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Annual Report

Period Covered: August 15, 1998 – August 15, 1999

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Reducing Energy Costs in District Heating Systems

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EXECUTIVE SUMMARY

The major goals of this project are to enhance the research capabilities (personnel, equipment, etc.) at the Czech Technical University (CTU) and the Czech Academy of Science Institute of Hydrodynamics (IH) in several areas related to turbulent friction reducing flows; develop appropriate surfactant additives for use as friction reducers in district heating systems, obtain fundamental data on the rheological, turbulent flow and heat transfer characteristics of effective surfactant drag reducing additives; and carry out field tests in one or more district heating systems in or near Prague.

Toward these ends, the following were accomplished in the 1998-99 year.

- Work on enhancing heat transfer by temporary degradation of surfactant microstructure at the entrance of the heat exchanger was continued. Different degrading designs at the entrance as well as spirals inside or outside the tube in the exchanger were studied. The recovery times of the surfactant microstructures were measured.
- Drs. Myska and Chara are doing turbulence measurements in their test loop in the Institute of hydrodynamics on a new surfactant additive developed by Akzo Nobel for commercial use in district heating systems. This same additive is being used in the heat transfer studies described in the previous paragraph.
- Dr. Zdenek Chara of the Institute of Hydrodynamics (one of our colleagues) and Professor Jaroslav Pollert of the Czech Technical University (Co-PI) are the co-Organizers of the 11th European Drag Reduction Working Meeting, September 15-17, 1999, to be held in Prague. Prof. Zakin has assisted in contacting U.S. and Asian investigators. Sixty papers have been submitted for presentation, an unexpectedly large response. This meeting will be a good venue to present our collaborative research results obtained at the Institute of hydrodynamics, at the Czech Technical University and at Ohio State. Prof. Zakin will be one of the two Keynote Speakers.

SECTION I

A & B. Research Objectives and Research Accomplishments

In addition to the objectives listed in the Executive Summary, studies of the rheological behavior of surfactant systems using a variety of rheological techniques continued in order to establish correlations between drag reduction effectiveness and one or more rheological property. This would provide a rapid and convenient rheological measurement for screening new drag reducing additives. It also complements our cryo-TEM imaging studies designed to relate surfactant microstructure to drag reducing effectiveness.

Two papers were published in major archival journals. They are:

- Zakin, J.L., B. Lu and H.-W. Bewersdorff, "Surfactant Drag Reduction," *Reviews in Chemical Engineering*, 14, 253-320 (1998) – an invited review paper based in great part on research done under AID Project 12.074E.
- Lu, B., Y. Zheng, H.T. Davis, L.E. Scriven, Y. Talmon and J.L. Zakin, "Effect of Variations in Counterion to Surfactant Ratio on Rheology and Microstructures of Drag Reducing Cationic Surfactant Systems," *Rheol. Acta*, 37, 528-548 (1998).

In addition, Prof. Zakin presented a paper, "Similarities and Differences in Drag Reduction Behavior of High Polymer and Surfactant Solutions" at the Fifth European Rheology Conference in Portoroz, Slovenia, September 6-11, 1998. An extended abstract was published in the Proceedings.

C. Scientific Impact of Collaboration

Dr. Myska and coworkers at the Institute of Hydrodynamics at the Czech Academy of Sciences have observed a new limiting drag reduction asymptote in their recent experiments—lying below that previously reported by Zakin, Myska and Chara. It is possible that further experimental studies will demonstrate even more efficient drag reduction.

D. Project Impact

As a result of the results reported above, Dr. Zakin was invited to present a seminar on this work at the University of Michoaca in Mexico in March 1999 and at the Casali Institute of Applied Chemistry of the Hebrew University also in March 1999.

E. Strengthening of Developing Country Institutions

Drs. Myska and Chara are continuing their turbulence measurements on drag reducing surfactant solutions under a Czech Government Grant. The same surfactant system (from Akzo Nobel in Sweden) is being characterized at Ohio State as part of our effort to relate surfactant chemical structure, micellar microstructure and rheological behavior to drag reduction effectiveness. Prof. Pollert and his students are still making frequent use of FLUENT, a fluid dynamics program purchased earlier under this grant.

F. Future Work

Collaborative work with the Institute of Hydrodynamics and Akzo Nobel to evaluate their surfactant additive (zwitterionic/anionic surfactant combination) which is more environmentally benign than the cationic surfactants studied heretofore is continuing.

As noted in earlier reports, one of the drawbacks to use of drag reducing additives in district heating systems is the reduction of heat transfer coefficients. We have completed preliminary studies of this very important problem using a heat transfer test section as part of a flow loop. Our initial results suggest that the best design to temporarily destroy the surfactant microstructure and enhance heat transfer by the resultant water-like solution is to utilize an inside fluted tube design. This design enhances Newtonian fluid heat transfer coefficients as well as drag reducing fluids. We are also studying recovery times as a function of surfactant nature and concentration and design of the flow resistor in order to find combinations where enhanced heat transfer behavior will be observed in the heat exchanger and recovery and normal drag reduction behavior will occur soon after the fluid leaves the exchanger.

The 11th Annual European Working Party on Drag Reduction Meeting will be held in Prague September 15-17, 1999. Dr. Pollert is the overall Chair and Dr. Chara is the Program and Local Arrangements Chair. Prof. Zakin has been assisting them in soliciting contributions and participants from the U.S., Japan, Korea and the Middle East as well as Europe. Prof. Zakin will be the Keynote Speaker on active (additives) drag reduction. Dr. Myska will be a coauthor of the paper. Another portion of the meeting will be devoted to passive drag reduction.

SECTION II

A. Managerial Issues

Productivity continues at a high level.

B. Budget

A budget was submitted in our request for a no-cost-extension listing the proposed expenses for the 1998-99 budget year extending to December 31, 1999.

C. Special Concerns

None.

D. Collaboration

Communication with Dr. Pollert by E-mail has been very efficient and quick. Likewise, FAX and mail communications with Dr. Myska have been frequent and the Institute of Hydrodynamics came on-line with E-mail a few months ago. Joint papers have been written with both groups and discussions of research plans, results and their analyses have been carried out without serious difficulty.

In 1998-99, two papers were published in major archival journals:

- Zakin, J.L., B. Lu and H.-W. Bewersdorff, "Surfactant Drag Reduction," *Reviews in Chemical Engineering*, 14, 253-320 (1998) – an invited review paper based in great part on research done under AID Project 12.074E.
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E. Request for A.I.D. Action

None.