Team 2- Biaxial Tensile Test

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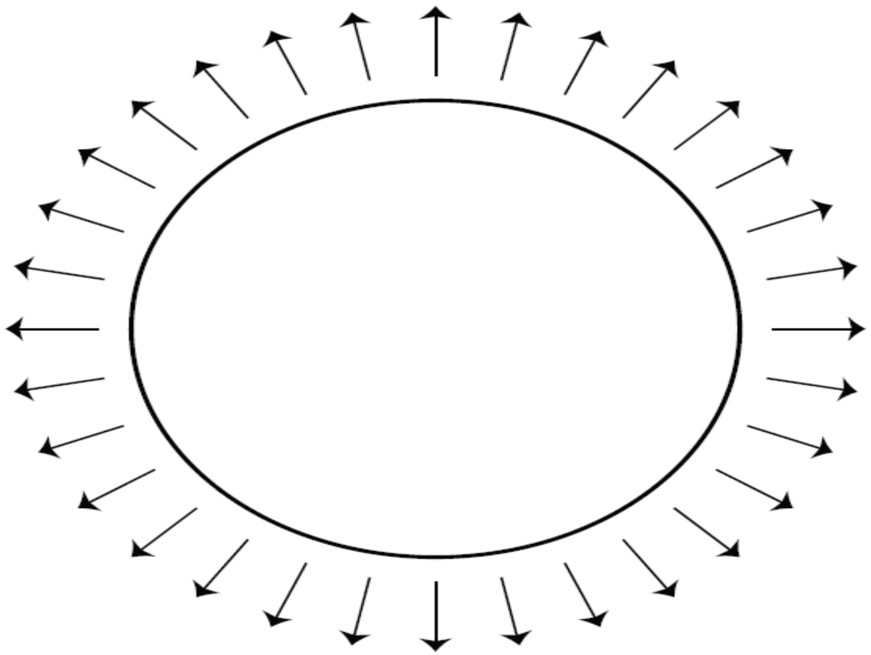
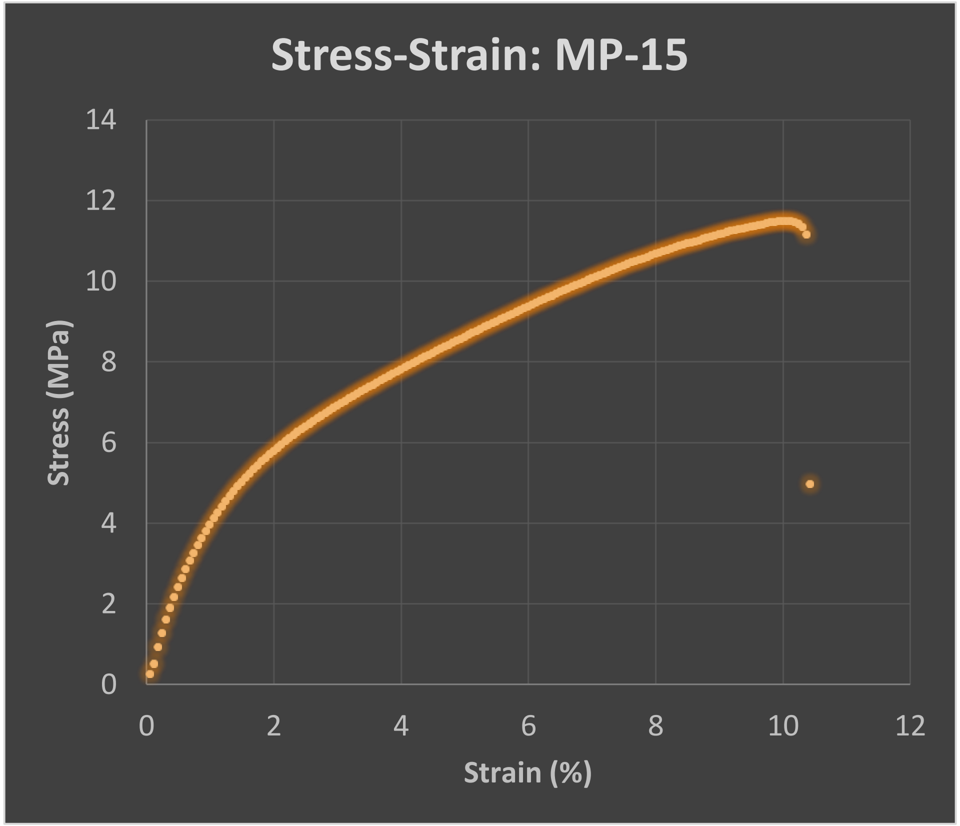
Equal Biaxial Tension

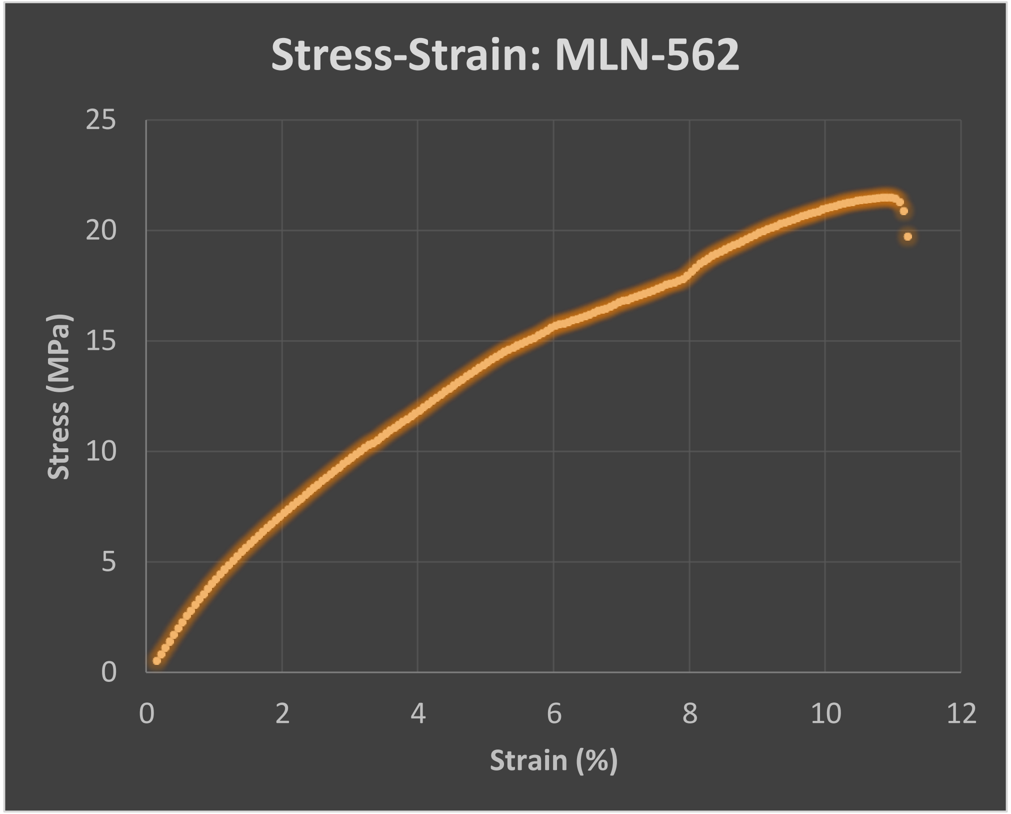
- For incompressible materials this creates a state of strain equivalent to pure compression.
- Free from the frictional effects that are detrimental during a uniaxial compression test
- The top and bottom surfaces will contract



Ideal loading conditions for biaxial testing [1]

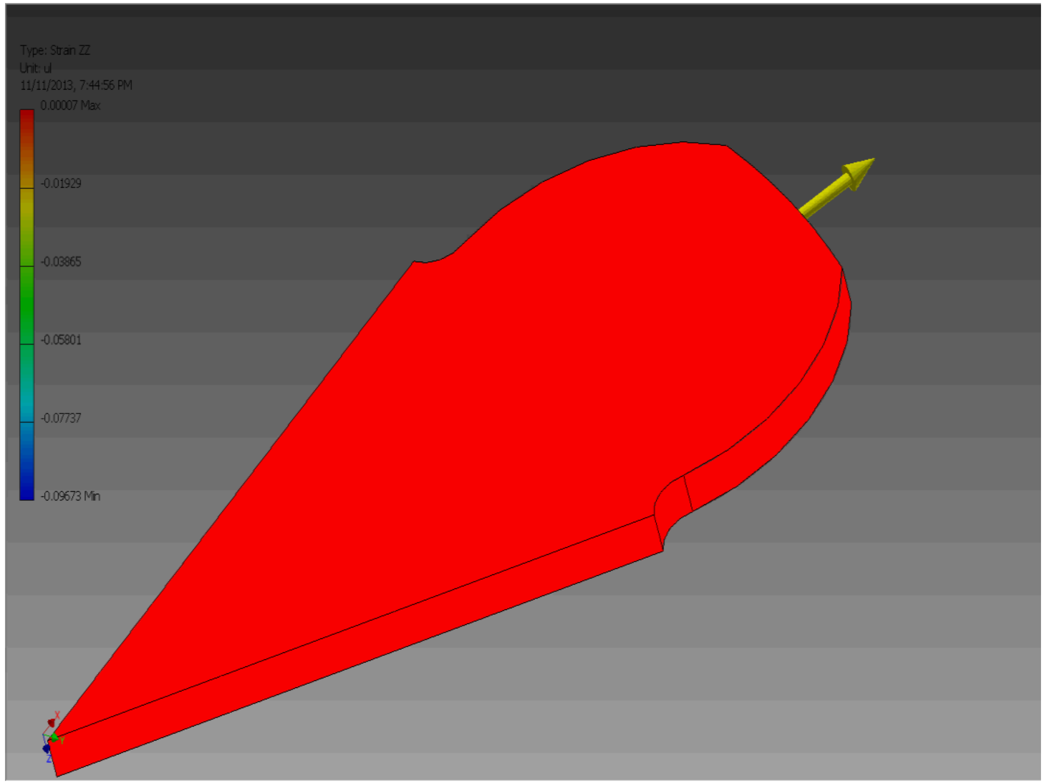
Stress-Strain Curves of Select Gaskets



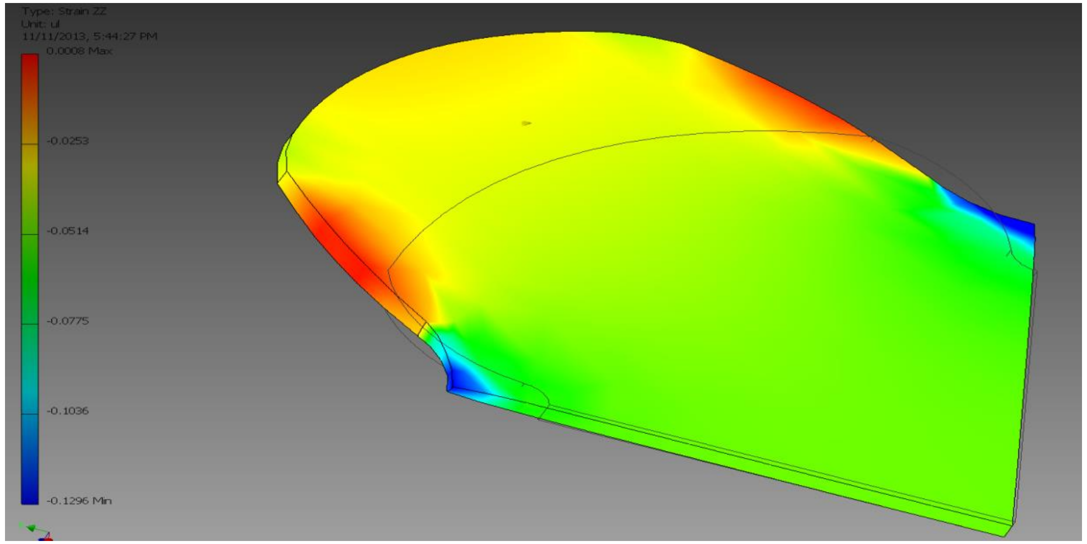


Specimen Geometry

- Modeled with natural rubber's material properties
- Assumed a symmetric load applied radially
- Neglected the effects of the clamping from the grips during testing
- Need a uniform strain distribution throughout sample

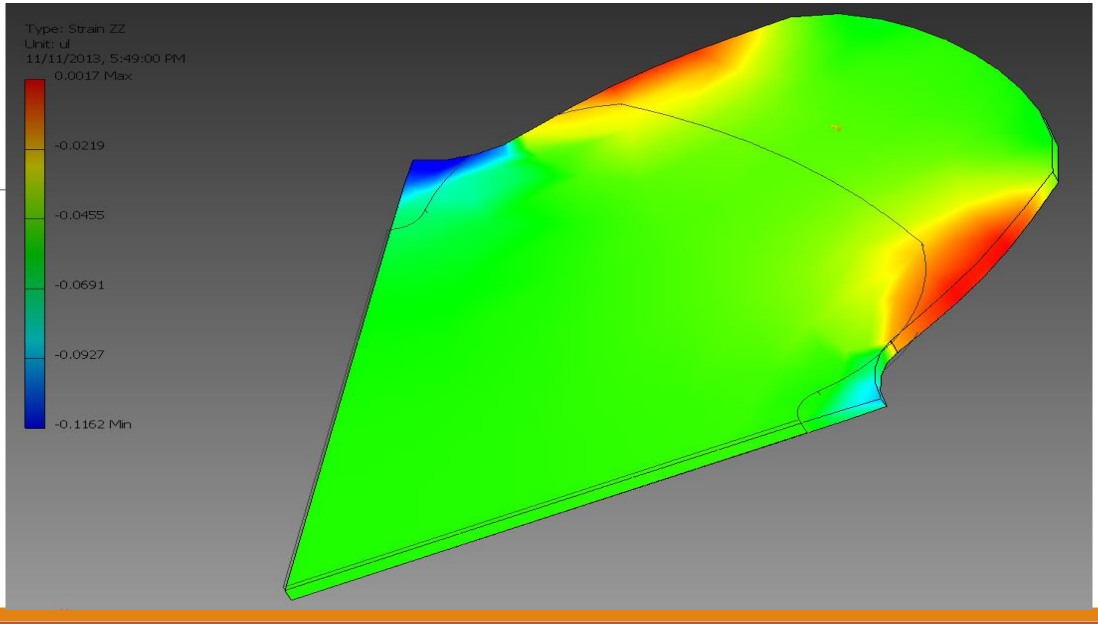


Specimen Geometry Cont.

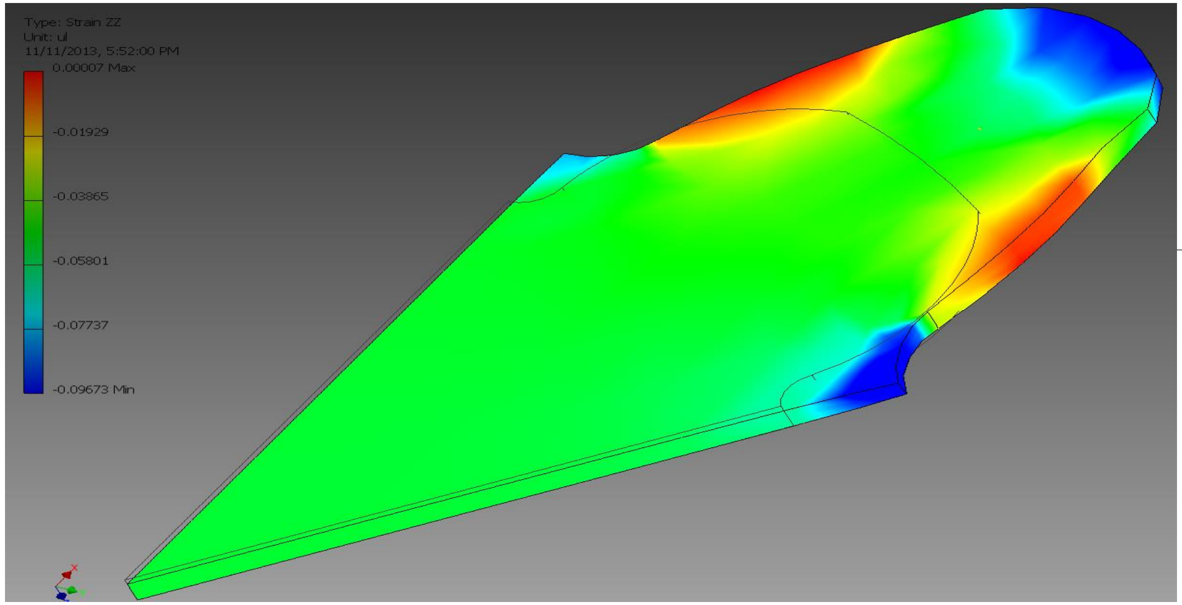


4 axes

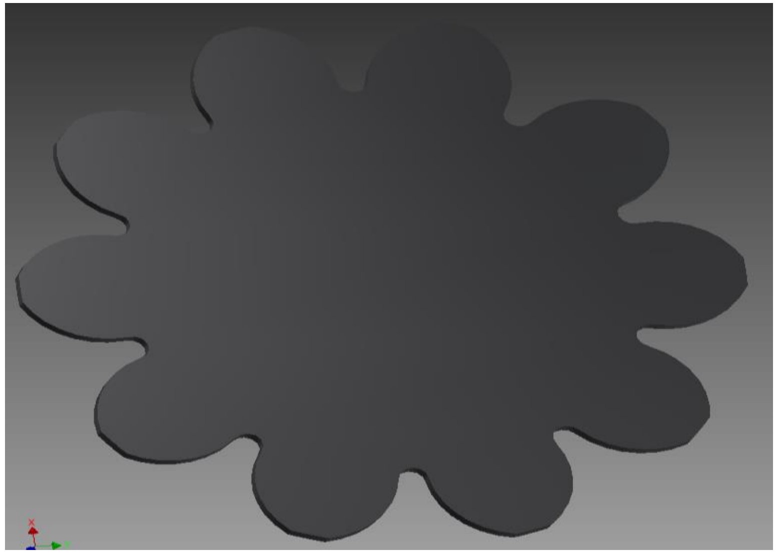
6 axes



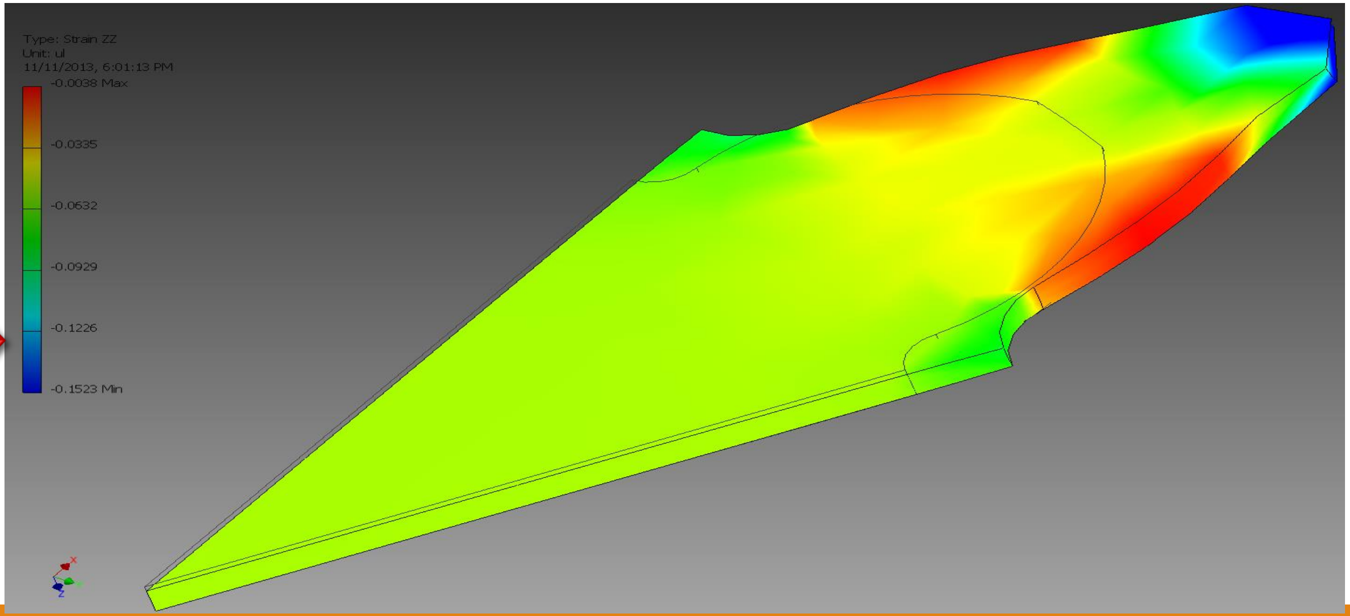
Specimen Geometry Cont.



8 axes

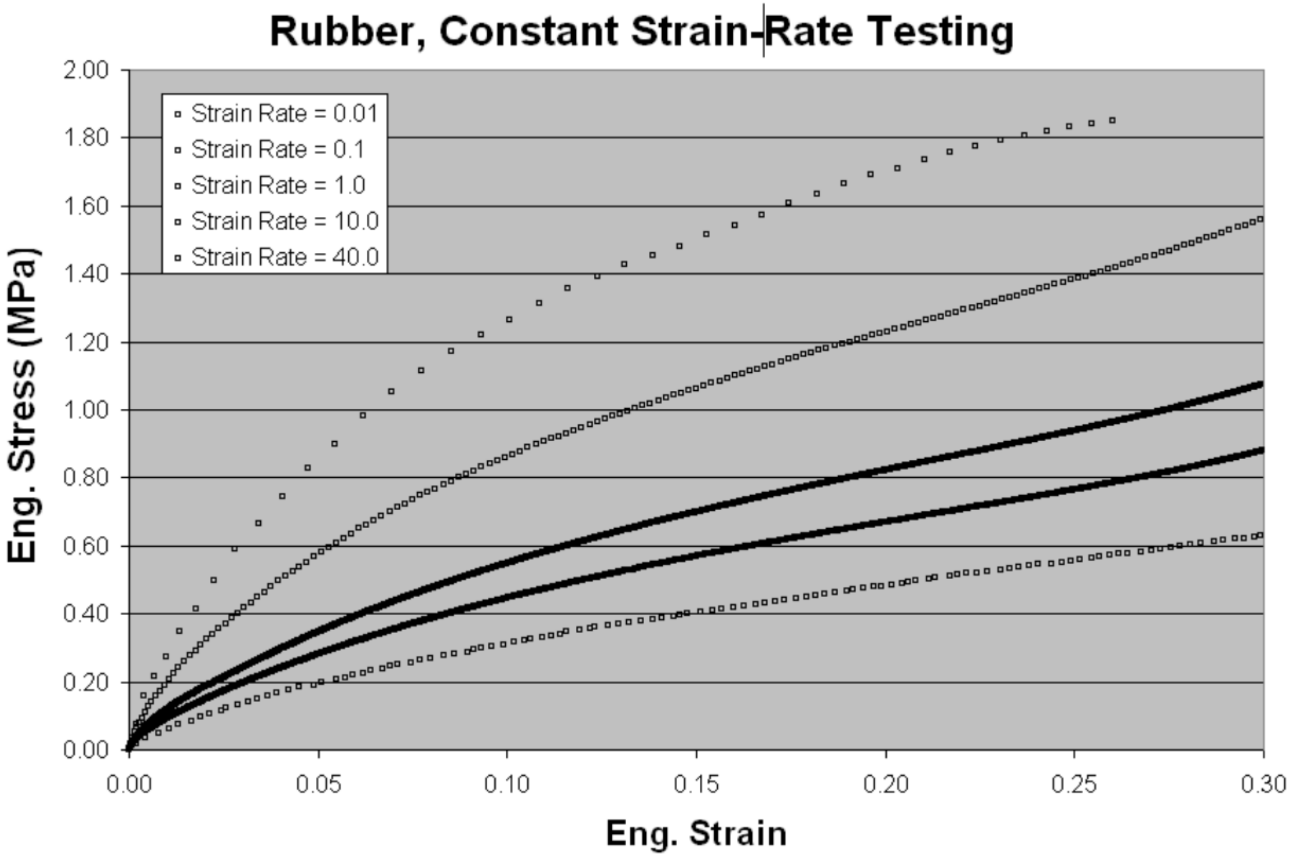


10 axes



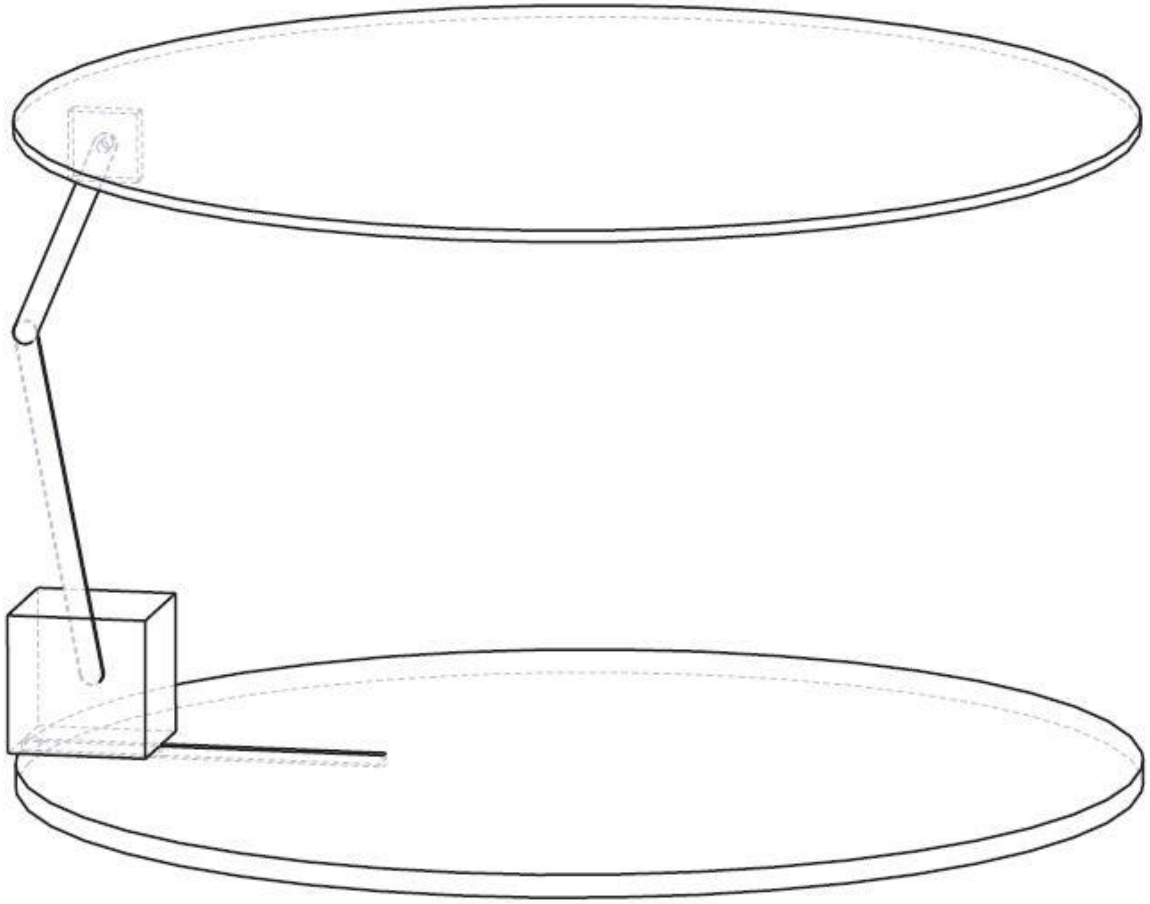
Strain Rate

- Constant strain rate testing will be used for the biaxial tensile test
- For elastomers, the strain rate greatly influences the material properties
- No ASTM standards for biaxial testing



Loading curves that depict the strain dependence of elastomers. [2]

Concept 1 – Linkage Design



- Gripping mechanism would come attached to slider
- Axes would be added after ideal amount is determined
- Would only allow uniaxial movement of the slider due to the design of the linkages

Concept 1 – Pros and Cons

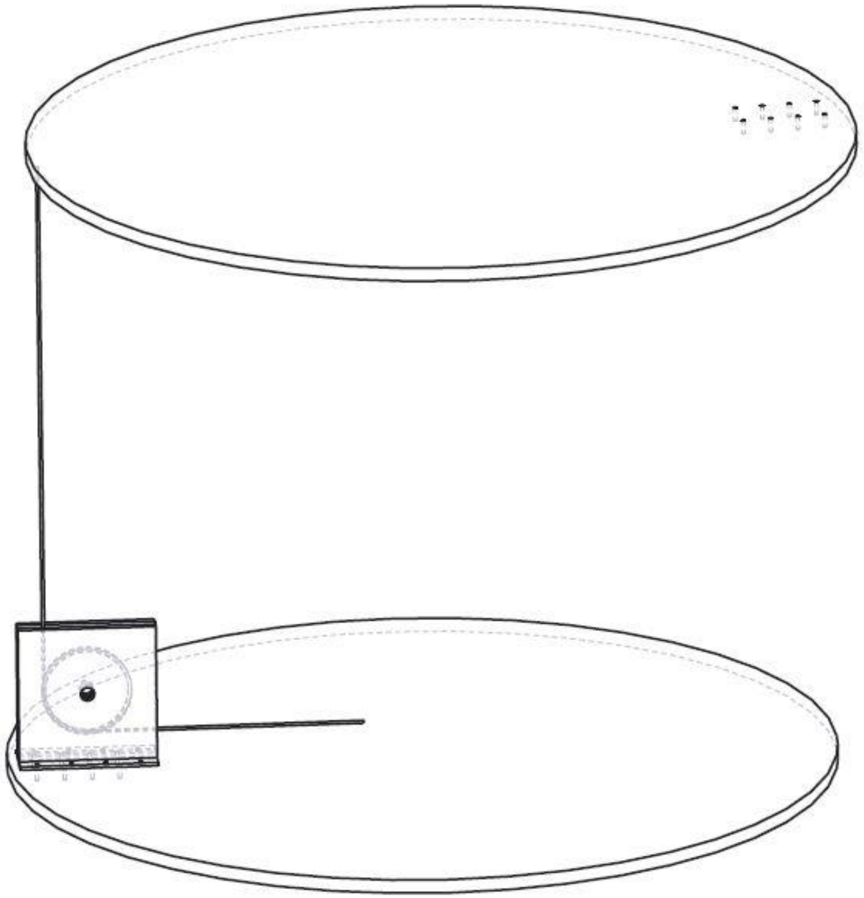
<u>Pros</u>

- Mirror linkages for all axes
- Very easy to machine linkages
- Simple to analyze and build
- Very cheap

<u>Cons</u>

- Could have unbalanced forces and moments in linkage
- Can't adjust linkage for variable strain rates

Concept 2 – Pulley Design



- Gripping mechanism would be rigidly attached to lower end of pulley
- More axes will be added when ideal amount is found
- All pulleys would need to be perfectly level to allow 100% planar tension along all axes

Concept 2 – Pros and Cons

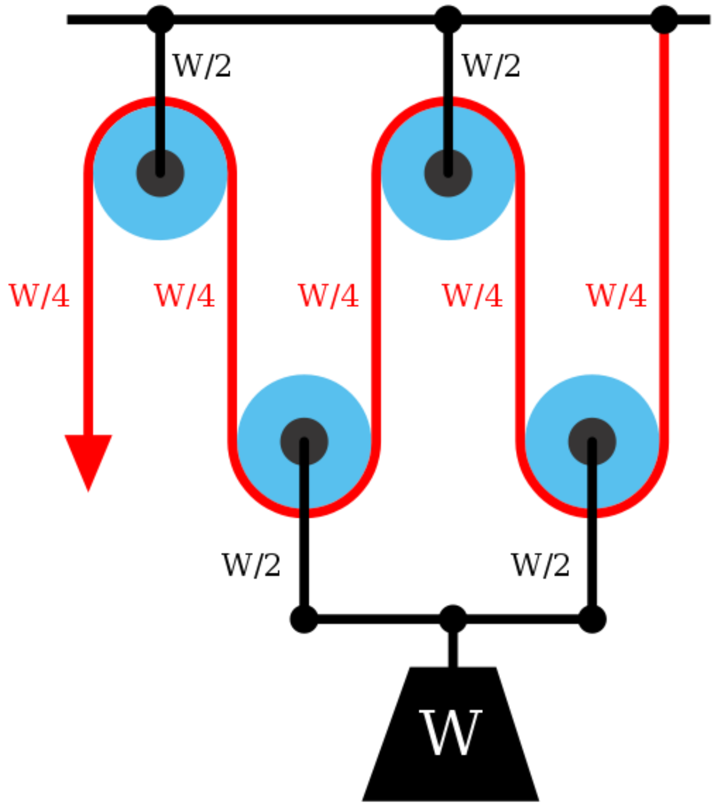
Pros

- Allows for variable strain due to opportunity for compound pulley system
- Pulley system can be mirrored along every axis

Cons

- Heavy duty pulleys are needed to support load required
- Strong wire is required so as to not allow any deformation in the straining process

Compound Pulleys



- Compound pulley system would vary strain rate and force applied as pulleys are added or removed from the system
- This may be of interest because it provides more data on the material

Concept 3 - Electro-Mechanical Test Machine

Unique Features

Actuators at each pull point

Load cells at each grip

Independent of MTS machine

Concept 3 – Pros and Cons

Pros

- Each actuator can pull at a different rate
- Stress directly measured at each pull point and is adjustable
- Strain at each point can be measured and adjusted
- Does not require integration to MTS machine

Cons

- Actuators and load cells are expensive
- Requires integration to microcontroller and software program
- More complex than purely mechanical system

Gripping Mechanism

- Bolts will be placed in holes to allow

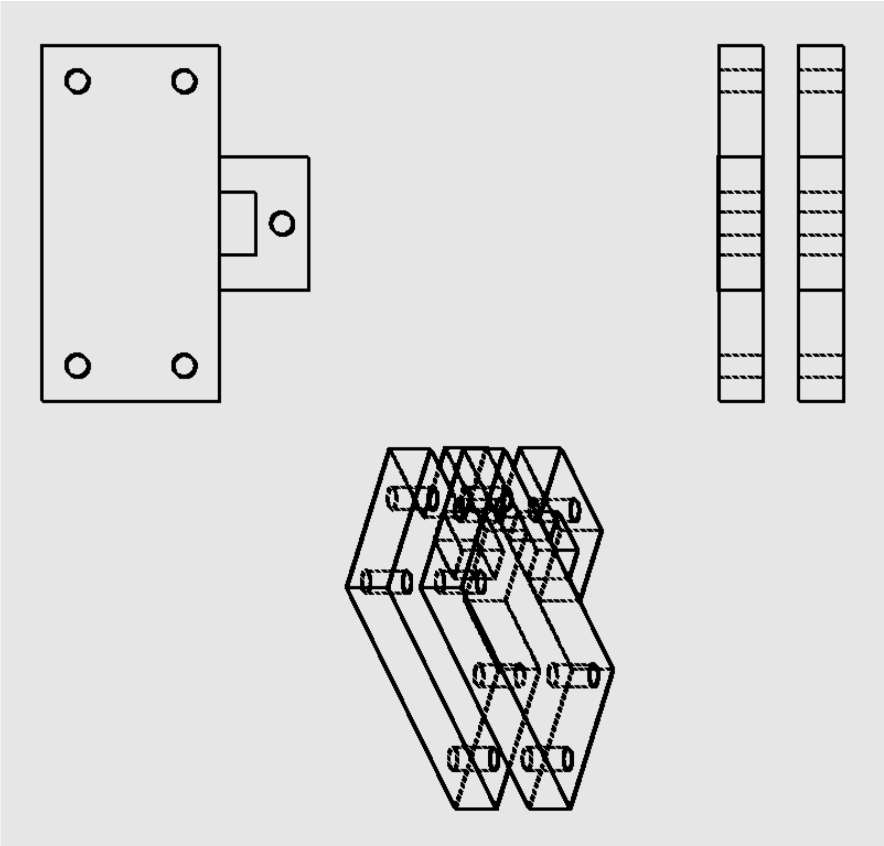
  plates to be tightened together

- Torque wrench will be used to assure

  the same tension on each bolt is equal

- The wire from the pulley will slip through

  the hole in the smaller protrusion



Future Steps

- Kinematic analysis of each design to verify the load that is applied to each axis.
- Verification of specimen design with a proof of concept test
- Develop decision matrix for all designs
- Provide dimension and load specifications for final design
- Continue uniaxial testing for remaining gasket samples

References

1. Day, J. and Miller, K. (July 2000), Equibiaxial Stretching of Elastomeric Sheets, An Analytical Verification of Experimental Technique. *Equibiaxial Stretching, Rev 2. 1-8.*
2. Dalrymple, T. Choi, J. and Miller, K.(Oct. 2007) Elastomer Rate-dependence: A Testing And Material Modeling Methodology. *172nd Technical Meeting of the Rubber Division of the American Chemical Society, Inc.*