CALIFORNIA STATE SCIENCE FAIR
2008 PROJECT SUMMARY

Name(s)
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Project Number
J1222

Project Title
The Hysteresis Curve of a Compressible Fluid

Abstract

Objectives/Goals
Many things exhibit hysteresis curves: electromagnetic components, some mechanical systems (compliance), and elastomers. The goal is to experiment with compressible fluids and to find quantificable hysteresis curves. Using a newly designed apparatus, I sought to identify synthetic elastomer materials that were compressible and to measure the relationship between stress (force applied) and strain (displacement produced) when compressing a fluid (painter's putty). I hypothesize that the painter#s putty would be the only compressible fluid. Also, I assert that this material would have a double-J hysteresis curve.

Methods/Materials
To find the compressibility of the tested materials: drum putty, painter's putty, play dough, window caulk, an experimental apparatus was designed and constructed to compressed a fluid filled chamber using a screw mechanism. The force applied to the fluid was measured using a scale and the displacement is enhanced with the use of an optical amplifying device which works by turning the angle of a laser to project on a wall. I then compressed the fluid by turning the screws until they read the needed force (strain) on the scale and recorded the displacement (stress) on the projection. Each of 21 trials had 20 data points in increments of 5 kilograms from 0-50-0. The data was statistically analyzed using an EXEL program. The resultant data was used to construct the hysteresis curves.

Results
DAP Painter#s Putty ʻ53# was the only fluid found to be compressible. Also, it did had a significant, repeatable, hysteresis curve. While force was added, it compressed linearly much like Hooke's Law, but when the force was relaxed, a non-linear (second degree) curve was observed. While loading appeared to follow Hooke's Law unloading did not. The typical lead-lag relationship of a non-linear material was observed showing a significant dissipation of energy as "heat."

Conclusions/Discussion
The hypothesis was supported for a hysteresis curve under compression (a one-loop curve). The custom-made experimental apparatus performed well giving accurate and repeatable results. Given the results of the experimentation, a modification to the apparatus was designed to produce hysteresis curves under both compression and tension (the characteristic double-loop curve) with torsion controlled. The results clearly demonstrate an important physical property of elastomers undergoing stress.

Summary Statement
Hysteresis curves of elastomers were experimentally produced and analyzed.

Help Received
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