guides that controlled to movement of the pistons and then returning the spacers to floating on both ends. this greatly reduced the amount of friction and binding in the machine.

MOVING FORWARD

- Team 108 was able to prove the concept of an electric motor driven system using pneumatic cylinders to deliver force to the bike frame.
- However, due to a very steep torque curve, seen by the motor, at specific points in the cycle, the system has mirrored locations where it jumps and cuts out.
- We believe that the speed control has a safety cut off that shuts down the motor when it sees the current draw increases to rapidly.
- The team believes an encoded motor that can communicate with a speed controller to output constant torque, could eliminated the jumping seen in the system.
- Problems we discovered that were out of our time frame of solving were obtaining larger diameter pistons with a four inch stroke.
- Larger diameter and shorter stoke allows for lower pressure needed to generate the required force, as well as decrease the size of the cantilever and overall system.