Robotic Blacksmithing Apparatus

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Introduction

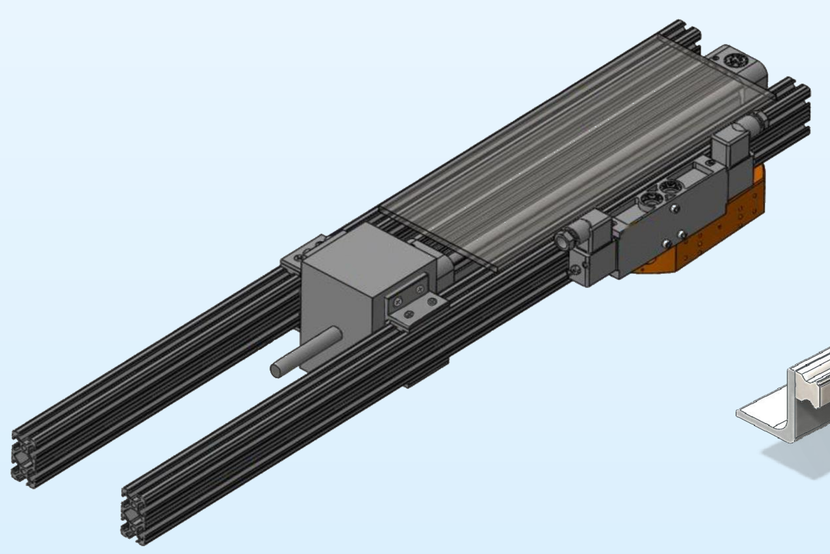
Under funding from the National Science Foundation (NSF), the University of New Hampshire is looking to develop a robotic blacksmithing apparatus for post-processing tasks. This would be completed through the production of an end-effector attachment for the forging of an aluminum composite. The current material suffers from rough surfaces and internal voids, so creating an end-effector to deform this material will produce a better surface finish. This ultimately will be used for the addition of Additive Friction Stir Deposition (AFSD) from Baylor University to improve the material properties of aluminum.

Criteria and Design Constraints for the Redesign:

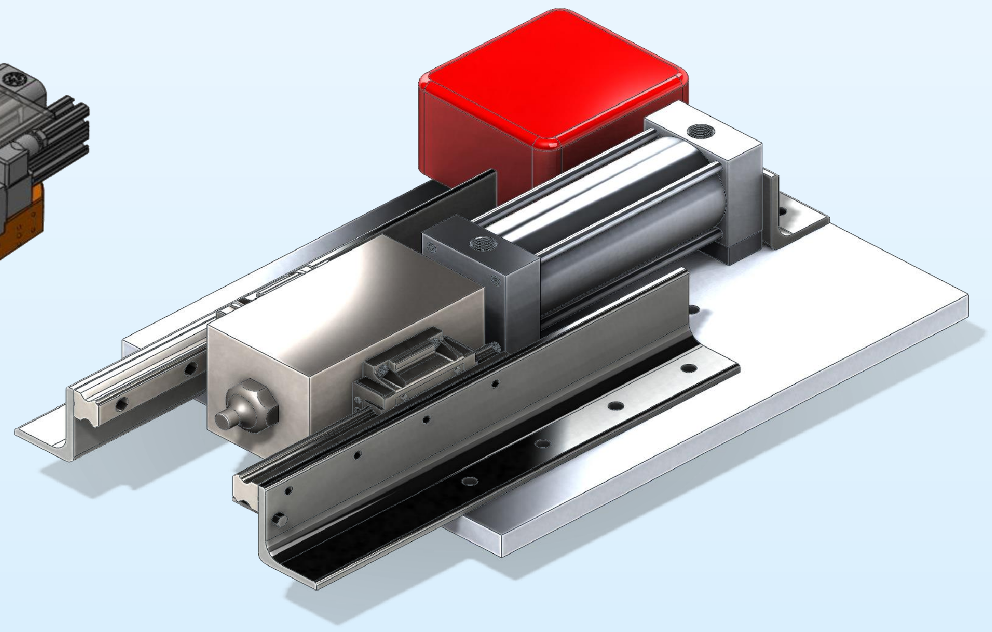
- Weight limit of 150 kg to attach to KUKA & Robot
- Manufacturability
- Strike aluminum with at least 290 MPa of pressure to cause deformation

Design

Last Year's Design (11.3 kg)



This Year's Design (32 kg)



Previous Design:

- Aluminum block (2.8 kg)
- Ceramic friction surface
- 300mm stroke, 38mm bore
- Long and slim aluminum end effector
- Difficult to mount

New Design:

- Larger steel block (11 kg)
- Ball-bearing carriage and guide rails
- 100mm stroke, 63.5mm bore
- Multiple sturdy end-effector designs
- Large base plate for multiple mounting options

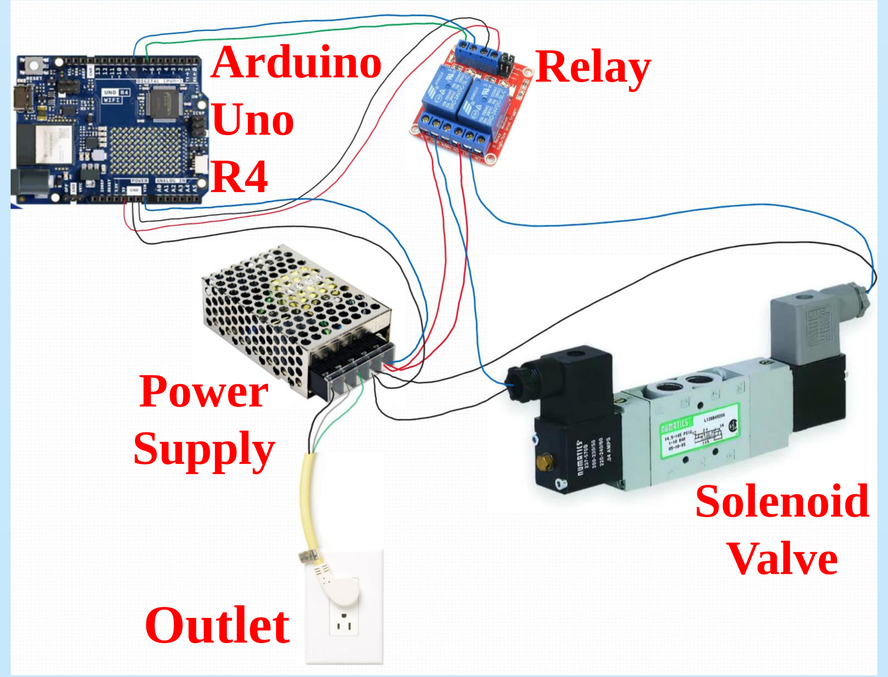
Electronics

The pneumatic cylinder is controlled remotely via Wi-Fi. This is possible thanks to the Arduino Uno R4's Wi-Fi module.

Both the Arduino and the solenoid valve are powered by a single 24V power supply plugged into a standard wall outlet. The Arduino controls the solenoid valve through a 2-channel relay.

The Arduino can be programmed to fully automate the process or give full control to a person viewing from a safe distance.

Schematic of Wiring Setup when Connected to the Solenoid Valve

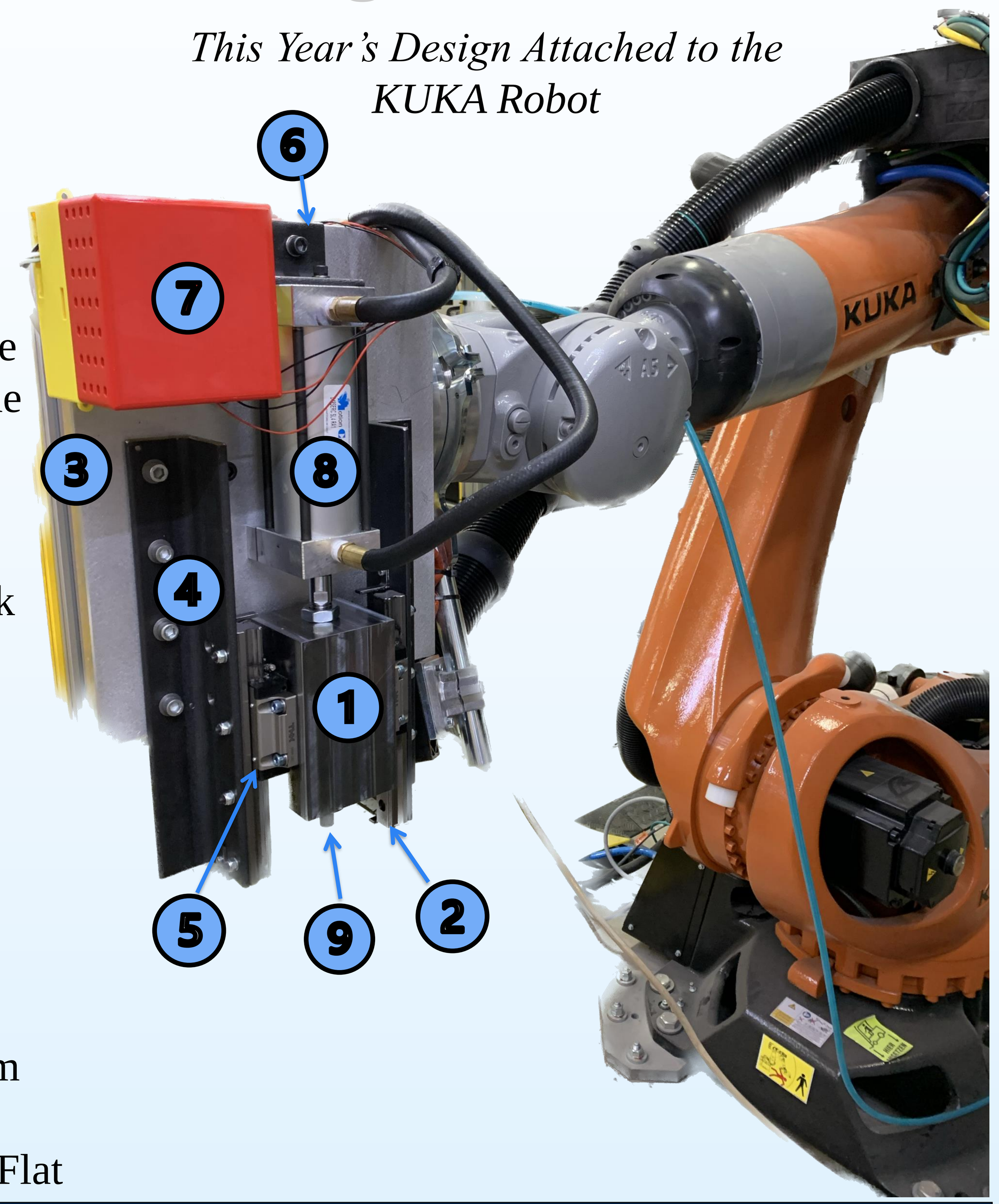


Testing

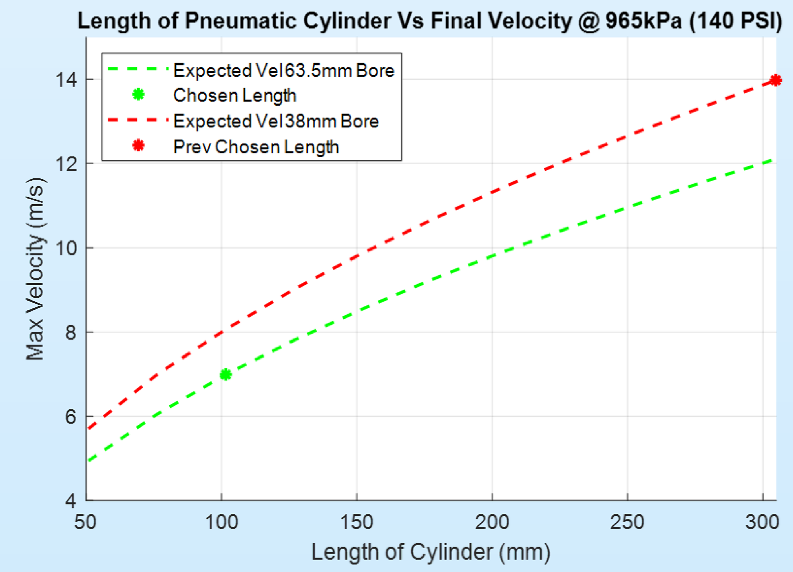
Speed was calculated for this by use of a stopwatch being held next to the attachment as it was running to record the distance the end effector moved in comparison to the difference in time, while the apparatus was oriented in the downward position.

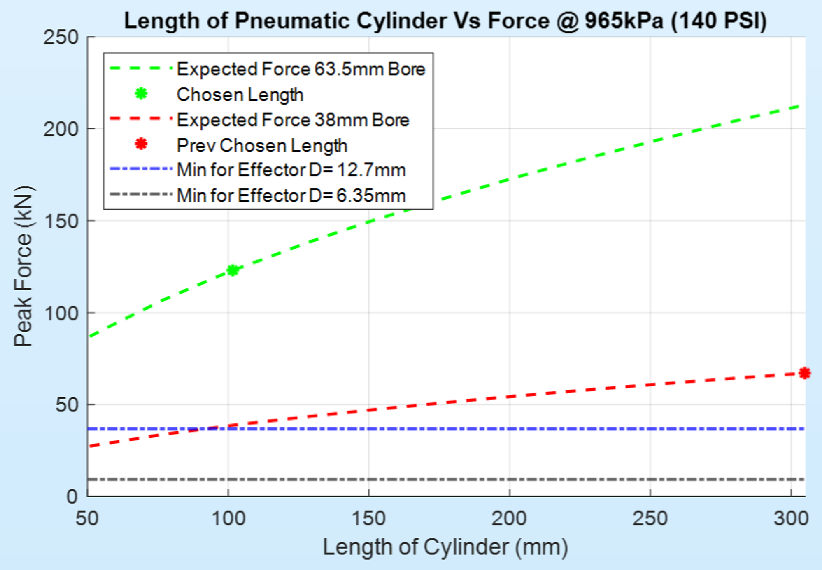
1) 4041 Alloy Steel Block
2) Guide Rails (x2)
3) Aluminum Plate
4) Low Carbon Steel 90 Degree Angle
5) Ball bearing Carriage
6) Low Carbon Steel 90 Degree Angle
7) Arduino Housing
8) 100mm Stroke 63.5mm Bore Air Cylinder
9) End Effector 12.7mm Flat

This Year's Design Attached to the KUKA Robot

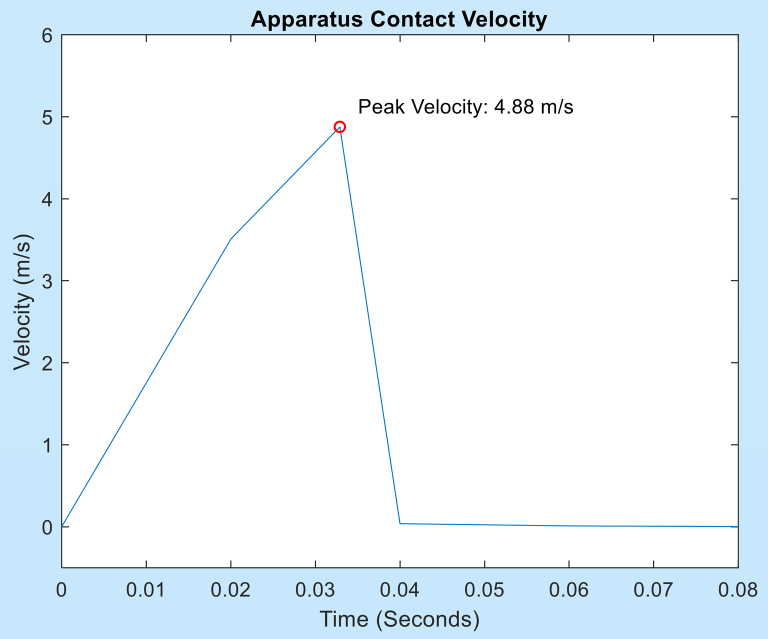


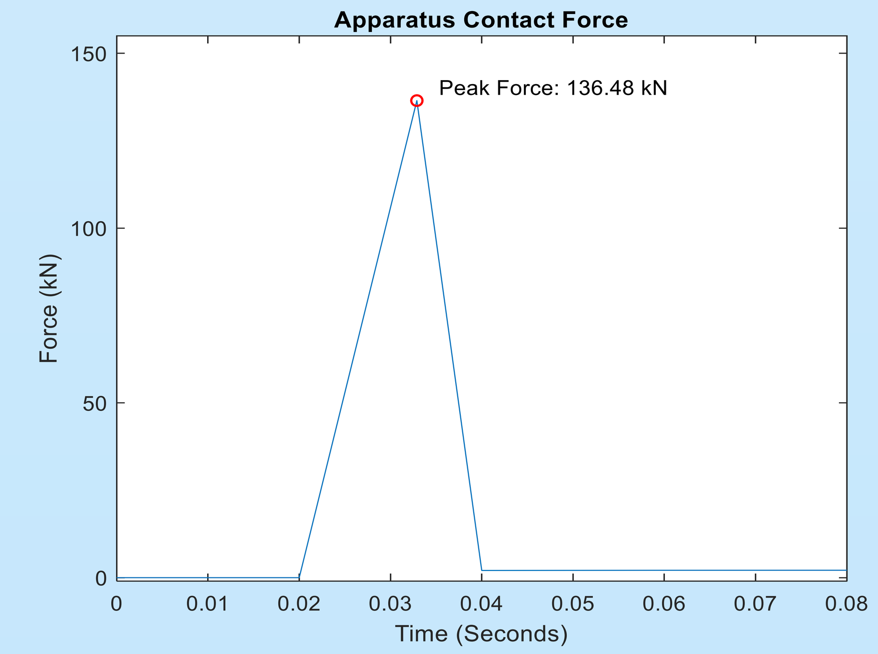
Theoretical Calculations





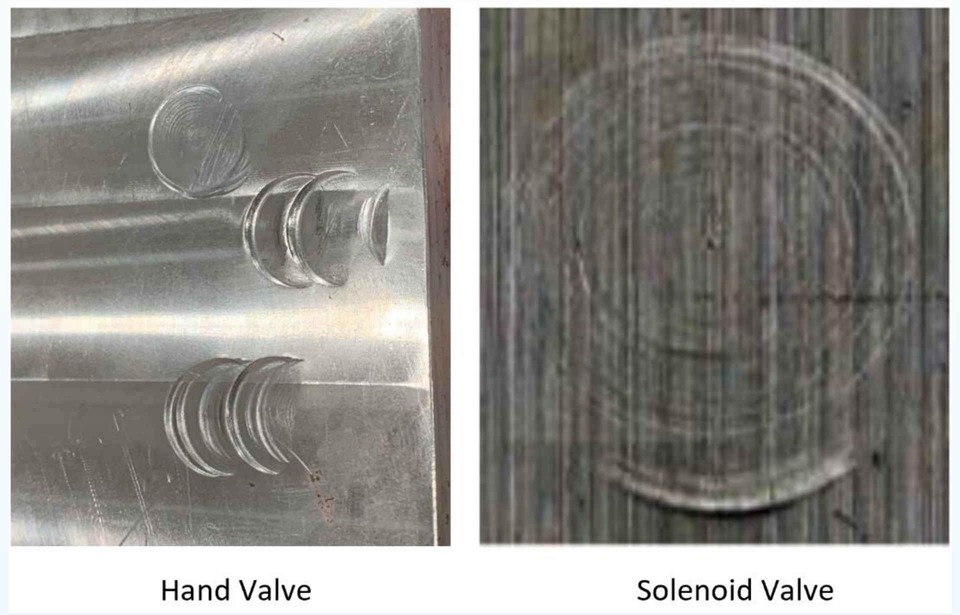
- Found the maximum final velocity for a range of cylinder lengths
- Using speeds and masses, calculated expected impact forces
- New cylinder design able to produce more force at lower speed
  - Lower effect of high strain rate hardening
- 63.5mm bore cylinder was chosen for high force and quick follow-up impacts



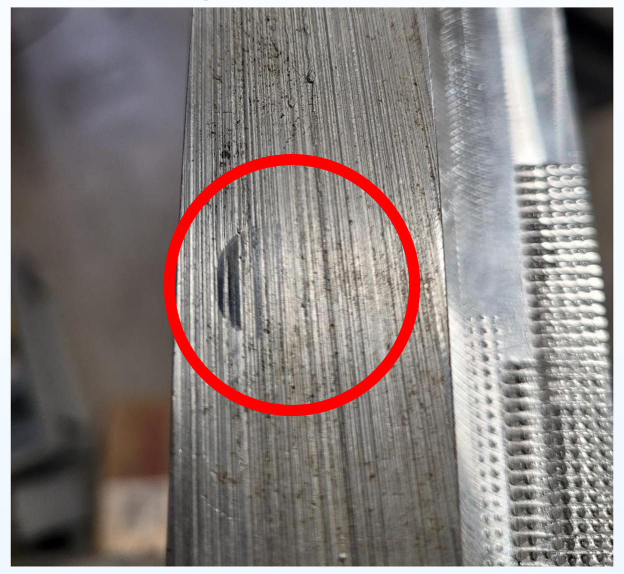


Analysis & Deformation Results

Testing Last Year's Design

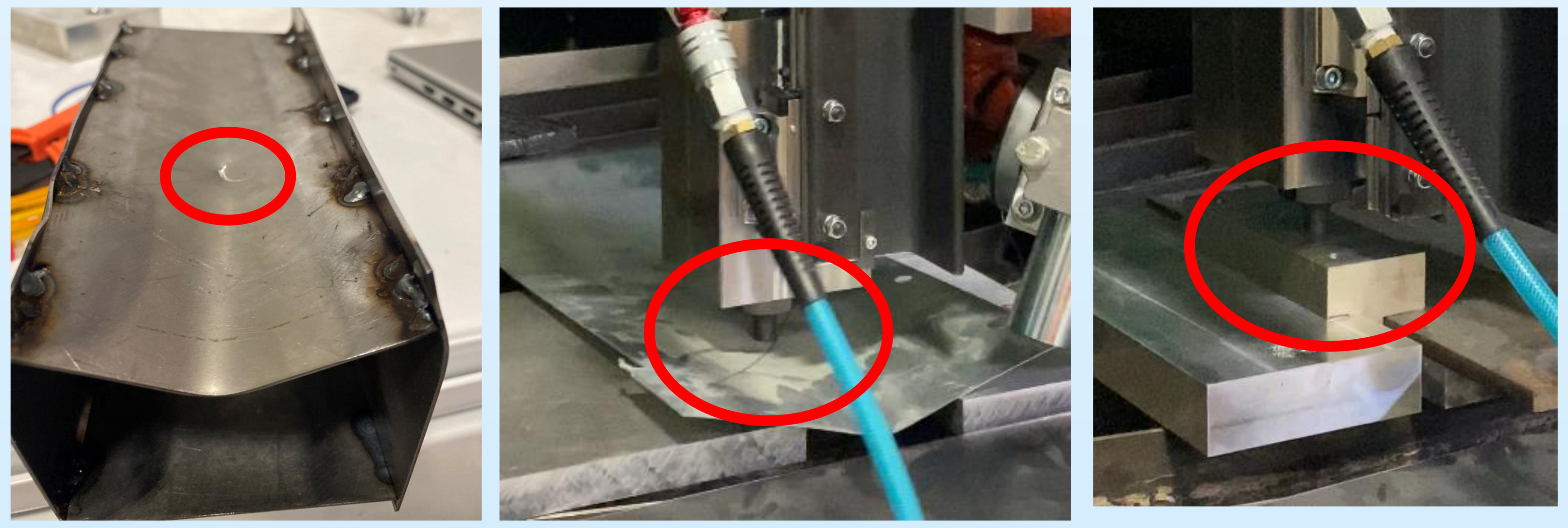


Testing This Year's Design Using Solenoid Valve



- Tested previous design to compare a hand valve against the solenoid valve purchased last year (picture on the left)
- Tested current design using old solenoid valve and poor material mounting
  - Limited airflow
  - Increased impact time limiting effectiveness
- Tested this year's design using the stopwatch alongside the apparatus and video documentation
  - Final speed found from a slow-motion video was approximately 2.5 m/s.
  - The predicted value for this was close to 5 m/s, likely off due to air flow

Testing This Year's Design on Multiple Surfaces



Conclusion & Next Steps

In conclusion, the team designed and manufactured a movable apparatus that is projected to deform aluminum. Due to its KUKA quick attach feature and its autonomous applications, this blacksmithing apparatus can be applied to a vast amount of research projects.

Next Steps:

- Improve Testing methods
  - Brinell/Vickers Hardness Test
  - High-Speed Camera
- Update Valve
  - Testing Required
- Optimize Code for Solenoid Valve
- Implement Lexan Guard & Handles
- Testing with AFSD

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