CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)

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Project Number

S0102

Project Title

Persistent Holes in Non-Newtonian Fluids

Abstract

Objectives/Goals

The objective of this project is to induce persistent holes in non-Newtonian fluids and to understand the dynamics of fluid behavior under the application of shear force.

Methods/Materials

Experiments were performed by vertically shaking a variety of Newtonian and non-Newtonian fluids (shear-thickening and shear-thinning) in an acoustically driven vertical shaker. Air puffs were administered to the agitated fluid, and if holes were obtained, they were quantified.

Results

Persistent holes were not obtained in the Newtonian fluids; however, persistent holes were produced in the non-Newtonian fluids. They were found in both the shear-thickening and shear-thinning fluids, but appeared to be of different character and driven by different processes. The appearance of persistent holes in shear-thinning fluids extends the known published literature. Complex hole dynamics were observed in the shear-thickening fluids that were studied.

Conclusions/Discussion

The holes formed in the shear-thinning fluid appear to result from processes different from those which produce holes in shear-thickening fluids. The holes formed in the shear-thinning fluid appeared at lower frequencies, and they could be induced spontaneously. The graph of lifetime versus frequency reveals a threshold at which a hole can be determined to be persistent. However, the system dynamics are so complex that this threshold is highly variable for the holes observed. By viewing the video recordings of holes in shear-thickening fluids at an accelerated frame rate, it was observed that the diameters of the persistent holes oscillated slowly in time with small amplitude. Review of the video recordings of holes in shear-thinning fluids revealed a torodial wall structure in which fluid was observed to move more rapidly than in the surrounding regions. Faraday waves were observed to be present when persistent holes were induced in both shear-thickening and shear-thinning fluids. The results of these experiments agree with the known published literature, and the results for the shear-thinning fluids extend the known published literature. Areas for further investigation were identified, including the application of shear-thickening fluids to infantry-soldier body armor and design of antiterrorist patrol vehicles.

Summary Statement

Persistent holes can be induced and sustained in both shear-thickening and shear-thinning non-Newtonian fluids, and shear-thickening fluids have practical applications in personal and vehicular armor.

Help Received

Dr. John C. Howe and Dr. Charles Barker provided supportive mentoring. Also, they provided ongoing supervision to ensure that proper safety procedures were followed during experimentation. The tests were completed at Aurora Networks, Inc. in Santa Clara, California.