

**TULSA UNIVERSITY FLUID FLOW PROJECTS**

**NEWSLETTER**

**August, 1985**

THE UNIVERSITY OF CHICAGO

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1911

## ADVISORY BOARD MEETING

The Fall, 1985 TUFFP Advisory Board meeting will again be held at the Tulsa Excelsior Hotel on Wednesday, November 13, 1985. The meeting will begin at 8:30 a.m. and adjourn at 4:30 p.m. A pre-meeting cocktail party will be held at the Excelsior Hotel from 5:00 - 7:00 p.m. on Tuesday, November 12, 1985. Members wishing to tour TUFFP test facilities are urged to do so Tuesday afternoon from 3:00 - 4:30 p.m.

The above meeting date was selected to accommodate those member companies that will also attend Advisory Board meetings for other cooperative research programs at Tulsa University during the same week.

TURRP - November 11, 1985

TUDRP - November 12, 1985

TUALP - November 14, 1985

TUCFP - is not having an Advisory Board meeting but their laboratories will be open and visits can be arranged by contacting the Director, John Hendrickson.

The University of Tulsa Erosion/Corrosion Research Center Advisory Board meeting will also be held November 12, 1985.

An Advisory Board meeting brochure will be mailed to all members prior to the meeting. It will contain sufficient information to prepare each attendee for active participation in discussions on current and future research projects, financial matters, and operating procedures.

A REQUEST FOR INFORMATION form will be mailed to all members on September 25, 1985 to determine attendance at the meeting. The form will be accompanied by information pertaining to Excelsior Hotel reservations, accommodations, and limousine service to and from the airport.

## STATUS OF RESEARCH PROJECTS

### Horizontal Slug Flow Modeling and Metering (Kouba)

Most of the summer has been spent preparing computer programs, calibrating instruments and modifying the dynamic calibration system for the capacitance sensors. One unexpected problem was the greater sensitivity of the capacitance sensors to temperature than previous work had indicated. This is believed to be caused by the change in the dielectric constant of the pipe wall with temperature. The response of the capacitance sensors as a function of flowing temperature has now been documented for both single-phase kerosene and air. The dynamic calibration of the capacitance sensors in slug flow has proved to be a much more difficult task than expected. A calibration system is now in place and the most recent runs look very encouraging.

As part of an independent study project, Mr. Guohua Zheng has taken many photographs showing in various detail the inner structure of the mixing region at the front of the slug. These pictures were taken during preliminary data runs and are presently being studied and compared with the output of the capacitance sensors in an effort to learn more about the mixing region of the slugs.

Testing was halted in mid August for approximately two weeks due to compressor motor failure. The dynamic calibration and slug flow data acquisition has now resumed and should be completed within two months.

#### Two Phase Flow Splitting in a Reduced Horizontal Pipe Tee (Shoham)

Efforts are underway to extend the model developed for the regular tee to the reduced tee configuration. The extension includes the following physical characteristics of the flow splitting in a reduced tee: shorter passage time; smaller area for flow (in the branch arm); and, gravity forces. These factors tend to reduce the liquid flow into the branch arm. Preliminary results show the right trend of reducing branch liquid fraction intake, but the agreement with the experimental data is not satisfactory. More work is needed to refine the model and improve its predictions.

After compiling all questionnaire results, a decision will be made on possible future extension of this project to non horizontal tees and to slug flow conditions.

#### Two-Phase Flow in a Vertical Annulus (Caetano)

Since the last Advisory Board meeting, work has been conducted on:

1. writing a draft of the dissertation;
2. enhancement of the two-film annular flow model. After conducting a literature survey, it was decided to use radiation theory to predict the splitting of the liquid flow in the two films. The predictions of the modified model agree better with the experimental results than the ones given by the original model;
3. analysis of the Taylor bubble rise velocity phenomenon in annular configurations. It has been found, theoretically and experimentally, that these bubbles rise faster in annular configurations than in circular pipes.

In early July, PETROBRAS extended support for Mr. Caetano until December, 1985. This will ensure completion of the report on this topic. If time permits, an attempt will also be made to develop a model for the prediction of friction factors for turbulent single-phase flow in annular configurations.

### Modeling Transient Two-Phase Slug Flow (Sharma)

At the May, 1985 Advisory Board meeting it was stated that the mathematical and numerical models to study transient two-phase slug flow were completed. Work had begun on applying the simulator to study the effects of transients induced by changes in the flow rates of the two fluids. Since then, several cases have been formulated to study the following:

1. effect of time step size and spatial increment on the simulated results, i.e. a sensitivity analysis;
2. effect of time to induce the flow rate changes;
3. effects caused by transients induced by flow rate changes (a total of six combinations of flow rate changes have been considered); and,
4. effect of pipeline inclination.

Most simulation runs have been completed. Results have been analyzed and writing of the dissertation is nearing completion.

### Dynamic Simulation of Slug Catcher Behavior (Genceli)

The final report on this project will go to the printer within two weeks.

### Flow of Oil-Water Mixtures

#### in Horizontal Pipes (Martinez and Arirachakaran)

Construction of the experimental facility has been completed. The following problems related to its operation have been identified and solved:

1. instruments and components of the temperature control system required adjustment;
2. excessive pressure pulsations in the flow loop called for the installation of an accumulator in the line;
3. undesired fluctuations on the pressure recording instruments were eliminated by means of capacitors installed on the analog signal wires. In addition, electrical grounding of the instrumentation was performed; and,
4. the flow loop was insulated to improve temperature control.

The validity of the experimental facility, data acquisition system and procedures was tested running the system with water. Data collected for water friction factors agree very well with the "Moody" friction factor chart. Also, the absolute pipe wall roughness was determined.

Experimental runs with single-phase oil are now under way for these conditions:

1. temperature range: 60-90°F
2. flow rates: 50-300 lb<sub>m</sub>/min

The calculated viscosities for these runs agree very well with viscosities measured with Cannon Fenske viscometers.

Future work will include water-oil runs with different water fractions to determine apparent viscosities.

Simultaneously, Arirachakaran is conducting a literature search on emulsion theory. This should result in a more thorough understanding of emulsion behavior and characteristics, and enable the investigator to identify the governing physical parameters and their varying degrees of importance, especially in pipe flow. One major area of emulsion characteristics which is highlighted in the literature search is drop size and drop size distribution of oil-water emulsions. Both physical mechanisms and measurement techniques are being investigated in detail.

#### Prudhoe Bay Data Base System and Slug Length Correlation (Scott)

Two-phase flow data from Prudhoe Bay can be classified into three groups:

1. 16 and 24 inch PDP11 tests;
2. high pressure Modcomp tests; and
3. low pressure Modcomp tests.

Group 1 and a portion of group 3 have been converted to a new data base format. The group 2 data and some of the group 3 data are available only in their raw data form. Processed data must be obtained from a Prudhoe Bay Unit member company or the raw data must be reprocessed into engineering units by TUFFP. The status of a request for release of Prudhoe Bay data to TUFFP is covered in another section of this Newsletter.

A program has been written to access interactively the data base and extract any desired portion to a users file. A set of subroutines has also been written to give the user a port into the data base from an applications program. The new data base format has been found to be three times more efficient in terms of storage and speed than the original format.

Programs have also been written to identify slug to bubble and bubble to slug transitions and plot the device response. A program to calculate slug lengths by matching slugs at different densitometers has been written. A program is currently being

refined to automatically process data from all densitometers operating during a test and calculate slug lengths.

There appears to be a large amount of data in slug flow that can be effectively used to develop an improved slug length correlation. Current plans call for preparing a report on the data and revised slug length correlation. Procedures to share released data with TUFFP members are being formulated.

#### EQUIPMENT AND FACILITIES

The replacement Worthington compressor has not yet been received. The vendor has been asked to accelerate repairs and delivery of the compressor or repay TUFFP for providing the Chicago-Pneumatic compressor as a trade item which the vendor has already sold.

The Harris 800 computer continues to operate extremely well and provides unprecedented computing capabilities for TUFFP graduate students and staff. The entire computing system has been on a maintenance agreement for the past year. Selected peripheral equipment will be removed from the maintenance agreement to reduce maintenance costs for the next year. Since the last Advisory Board meeting several offices have been recabled to the Harris 800. Several remote CRT terminals have been connected successfully to the Harris computer using synchronous line drivers. Both IBM AT microcomputers have also been interfaced with the Harris. A new patch panel is in the process of being built to enhance distribution of ports to various users. Four ports to the Harris 800 have been allocated via multiplexer to the Petroleum Engineering Department on the main campus. In return, the Petroleum Engineering Department has paid approximately 20% of the maintenance agreement. Attempts to sell the previous Harris /7 computer have been unsuccessful.

Remodeling of the TUFFP library, Director's office, and Administrative Assistant's office is nearing completion. The Director and Administrative Assistant moved back to the North Campus during August, 1985. The graduate student who was doing the remodeling work has chosen to seek full time employment and further remodeling will be delayed until 1986.

Paving of a new parking lot and access roads for the North Campus is now complete. A 10 ft high wood fence has been installed along the remaining portion of the North side of the property. Fencing of the South side has been delayed pending a decision on who will finance this item.

A small building to house a security guard has been constructed along the entrance road to the North Campus. This will enhance security during non-working hours.

Bearing problems in the electric motor which powers the Joy compressor necessitated a complete overhaul of the motor during mid August. The new motor has a higher horsepower rating and a different type of bearings which should improve future compressor performance.

#### PERSONNEL

Several changes will occur in graduate students in TUFFP during the remainder of 1985. Mr. Goyon has decided not to continue his graduate program at the Ph.D. level. Mr. Arirachakaran has now been awarded a full Assistantship funded by TUFFP. Mr. L. Tianlu severed his relationship with TUFFP since funds were not available to award him a partial TUFFP Research Assistantship. Mr. G. Zheng currently assists Gene Kouba and will receive a partial Research Assistantship beginning January 1, 1986. Mr. Stuart Scott has made a decision to pursue a Ph.D. degree in Petroleum Engineering on a TUFFP research project. TUFFP will provide him a partial Research Assistantship during his graduate program. Since he already has an M.S. degree in Computer Science, a decision was made that he not be required to complete an M.S. degree in Petroleum Engineering. Mr. R. Bhatia from India, who has an M.S. degree in Chemical Engineering from the Asia Institute of Technology, will begin his graduate program in September, 1985. TUFFP will not support him during the first two semesters while he removes undergraduate deficiencies. Pending satisfactory performance during the next two semesters, he will be awarded a TUFFP Research Assistantship for the remainder of his Ph.D. program. Final decisions on research projects for Mr. Scott, Mr. Zheng, and Mr. Bhatia will not be made until after tabulating results of the 1985 Questionnaire and the November Advisory Board meeting.

Outstanding Distinguished Lecturer Graduate Seminars were presented by Dr. T. Hanratty on April 11, 1985 and Dr. W. Paul Jepson on August 2, 1985. In addition to lecturing, they provided significant contributions to enhance research projects for selected graduate students. Lectures planned for the Fall semester include Dr. Lee Norris on September 13, 1985 and Dr. Khalid Aziz on October 11, 1985. Dr. Yehuda Taitel provided a week of valuable consulting with various graduate students during late August and early September, 1985.

During the summer, Eric Nielsen and Stephen Wilcox performed excellent work assisting with construction, operation and maintenance of TUFFP test facilities. They have been asked to continue on a part time basis during the school year. Tami Brill completed preparation of a TUFFP magnetic tape library and a key word search program for the Harris computer to assist students in utilizing the TUFFP library.



## MEMBERSHIP

No new TUFFP members have been obtained since the May Advisory Board meeting. Notification of intent to cancel membership has now been received from Conoco, Inc., Marathon Oil Co., and Panhandle Eastern Pipeline Co. Compagnie Francaise des Petroles has agreed to pay their 1985 membership fee, but has terminated membership for 1986. Discussions are underway with these companies in an attempt to reverse their decisions. Communications during the past few months with potential members indicate excellent possibilities for new 1986 members are Nippon Steel, Snamprogetti, Statoil, and BEB.

## FINANCIAL

Total expenditures are on schedule according to the revised budget submitted in the May Advisory Board meeting brochure. Supplies and expenses are somewhat higher than indicated but are offset by lower equipment expenditures.

Invoices for \$14,000 representing 1986 membership fees will be mailed to all members on October 14, 1985. Members are reminded that TUFFP must receive their intent to cancel 1986 membership prior to October 1, 1985. Payment of 1986 invoices at the earliest possible date would be appreciated to permit identifying delinquent members as soon as possible. Two companies have not yet paid their 1985 dues and two additional companies have paid only half of their dues. All have been contacted and payment is expected in the near future.

## MISCELLANEOUS

A response has now been received on the TUFFP request for release of two-phase flow data from large diameter flow lines in the Prudhoe Bay field of Alaska. ARCO, EXXON, and SOHIO, major owners representing the Prudhoe Bay unit, have agreed to release all raw data without finished reports and all data processed into engineering units that was funded jointly by the Prudhoe Bay unit co-owners. The status of the data and analysis is covered in a progress report in this newsletter. No response has been received yet on a request for release of pressure and temperature data for wells in the Prudhoe Bay field and the Kuparuk field of Alaska.

The TUFFP short course in Tulsa will be held May 19-24, 1986 at the Westin Hotel rather than the Tulsa Excelsior Hotel. The Excelsior Hotel was not available during this week. In addition, the TUFFP London course has been scheduled June 23-27, 1986 at the Strand Palace Hotel. A brochure describing the course and all related details should be ready for distribution in November, 1985.

Once again, TUFFP members did not support the short course in May, 1985 as well as they had in years prior to 1984. As a result, a loss of \$4,187 was incurred. This was partially offset by a profit of \$1,323 from the March, 1985 TUFFP course in London.

Although many companies have now signed the new Letter of Agreement, several companies have requested changes in the Letter. After all of the comments have been received, a decision will be made on how to address the recommended changes. One possibility would be to distribute amendments that satisfy all recommended changes.

By late 1985, an updated magnetic tape will be distributed to all TUFFP members requesting the tape in the Questionnaire. In addition to previous files, the magnetic tape will also contain files pertaining to the research projects by Goyon, Genceli, Dutta-Roy, and Sharma. By early 1986, it might be possible to distribute a series of magnetic tapes containing released Prudhoe Bay data and data analysis programs to members.

#### QUESTIONNAIRE RESULTS

Completed questionnaires have now been received from 18 members. The following summarizes questionnaire results received to date. An updated summary will be included in the November Advisory Board meeting brochure.

1. The following table lists titles of current and possible future TUFFP research projects. Please check the appropriate boxes that represent your company's level of interest in each project.

		LEVEL OF INTEREST			
		very high	high	medium	low
1.	Oil-Water Emulsion Flow	6	6	4	1
2.	Oil-Water Core Flow	4	2	3	7
3.	Flow in Inclined Annulus	0	3	5	8
4.	Slug Flow Modeling/Metering	3	9	5	1
5.	Two-Phase Splitting at Tee	3	8	6	1
6.	Transient Two-Phase Flow	6	6	4	2
7.	Flow Through Adjustable Chokes	4	1	8	3
8.	Slug Catcher Behavior	9	4	4	1
9.	Flow Through Hilly Terrain Pipelines	10	3	2	3
10.	Prudhoe Bay Data Processing and Analysis	7	5	5	0
11.	Two-Phase Metering	2	8	4	3
12.	Stability of Severe Slugging in Pipeline-Riser Pipe Systems	8	8	2	0
13.	Well Data BANK Expansion, Evaluation of $\Delta p$ Correlations for Wells, Development of $\Delta p$ Model	5	5	5	2

2. a) Should the European TUFFP short course be continued?

11      3  
yes      no

- b) If yes, where? 10      Aberdeen (1)  
London      Other

- c) If yes, when? 7      0      2  
June      July      August

d) If yes, how often?      8      3  
                                 Annually      Bi-Annually

3. TUFFP will soon add files to the magnetic tape that is distributed to TUFFP members upon request.

Do you want a magnetic tape that contains the above files?

16      1  
                                 yes      no

4. What changes do you suggest in TUFFP operating procedures?

a) Quarterly Newsletters:

-Continue with August and February letters 15

-Discontinue Newsletters 1

-Replace May Advisory Board meeting with a Newsletter 1

b) Advisory Board meetings

-Facility Tours      16      0  
                                 continue      discontinue

-Cocktail Party      14      1  
                                 continue      discontinue

-Invite Students to Cocktail Party 10      2

5. a) Should TUFFP computer programs be better documented and made "user friendly"? 13      3  
                                 yes      no

b) Should TUFFP computer programs be made available on floppy disks for use on personal computers or work-stations? 9      6  
                                 yes      no

6. If TUFFP membership suffers significant decline in future years, what approach would your company recommend?

- Increase membership fee 5

- Reduce research level 7

- Seek government cofunding 5

- Variable membership fee based on interest in specific projects 1