DROP FORMATION IN NON-NEWTONIAN JETS AT LOW REYNOLDS NUMBERS

Paul E. Sojka
Maurice J. Zucrow Laboratories
School of Mechanical Engineering
Purdue University
West Lafayette, IN 47907-2088

Wednesday, Oct. 11 at 4 PM

1402 Broughton Hall

ABSTRACT

The primary objective of this work is to develop accurate computational models to predict evolution of shear thinning liquid jets. A secondary objective is to investigate the formation of satellite drops, and to determine the conditions under which their diameter can be controlled.

A Galerkin-finite element analysis is used solve the complete two-dimensional set of axisymmetric governing equations along with the kinematic and dynamic boundary conditions at the free surface. The effect of shear thinning behavior on break-up is studied for the case of an infinitely long non-Newtonian jet. It is found that the shear thinning behavior may be useful in controlling satellite drop sizes. (For instance, we observe that increasing the shear thinning behavior at moderate Reynolds number leads to an initial increase in satellite drop size, followed by a subsequent decrease.) Experimental validation for the theory is presented for the case of a shear thinning non-Newtonian jet. The experimental fluid is forced through a capillary and drop shapes are obtained using a high speed camera. The experimentally obtained shapes are compared to those predicted by theory with results found to be in good agreement.

Bio-sketch for Paul E. Sojka

Paul E. Sojka has studied a variety of spray and particulate transport related topics with applications ranging from droplet formation using multi-phase fluids (detergents, paints, and coal-water slurries) through rheologically complex single-phase fluids (bio-sprays including consumer products and pharmaceutical/medicinals), and on to Newtonian liquids (fuels). Research by Prof. Sojka and his students has showed the importance of efficient atomizing air utilization when forming small drops from rheologically complex fluids, the requirement of swirl to generate the two-dimensional disturbances that lead to axisymmetric sheet breakup, and the advantages of controlling ligament diameter during the initial stages of spray formation when attempting to form sprays having narrow drop size distributions. Dr. Sojka and his students have also developed diagnostic techniques for measuring mean drop sizes in media with time dependent indices of refraction, for determining particulate jet patternation, and for capturing three dimensional particulate jet structure (particularly the near-nozzle phenomena necessary to develop engineering guidelines for atomizer design). These advances have been incorporated into commercial instruments, or have served as the basis for them. Additional contributions by Prof. Sojka and his students include an understanding of particulate jet entrainment, and the importance of its unsteadiness when estimating entrainment. Most recently, he is the co-developer of the discrete probability function (DPF) approach for predicting spray drop size distributions. His work continues to be a mix of analytical, theoretical, and experimental, with contributions to both fundamental and applied problems.

Dr. Sojka has been awarded over 40 spray related research grants and contracts during the past 23 years. Over 30 of those have been from industry. These grants have resulted in over 30 spray related graduate student theses with another 4 graduate students being supported at this time. Of the students graduated, 17 are in industry and 2 are continuing their education. Finally, more than 30 undergraduate students have performed independent study work on related topics.

Prof. Sojka has also been active in developing and maintaining ties with industry. He has designed atomizers for 14 companies, and consulted with an additional 7 on spray- and particulate-related matters. Dr. Sojka developed an Atomization and Sprays Short Course that has been presented to ten industries, including those manufacturing gas turbine fuel injectors, Diesel engine fuel injectors, consumer products, food products, pharmaceutical/medicinals, paint sprays, agricultural fertilizers and pesticides, petrochemicals, and combustion systems. He also developed and teaches a graduate course at Purdue entitled “Spray Applications and Theory,” and is now devising a short course on the spray aspects of pharmaceutical tablet pan coating.

Education:
B.S., 1976, Physics, Michigan State University
M.S., 1978, Mechanical Engineering, Michigan State University
Ph.D., 1983, Mechanical Engineering, Michigan State University

Employment:
August 1999 to present: Professor of Mechanical Engineering, Purdue University
August 1997 to July 1998: Adjunct Associate Professor of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign
August 1989 to July 1999: Associate Professor of Mechanical Engineering, Purdue University
January 1983 to August 1989: Assistant Professor of Mechanical Engineering, Purdue University