

TULSA UNIVERSITY FLUID FLOW PROJECTS

NEWSLETTER

February, 1987

ADVISORY BOARD MEETING

The Spring, 1987 TUFFP Advisory Board meeting will be held at the Sheraton-Kensington Hotel in Tulsa, Oklahoma on Wednesday, May 13, 1987. 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 Kensington Hotel from 5:00 - 7:00 p.m. on Tuesday, May 12, 1987. Tours of TUFFP test facilities will be held Tuesday afternoon from 3:00 - 4:30 p.m.

The above meeting date was selected to accommodate those member companies who will also attend Advisory Board meetings of other cooperative research programs at Tulsa University during the same week. Following is a summary of these meetings.

<u>Program</u>	<u>Meeting Date</u>
Erosion/Corrosion Research Center	May 11, 1987
Drilling Research Projects	May 12, 1987
Fluid Flow Projects	May 13, 1987
Artificial Lift Projects	May 14, 1987
Corrosion Fatigue Projects <u>tentative</u>	May 14, 1987

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 brochure containing slide copy for all presentations will be distributed at the meeting.

A REQUEST FOR INFORMATION form will be mailed to all members on March 23, 1987 to determine attendance at the meeting. The form will be accompanied by information pertaining to the Sheraton-Kensington Hotel reservations, accommodations, and transportation service to and from the airport.

STATUS OF RESEARCH PROJECTS

Prudhoe Bay Large Diameter

Slug Flow Experiments and Data Base System (Scott)

Installation of the Apollo computer system has delayed completion of this report and generation of the appropriate magnetic tapes. We now anticipate being able to begin distributing a report consisting of the User's Manual and data base in March, 1987.

Dynamics of Slug Flow in Pipelines (Scott)

Three technical papers or reports based on this study have already been completed. These include:

- 1.) "Prudhoe Bay Large Diameter Slug Flow Experiments and Data Base System" described above;
- 2.) "Prediction of Slug Length in Horizontal Large Diameter Pipes" presented at SPE 56th Annual California Regional Meeting, April 1986; and,
- 3.) "Modeling Slug Growth in Large Diameter Pipes" prepared for BHRA Third International Conference on Multiphase Flow, The Hague, May 1987.

Introductory sections of the Ph.D. dissertation on this topic have now been completed. Work proceeds on incorporating the above three papers or reports into the dissertation.

BHRA has completed a preliminary study on slug flow using their new large diameter horizontal pipeline test facility. They have agreed to share some of their data with TUFFP and these data will be used to confirm and possibly modify the slug growth model developed from Prudhoe Bay data.

System 86 (Corcoran, Kung, McCreery)

MULTI (Corcoran)

A review of the technical documentation for the Apollo workstations has been completed in order to facilitate development of a prototype for the MULTI system user interface. Extensive discussions have been held regarding the feasibility of using the GMR, GPR, and CORE graphics libraries for use in the proposed system. The GMR and GPR libraries offer speed but CORE is an ACM SIGGraph standard and therefore would offer portability. Apollos's Domain Software Engineering Environment (DSEE) has been examined and will prove to be extremely valuable in future TUFFP software development. Extensive reviews have been conducted on system level programming for the Apollo to permit future development of MULTI.

CORE (Kung)

Restructuring and documentation of the PVT and GRAD sub-routine collections have been completed. The changeover of computer systems from the Harris 800 to the Apollo has made this job more complicated and required familiarization with the Apollo system. Documentation for CORE was moved to the MacIntosh Plus computer in order to fully utilize the laser writer. The manual for PVT and GRAD has been revised several times and more accurate

values have been given for the internal error checking variables such as IERR. If the input data have unreasonable values, then the variable IERR is set to 1, and routines are exited without performing any calculations. IERR is set to 2 if the input data have reasonable values but are out-of-bounds for the correlation. In this case the calculation is performed but an error message is printed. The CORE manual is complete except for the TUPLOT sub-routines required by FLOPAT.

TUPLOT (McCrery)

A software package called Cricket graph is being analyzed to see if it can perform the functions required of TUPLOT. Cricket graph is an attractive alternative because it can output to both the laser writer and HP plotter. If Cricket graph performs well, the TUPLOT project may be reduced in scope for use in FLOPAT and as a software package for the Apollo computer system.

Miscellaneous

An evaluation has been performed of the Microsoft Fortran compiler for the Apple MacIntosh, version 2.2, released in 1986. Since this is the only Fortran compiler available for the MacIntosh Plus, we were interested in how well it would execute common Petroleum Engineering type applications as proposed in System 86. In particular, we were impressed with the compiler, its unique interface and the debugger that permits the user to step through his program. Benchmarks were performed using a single phase 2-D reservoir simulation program comparing compile and run times using the following systems:

1. Microsoft Fortran on the MacIntosh Plus
2. Professional Fortran on the IBM PC AT
3. Fortran on the Apollo DN3000

Compilation time for the MacIntosh was comparable to that of the Apollo and much faster than for the AT. However, the run time was extremely slow on the MacIntosh. We found that the Microsoft Fortran, with its excellent debugger and fast compiler, was superior for program development but that the actual running of the finished application would be performed better on a different computer.

Two-Phase Slug Flow in Hilly Terrain Pipelines (Zheng and Bhatia)

Much has been accomplished on this project since the November Advisory Board meeting. The construction of the test facility is essentially complete. The outlet section has been modified by installing an additional 10 ft long horizontal section of clear PVC pipe. This was added in response to suggestions from members at the November Advisory Board meeting. Two capacitance sensors will be installed in this outlet section to monitor downstream slug characteristics. Also, three new towers

Page Four

were constructed to support the clear PVC pipe and the outlet section.

An extensive remodeling of the instrumentation trailer has been completed. The PC-AT data acquisition system has been reformatted and moved into the trailer. The compressor for operating pneumatic valves is now in place and functional.

The LabMaster data acquisition card has finally been received. Additional accessories from other vendors are expected to arrive soon. Meanwhile, some software revisions and development work have been completed. The temperature transducer has been received and installed. Enough pressure transducers were available and routine maintenance and calibration have begun on these. The fabrication of 13 capacitance void fraction sensors is in progress and should be complete by March 1, 1987.

Two new 2-in. V-port-like ball valves will be added in the liquid feed line, providing a more precise control over the liquid flow rate. A JVC VHS Camcorder has been purchased to permit videotaping flow behavior in the transparent test section.

Slug Flow Splitting Phenomena In Side-Arm and Impacting Tees (Arirachakaran)

The three vertical separators which were donated by C. E. Natco arrived in early January, 1987. They are in the process of being inspected and serviced. C. E. Invalco has been approached to provide all necessary liquid level and pressure controls.

A PC-AT compatible microcomputer, which was purchased for use in the graduate course on "Instrumentation and Microcomputer Based Data Acquisition" taught by Dr. Kouba last Fall, was selected as the computer for use in the data acquisition system for this project. The computer was tested throughout the graduate course and was confirmed to be fully compatible with the Isaac Data Acquisition System and its accompanying lab software. The quality and reliability of this computer was also found to be at least as good as the IBM PC-AT, and even better in some areas. Data acquisition routines are being examined and software development will soon be underway.

The previous two-phase flow splitting facility was completely dismantled in early February. Equipment for the new experimental test facility has been ordered. As soon as the equipment arrives, construction of the new test facility will begin and should continue until late April, 1987.

Since the fluids used in this study will be air and water, it will be necessary to modify the electronics circuit of the capacitance void fraction sensor. This will make it possible to

use the revised sensor for obtaining void fraction measurements in air-water systems. These modifications will be made as soon as the capacitance void fraction sensors being prepared for the "Two-Phase Slug Flow in Hilly Terrain Pipelines" project are complete. When the flow loop is fully constructed in late April, installation of the data acquisition system interface will begin.

"Instrumentation and Microcomputer Based Data Acquisition"
Graduate Course (Kouba)

This innovative graduate course was offered during the Fall Term, 1986 as a special topics subject in Petroleum Engineering. The intent was to prepare graduate students for experimental research. A description of the course, including the associated laboratory, was presented in the November, 1986 Advisory Board meeting brochure.

Due to the general nature of this course, it was populated by students from Chemical Engineering and Mechanical Engineering as well as from Petroleum Engineering. A survey of students taken near the end of the semester revealed a unanimous recommendation that the course be offered on a regular basis. The students recognized the contribution of this laboratory intensive class to their experimental research and to their overall educational experience. At present there are no plans to offer this course again. TUFFP underwrote much of the cost of the course, including donation of equipment and instrumentation. A request for reimbursement of a significant portion of the cost has been submitted to the Dean of the College of Engineering and Applied Sciences.

PERSONNEL STATUS

Dr. Yehuda Taitel has now officially agreed to spend his sabbatical leave from the University of Tel Aviv at The University of Tulsa during the Fall Term, 1987. He will teach an inter-disciplinary graduate course on two-phase flow modeling and will assist all current graduate students with modeling the flow phenomena pertaining to their research projects. He will also direct a new research project on stability criteria during severe slugging in pipeline-riser pipe systems.

Dr. Gene Kouba has agreed to extend his post-doctoral Research Associate position until June 1 and possibly throughout the Summer, 1987. This will permit him to provide consultation on instrumentation and data acquisition problems pertaining to the research projects on two-phase slug flow in hilly terrain pipelines and slug flow splitting phenomena in side-arm and impacting tees. In addition, he will assist with the design, construction, and checkout of the new facility planned for studying the stability criteria for severe slugging in pipeline-riser pipe systems.

Both Arthur Corcoran and Dana McCreery will be receiving their B.S. degrees in Computer Science in May, 1987. Discussions are underway with both students to pursue M.S. degrees in Computer Science at The University of Tulsa. If successful, we plan to supplement any support they receive from The University of Tulsa to permit them continuing their work on the System 86 project. If unsuccessful, attempts will be made to hire two additional undergraduate Computer Science students to continue this work.

Applications for Research Assistantships have been received from several potential M.S. and Ph.D. students. No commitments will be made until after it is determined if The University of Tulsa will permit a reduction in the portion of Director's and Associate Director's salaries which must be purchased by TUFFP. Reductions would offset the decline in membership income for 1987 and permit awarding at least one additional Research Assistantship. Negotiations are currently underway with Petrobras to send one or more graduate students to The University of Tulsa to receive M.S. or Ph.D. degrees with research being conducted through TUFFP.

Distinguished Lecturer Seminars will be given by four persons during the Spring Term, 1987. Mr. Trevor Hill, of the British Petroleum Research Center in Sunbury, England, will talk on February 13, 1987 on "Proposed Two-Phase Flow Tests at the Magnus Field in the North Sea". Professor Dan Hill, from The University of Texas at Austin, will talk on February 27, 1987 on "Multiphase Research at The University of Texas". Mr. Clayton Evans of Phillips Petroleum will present a seminar on March 13 on "Application of Apollo Workstations in the Petroleum Industry". Mr. Duncan Butlin of Centrilift Hughes will talk April 3 on "Systems Analysis Using Submersible Pumps".

EQUIPMENT AND FACILITIES

Nearly all of the Apollo computer equipment has now arrived and been installed. The PCI8 board, which will permit interfacing IBM PCs to the network, is the only missing item that has been ordered and now has a shipping date of February 13, 1987. A modem to permit dialup access to the network from remote locations has not yet been selected. Seminars on the Apollo continue to be taught and use of the workstations by all TUFFP personnel is expanding rapidly.

Construction of the new instrumentation building for the pipeline-riser pipe system is nearing completion. A decision was made to terminate use of Job Corps personnel due to lack of performance. A temporary employee was hired to complete the job.

An improved security system was initiated on the North Campus by extending a chain link fence and installing a gate across the access road from East Marshall. Entrance to the property during non-working hours is now restricted to authorized personnel with keys.

MEMBERSHIP

One new TUFFP member has been obtained since the November, 1986 Advisory Board meeting. Conoco, Inc. has decided to rejoin TUFFP after a one year lapse of membership. In addition, we were delighted to learn that Britoil has decided not to terminate its membership for 1987. Unfortunately, we also learned in early February that Elf Aquitaine wishes to terminate its membership for 1987. This brings our 1987 membership to 26 companies. Two additional members will be required to approximately meet our proposed 1987 budget.

FINANCIAL

One member has not yet paid its 1986 membership fee. A final partial payment from an additional member has apparently been lost in the mail. We have been assured by both companies that full payments will be sent in the very near future. Membership fees for 1987 have already been received from 16 members. It is assumed that payment from the remaining 10 members will be received in the near future.

The official TUFFP Reserve Fund balance as of December 31, 1986 is not yet available. We anticipate that this balance could be approximately \$30,000. Expenditures are on schedule for 1987 and will be monitored closely to prevent a deficit from occurring if income projections are not met.

MISCELLANEOUS

Enrollment in the May 4-8, 1987 TUFFP short course in Tulsa now stands at 5, including 3 from 3 member companies and 2 from non-member companies. Enrollment in the May 26-29, 1987 TUFFP/BHRA short course in London now stands at 1 non member. Members are urged to support these two short courses to prevent excessive financial losses that would contribute to a deficit for 1987 or require a reduction in research effort. The Tulsa short course has been scheduled the week preceding the Advisory Board meeting to accommodate members that might wish to attend the short course prior to the meeting. The London short course has been scheduled the week following the BHRA Third International Multiphase Flow Conference in The Hague to accommodate persons who might wish to remain in Europe following the BHRA conference to attend the TUFFP/BHRA short course.

Page Eight

Approximately 485 flowing pressure and temperature surveys for wells in the Prudhoe Bay field of Alaska have now been released by Arco Oil and Gas Company on behalf of the Prudhoe Bay Unit Co-owners. The wells in question have tubing IDs of 3.958 or 4.892 in. Efforts are underway to find a graduate student who does not require funding from TUFFP to add these data to the TUFFP Well Data Bank. The data bank could then be used to further evaluate existing correlations and to develop an improved flow pattern dependent mechanistic model for predicting flow behavior.

TUFFP has agreed to participate in a proposed multiphase flow conference to be held in October or November, 1987 in Stavanger, Norway. The conference would be sponsored by the Norwegian Petroleum Society. Additional details will be provided to TUFFP members when they become available.