Taylor-Couette System for Superimposed -shear Cavitation Experiments

College of Engineering – Department of Mechanical Engineering

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Purpose & Motivation of Research

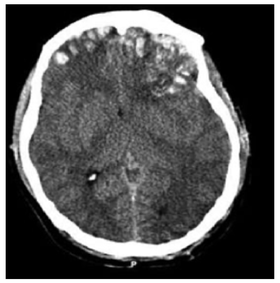

Figure 1. *CT scan of a traumatic brain injury (TBI).*

Laboratory Details

The Taylor-Couette systems were fitted, assembled, function-tested, and utilized for graduate research in Dr. Justin Wilkerson's Laboratory for Nonequilibrium Phenomena, located on Texas A&M University's main campus in College Station, Texas.

High-Level Summary

The newly developed superimposed shear cavitation experiment is applied to study soft material response under complex stress states. The experiment is developed based on research in Taylor-Couette flow and conventional needle-induced cavitation experiment.

Relevant Publications

Ji, **Karber**, Byrd, Wilkerson. (2022, October) Cavitation of Soft Tissue Surrogates Under Complex Stress States [Paper Presentation]. Society of Engineering Science, College Station, Texas, USA.

Lopez-Pamies, Oscar, et al. "Cavitation in Elastomeric Solids: II—Onset-of-Cavitation Surfaces for Neo-Hookean Materials." Journal of the Mechanics and Physics of Solids, vol. 59, no. 8, Jan. 2011, pp.1488–505.EBSCOhost, doi.org/10.1016/j.jmps.2011.04.016.

CT scan showing cerebral contusions, hemorrhage within the hemispheres and skull fractures (Rehman, 2008)

I. Need and Methodology

•Develop an experimental apparatus to validate a general theory of the onset of cavitation in any nonlinear elastic isotropic material under an arbitrary stress state.

•Through experiments on an ultra-soft triblock copolymer (PMMA-PnBA-PMMA), induce different stress states by controlling the rotation of the inner cylinder in a coaxial-cylinder (Taylor-Couette) system.

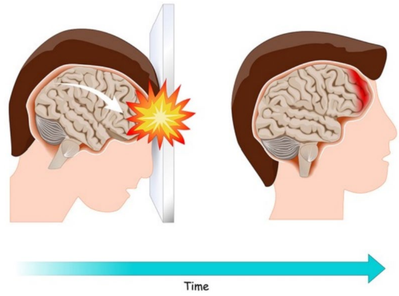

Figure 2. *Impact causing a traumatic brain injury (TBI).*

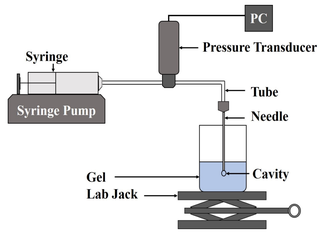

Figure 3. *Original experimental set-up.*

II. Final Design Concept and Assembly Modeling

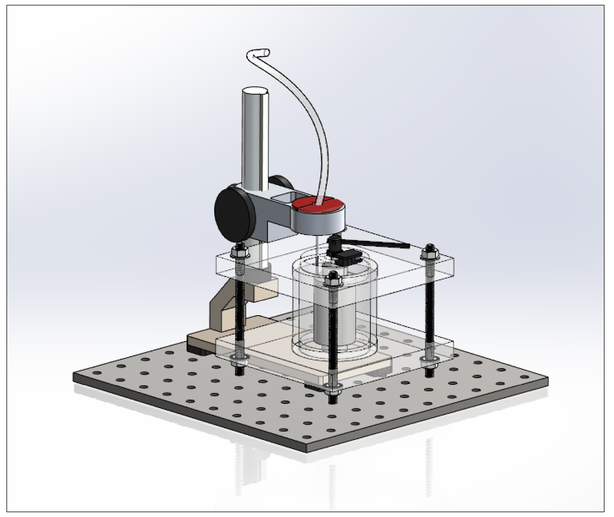

Figure 4. *Final design (V4) of the custom Taylor-Couette system.*

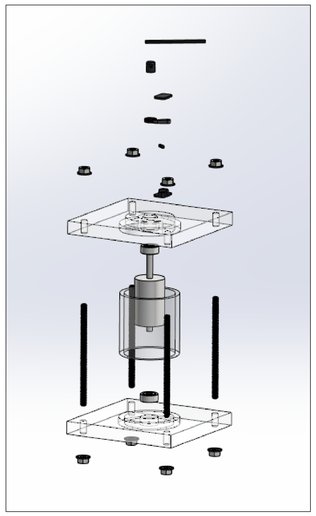

Figure 5. *Exploded assembly.*

III. Impact of New System

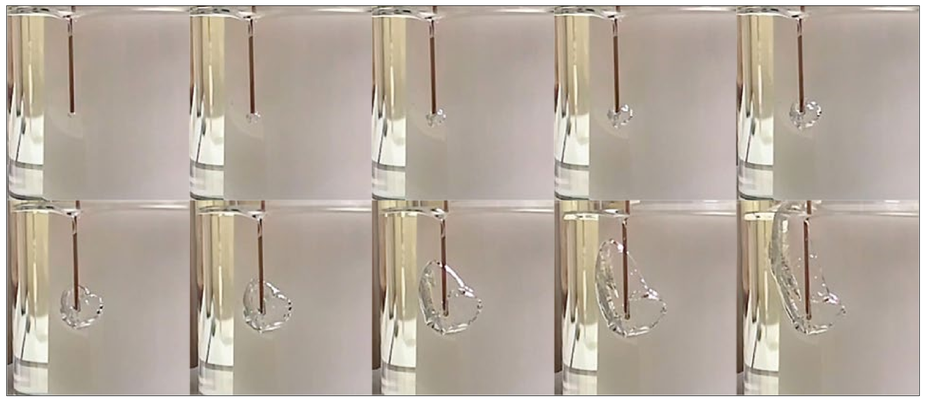

Figure 6. *Time-lapse of cavitation under a superimposed shear stress state (60° fixed rotation).*

- Low-profile angular locking mechanism allowed induced shear stress to be fixed throughout experiments.
- Single housing and locking gears accommodated multiple inner cylinders that allowed for a variable annular gap to control the induced shear stress state profile.
- Repeatable experiments for satisfactory data collection and analysis.

IV. Next Steps and Future Applications

- Significant value in the development of simple benchtop experiments to probe the non-linear, large deformation response of various materials under various types of high-rate loading.
- Further applications to understand other mechanical phenomena that contribute to TBIs and other soft tissue damage.

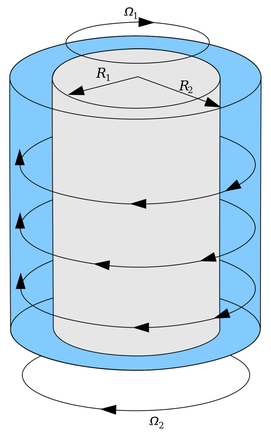

Figure 7. *Taylor-Couette Rotation*

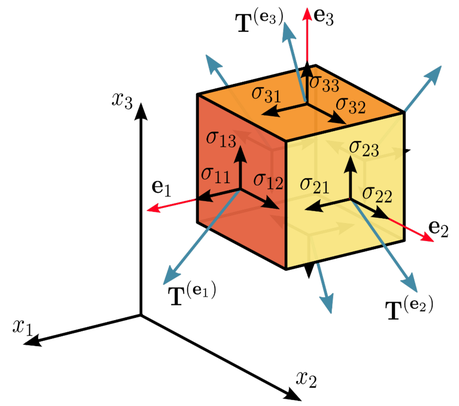

Figure 8. *3D Stress Tensor*

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