Large Scale CNC Inflatable Bladder Maker

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Motivation

People want convenient features in the products they use. Inflatables can be used in a wide range of products including automobiles. There are many ways to fabricate and prototype inflatables including 3D printing, injection molding, flat surface sealing, etc. For prototyping flat surface sealed inflatables, a relatively new approach uses a CNC bladder maker. The current bladder maker can only make smaller inflatables, and it is a time consuming process. We want a bladder maker that can produce larger inflatables which can be used in real life applications in the automobile industry.

Interior of car

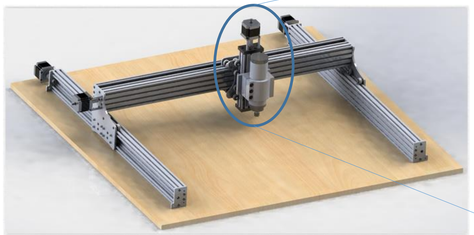
Inflatable Bed Liner

Objectives

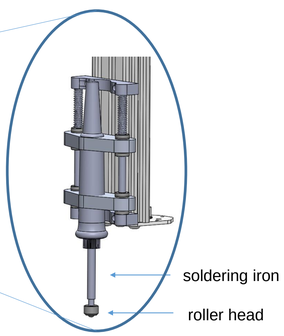
1. Design and build a higher-speed, larger CNC sealing capable of producing heat-sealed inflatable bladders upwards of 4'x4'.
2. Characterization of the bladder maker for sealing parameters
3. To understand the impact of bladder shape on seal quality and strength

Bladder Maker Design

- Designed and built the CNC bladder maker
- Combination of an open source CNC router and a custom designed heating head
- Size of CNC router: 1500mm x 1500mm
- The heating head consists of a soldering iron and a roller head
- Base made with sheet metal on top of plywood
- Uses magnets to hold down material



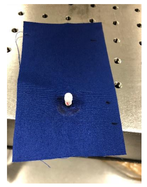
CNC Machine



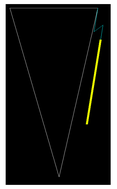
Roller heating head

Sample Fabrication

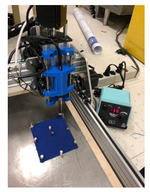
Infuse TPU rubber into fabric with heat press



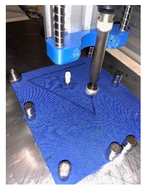
Fuse 3D printed rubber air nozzle into fabric



Draw shape and convert to gcode



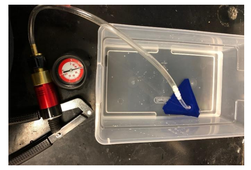
Attach 2 fabric layers to CNC bed with magnets



Seal outline at
Temp. = 850 °
Speed = 200 mm/min
Z-Offset = -41mm

Experiment Setup and Procedure

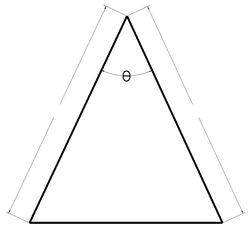
1. Attach pump to nozzle
2. Fully submerge bladder in water
3. Pump until air bubbles appear from the edges/corners
4. Record failure pressure on the pump



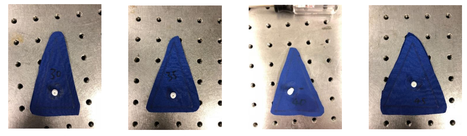
Experiment Setup

Angle Study

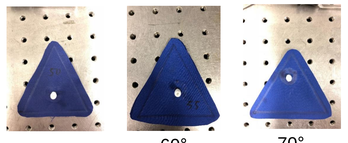
Hypothesis: Shaper angles have a lower failure pressure.



Samples with various angle θ



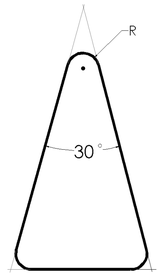
30° 35° 40° 45°



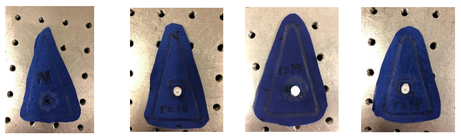
50° 60° 70°

Curvature Study

Hypothesis: While shaper angles have lower failure pressure, making the corners rounded alleviates the failure.



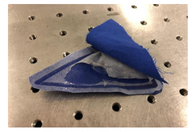
Samples with different corner radius for θ =30°



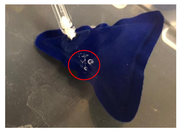
R = 8 mm R = 10 mm R = 14 mm R = 18 mm

Results

- Two types of failure
  - Fabric Failure
  - Seam failure: occurs at the sides or the corners

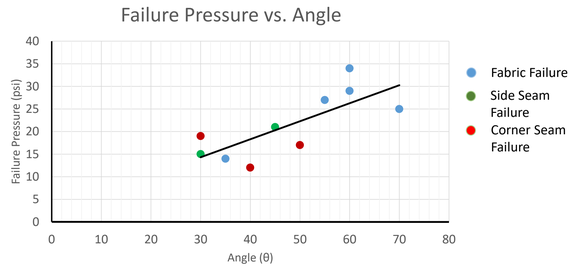


Fabric Failure

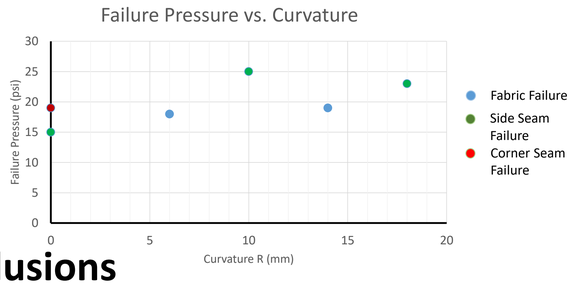


Seam Failure

- Results show a positive correlation between angle and failure pressure.
- At higher angles, fabric failure occurs more frequently even though fabric failure seems to occur across different top corner angles



- Results show no strong correlation between curvature and failure pressure
- Making the corners rounded does not alleviates the failure pressure but prevents failure at the corner.
- Overall shape impacts failure pressure rather than corner sharpness.



Conclusions

- We developed a working CNC inflatable bladder maker that is capable of producing bladders of sizes upwards to 4' x 4'.
- Shapes with sharp corners have a higher failure point
- Rounding corners does not improve failure pressure

Acknowledgements

Special Thanks to GM for their support: Paul Alexander, Wonhee Kim and Nancy L. Johnson And to Laura Giner for all her help and guidance. Thanks to Royce for working with me on bladder maker and the parameter tuning.

References

1. Jifei Ou , Mélina Skouras , Nikolaos Vlavianos , Felix Heibeck , Chin-Yi Cheng , Jannik Peters , Hiroshi Ishii, aeroMorph - Heat-sealing Inflatable Shape-change Materials for Interaction Design, Proceedings of the 29th Annual Symposium on User Interface Software and Technology, October 16-19, 2016, Tokyo, Japan [doi>10.1145/2984511.2984520]