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College of Engineering



Mission/SOW

Additive manufacturing has become increasingly popular in industry due to its ability to speed up production and reduce labor costs.

Using PA12 for our material, KCNSC has assigned us 2 tasks:

- **Task 1:** Test adhesives strength in shear version tension.
- **Task 2:** Design and conduct a failure testing of a 2-piece bonded 3D printed pressure vessel.

At completion of this project, KCNSC seeks to have a design guide that captures the design team's results, lessons, learned, and best practices.

Research

We focused our research on three main areas:

- Adhesive Strength
- Surface Preparation
- Maximizing Surface Area

During adhesive selection, we concentrated on identifying adhesives that not only offer exceptional shear strength but also demonstrate effectiveness when paired with thorough surface preparation.

Preliminary Testing

- Using a standardized lap shear specimens, we measured the bond strength of two chosen adhesives: Loctite 3DP Instant Bonder and Infinity Bond MMA 330.
- Surface preparation and bonding surface area were carefully controlled.
- Testing the joints via shear strength test indicated that MMA 330 was our optimal adhesive.



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3D Printed Polymer Bonding

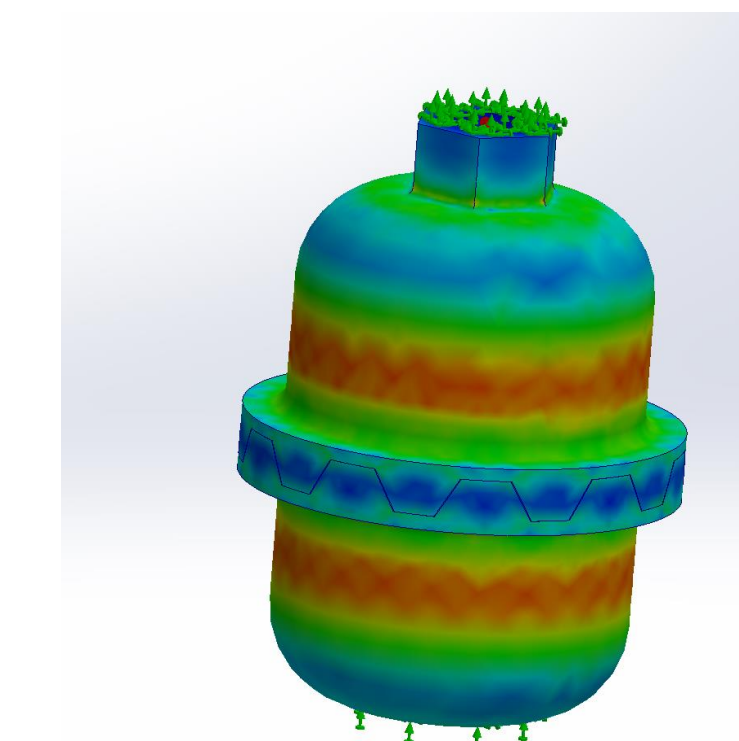
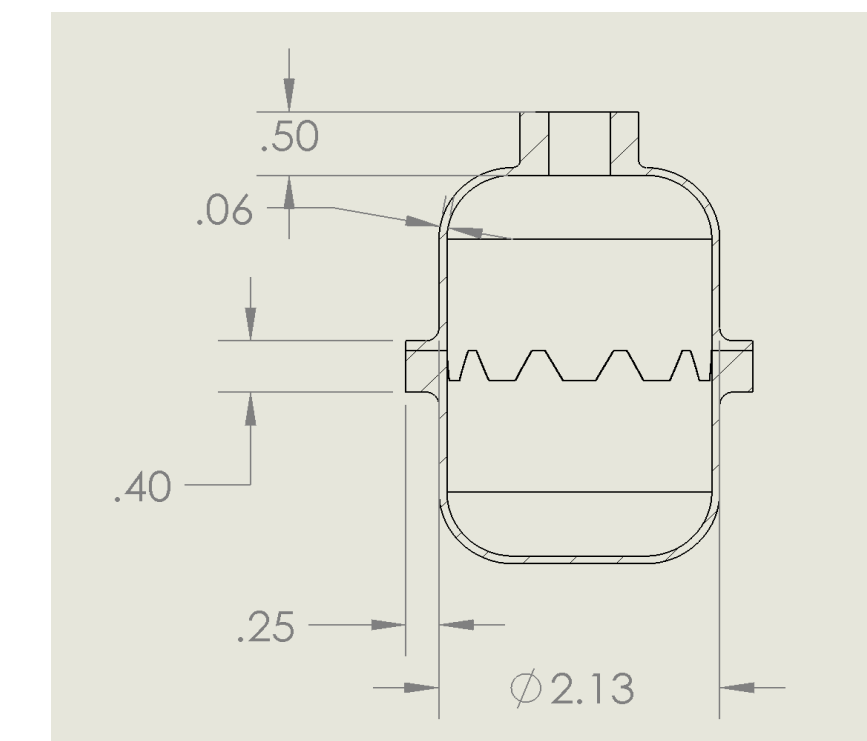
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QCAM and KCNSC

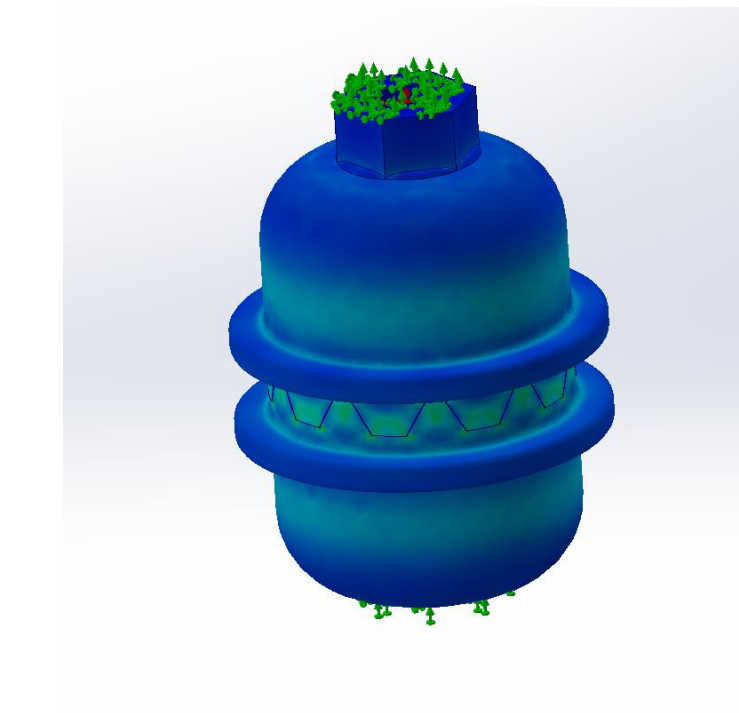
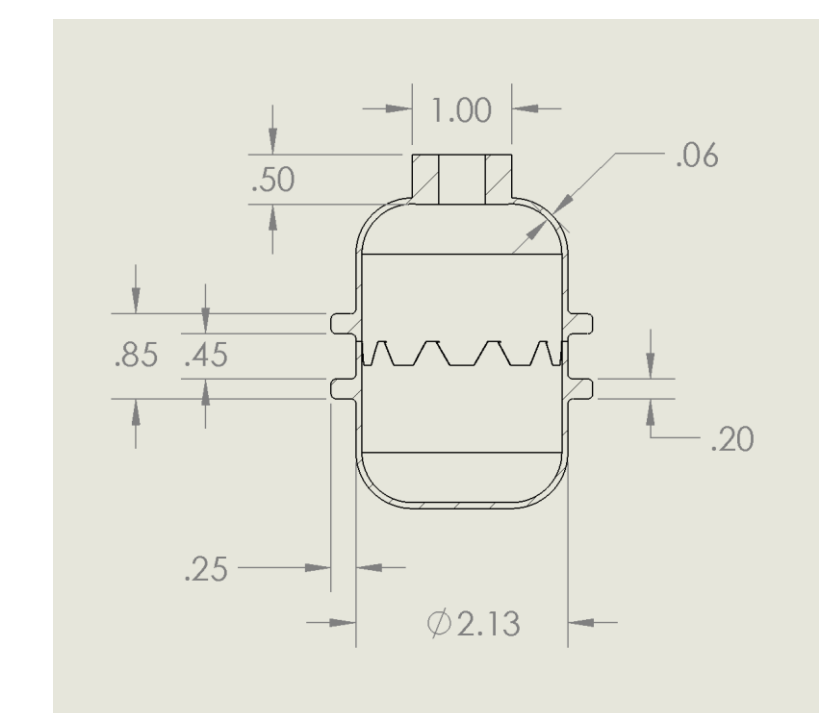
Concept Development

- **Pressure Vessel design:** 2 designs
 - Using the joint designed in the preliminary testing phase
 - A flange to help connect the two halves of the pressure vessel
 - The top to be held for tapping
- Calculated burst pressure for both designs at 193.33 psi, using Barlow's Formula
 - In industry, Barlow's Formula is used to determine 1) the safe operating pressures of pipes and pressure vessels and 2) maximum pressure before failure

$$P = \frac{2*S*t_m}{D}$$



Design 1. Thick flange



Design 2. Separated flange

Final Design

Construction:

- 3D-printed prototype were created and sent from KCNSC
- Infinity Bond MMA 330 was applied to the joint, pressure was applied to join halves together evenly, then the adhesive was left to set for 24 hours
- ¼” holes were tapped at Aggie Innovation Space Machine Shop.
- Quick-disconnect fittings were attached to each pressure vessel
- X-Pando was applied on the threads of the fittings to seal threads

Conclusion:

Final design of the pressure vessel was based off the above concepts, with an emphasis on minimizing the likelihood that the vessel would fail at the joint, at the nozzle, or at any sharp edges on the vessel. Design 1 meet our goal of failing outside of the joint area while Design 2 failed near the top of the head far before our expected values. When compared to our control sample designed by client, our design performed less than expected.

Future Recommendations:

- in-built pressure points
- Hydrostatic test mode
- Use furnace when curing adhesive

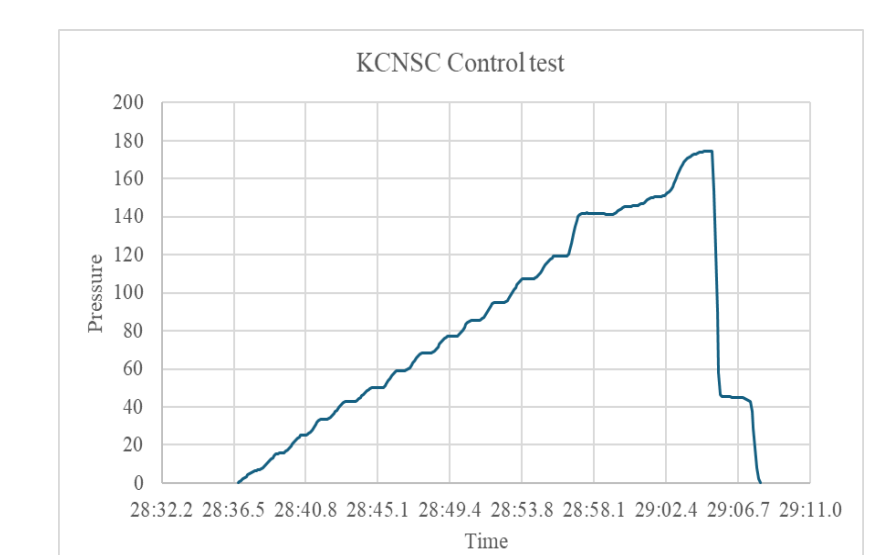
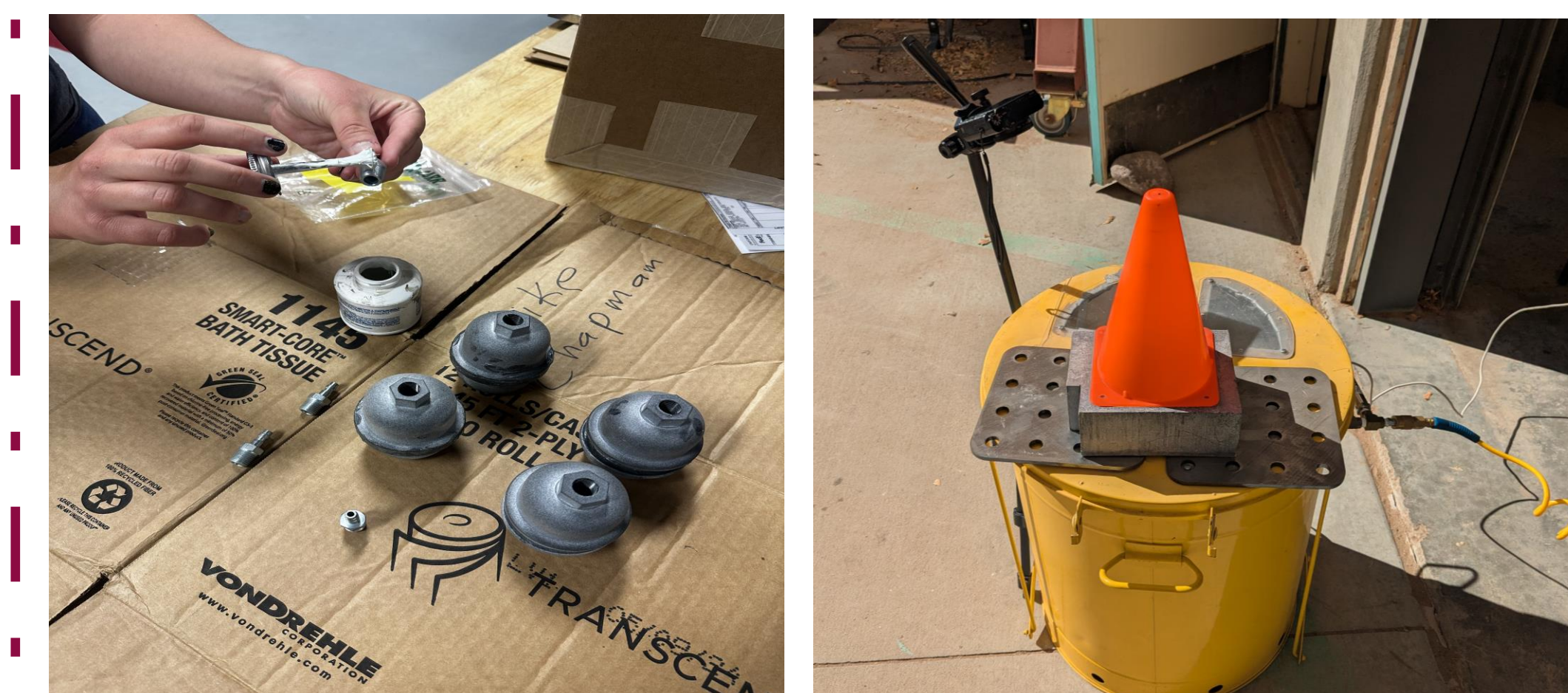


Pressure Vessel Test

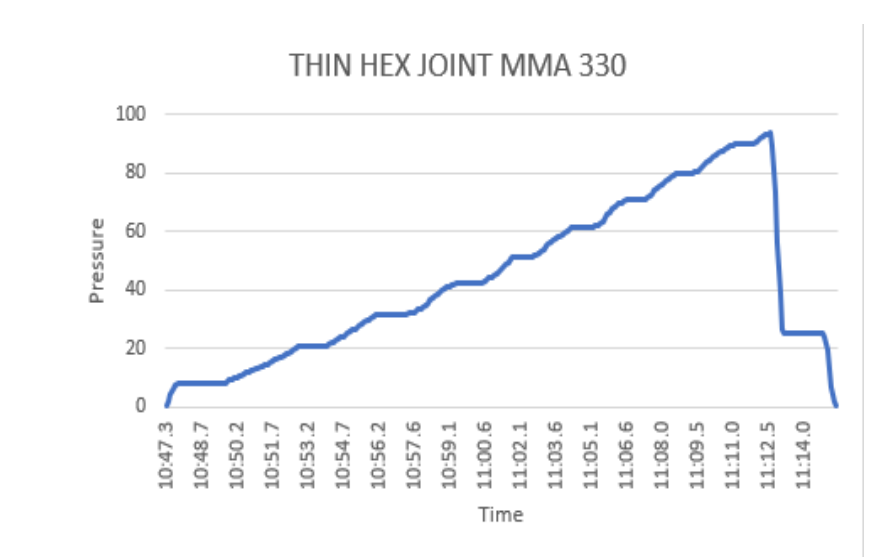
- Utilized a waste can as our burst chamber
- Using pneumatic testing, pressure vessels were filled with nitrogen to failure
- Pressure was monitored via a pressure transducer
- Mounted a camera outside the chamber

Results:

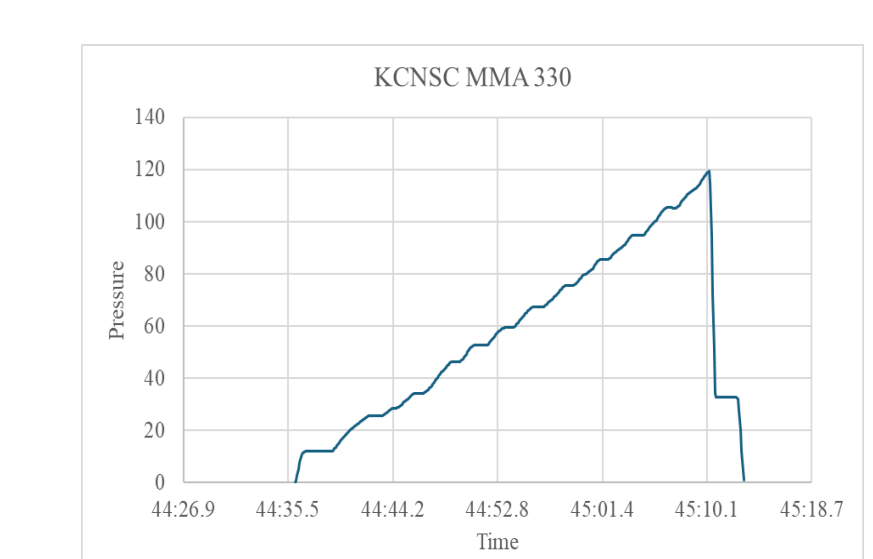
	1 Full	Split	KCNSC	1 ring	2 ring
2	110.9	92.6	174.5	79.4	119.4
3	144.6	78.5			99.23
4	125	93.8			
5	137				
Average (PSI)	129.375	88.3	174.5	79.4	109.315



Control Sample Test Results



Hexagonal Thin Joint Test Results



Hexagonal Thick Joint Test Results

References

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