

## *TUFFP Talk*

### **Centennial Symposium Plans Progressing Smoothly**

Plans for The University of Tulsa/SPE Centennial Petroleum Engineering Symposium to be held August 29 - 31, 1994, are nearing completion. Enclosed with this newsletter is the Preliminary Technical Program consisting of 48 outstanding technical papers selected from a "by invitation only" solicitation to ensure that leading authorities in the field would be authors for this prestigious celebration. Also included will be tours of The University of Tulsa campus and the state-of-the-art, large scale experimental test facilities in the various research consortia on the North Campus. A plenary session featuring visionary leaders from various sectors of the petroleum industry will address our technology needs over the next 25 years.

A significant effort is underway to beautify the North Campus in preparation for the tour. This will represent a rare opportunity for TUFFP members to view our test facilities at a time when they not only look great but when most are functioning at one time. A solicitation of funds from the domestic petroleum industry resulted in donations of more than \$60,000 to help underwrite the symposium, including the beautification of the North Campus. We are grateful to the many companies that contributed funds for this purpose.

We urge all TUFFP member companies to attend the Centennial Symposium and help us celebrate this significant event. On Tuesday, August 30, 1994, there will be a cocktail reception in the evening for alumni and friends of the university. President Robert Donaldson will make a brief presentation. Roy Koerner from Texaco, who is also SPE President Elect and a University of Tulsa alumnus, will be the keynote speaker at the Monday evening Symposium dinner.

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### **TUFFP Short Course - Another Big Success**

A very successful TUFFP short course on "Two-Phase Flow in Pipes" was presented May 9 - 13, 1994, in Tulsa. The course was attended by 21 engineers and scientists, including 16 from 11 TUFFP member companies and 5 from 4 non-member companies. A tentative date of May 8 - 12, 1995, has been established for the next TUFFP short course.

### **TUFFP Advisory Board Meeting Scheduled for September 2, 1994**

To ensure greater participation at the next TUFFP Advisory Board meeting, a decision was made to schedule the meeting in conjunction with the TU/SPE Petroleum Engineering Centennial Symposium. Accordingly, the next meeting will be held on Friday, September 2. The Tulsa University Artificial Lift Projects will hold their Advisory Board meeting on September 1. The meetings will be held again at the Doubletree Hotel at Warren Place in Tulsa, which is also the hotel for the symposium.

A "Request for Information" form is enclosed with this newsletter, together with information on hotel reservations and travel to and from the airport. Persons attending the Advisory Board meeting should complete the form and return it to us as soon as possible.

The September Advisory Board meeting will begin at 8:00 a.m. on September 2, and will adjourn at 4:30 p.m. A pre-meeting reception will be held on the 19th Floor of the adjacent Two Warren Place Building from 6:00 - 8:00 p.m. on Thursday, September 1. There will not be a tour of TUFFP test facilities the day before the Advisory Board meeting because of the tour being held on Monday morning, August 29, in conjunction with the Centennial Symposium.

TUFFP Advisory Board meeting brochures will be mailed to all members prior to the meeting. The brochures will contain sufficient information to help each attendee actively participate in discussions on current and future research projects, financial matters, and operating procedures. Brochures containing slide copy for all presentations will be distributed at the meeting but will not be mailed to members.

There will not be a TUFFP Advisory Board meeting in November, 1994. Rather, the meeting will be replaced with an additional newsletter. The next Advisory Board meeting will be held in May, 1995.

## TUFFP Financial Status Remains Excellent

Although final figures are not yet available for closing out TUFFP for 1993, it appears that our reserve fund balance on January 1, 1994, is slightly in excess of \$100,000. Expenditures for the budget presented in the November 1993 Advisory Board meeting brochure are on schedule. As a result, we are happy to confirm that there will be no increase in membership fees for 1995.

## GRI Project Delayed

Work on the GRI research project dealing with PCB migration in gas transmission and distribution systems was stopped on April 1, 1994. The project had been initiated in November 1992 and had continued for 17 months without a contract. A decision was made to stop all expenditures until a contract was in place. Authorization has now been received by Penn State University to issue The University of Tulsa a sub-contract for the 1992 and 1993 portions of the study. Work will resume when a sub-contract has been issued for 1994.

Two new graduate students have been recruited to work on the GRI project. Mr. Jose Flores, a Ph.D. student in Petroleum Engineering from Ecuador, and possibly Mr. Robert Marcano, an M.S. student in Petroleum Engineering from Trinidad, will serve as research assistants on the GRI project when work resumes. In addition, Dr. Tom Chen will serve as a post-doctoral research associate on the project and could be joined by a second research associate in late 1994.

## Paraffin Deposition JIP Status

Last November, Conoco and TUFFP hosted a joint industry workshop on the potential of forming a Joint Industry Project (JIP) to address the problem of wax deposition in wells and pipelines. Sixteen oil companies participated in the workshop and expressed a need to develop this technology. Since then, Conoco and TUFFP have developed a scope of work, objectives, deliverables, time table, and cost estimates for performing the study. This has culminated in a proposal that is being submitted to major and independent oil producers around the world. The proposal describes a five year, 3.3 million dollar study. DOE will be asked to fund approximately 50 percent of the study with JIP members and possibly GRI funding the remainder.

A meeting of all potentially interested companies will be held on September 1, 1994, at the Doubletree Hotel at Warren Place in Tulsa. Preliminary plans are to begin the meeting at 8:30 a.m. and adjourn by 4:30 p.m. The purpose of the meeting will be to finalize technical and administrative details pertaining to the JIP so that the project can be initiated on October 1, 1994.

Enclosed with this newsletter is an Interest Ballot that should

be completed and returned to us if you plan to attend the JIP meeting. This ballot is also being sent with the proposal. Additional copies of the proposal can be obtained by contacting Linda Jones, the TUFFP Administrative Secretary.



## TUFFP Membership Remains Stable

At this time, it appears that TUFFP will experience a decline of one company in membership for 1995. Chiyoda, a member since 1982, has informed us of intent to terminate its membership for 1995 with the provision that they would rejoin as soon as additional upstream projects are initiated within the company. Members are reminded that they are required to inform us no later than October 1 of the current year of their intent to terminate membership for the following year.

Communications continue with several possible new members for 1995. We hope that the anticipated increased attendance at the September Advisory Board meeting, as a result of both The University of Tulsa/SPE Centennial Petroleum Engineering Symposium and the Wax Deposition JIP meeting, might encourage additional companies to consider membership in TUFFP. A list of 1994 members appears on a following page.

## TUFFP Initiates New Slug Flow Project

For the past few years, the investigation of slug length distribution and liquid holdup in the slug body for two-phase horizontal flow has received a high ranking from member companies in annual questionnaires. A window of opportunity exists before testing begins for the GRI PCB project during which the slug flow experiments can be conducted. Dr. Tom Chen and Robert Marcano have been assigned to this project and data acquisition will take place beginning in mid-June and continuing for approximately one month.

Following a preliminary analysis of the data, a decision will be made whether or not the study can justify an M.S. thesis for Mr. Marcano. If not, a report on the subject, including analysis of the data and possible modeling, will be prepared by Dr. Chen. A presentation on the project will be made at the September Advisory Board meeting.

## Multiphase Flow Transient Forum Rescheduled

Following the November 1993 TUFFP Advisory Board meeting, a meeting of potential JIP participants was held to discuss a possible new project. This project would result in creating a transient multiphase flow databank and, using the databank, comparing and evaluating existing commercial simulators.

As an outgrowth of this meeting, a recommendation was made to hold a transient forum at which interested parties could meet and discuss experiences with using transient simulators. A planning meeting was held in Tulsa on January 17, 1994, at which a steering committee was established consisting of representatives from Amoco, Conoco, and Texaco. A forum was scheduled for Thursday, May 5, 1994, at the Texaco offices in Houston, Texas. This date coincided with the final day of the Offshore Technology Conference. Poor timing of the forum resulted in only five abstracts being submitted. As a result, the forum was delayed until a later date.

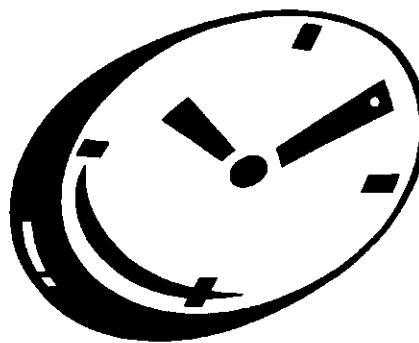
The new date for a possible transient multiphase flow forum is Thursday, September 29, 1994, at the Texaco offices in New Orleans, Louisiana. This date follows the SPE Annual Technical Conference in New Orleans September 25 - 28, 1994. Enclosed is an abstract form that should be completed by companies that wish to participate in the forum.

The forum steering committee has established the following guidelines for participation.

- No minutes, recordings, or publications to enhance discussion and information sharing.
- At least one representative from each company participating must make a presentation.
- Presentations will be selected from abstracts submitted to TUFFP by August 1, 1994.
- Typical presentations will involve case studies, transient data, or experimental studies.
- Each presentation will last up to 15 minutes.
- Additional information regarding travel, lodging, meals, and number of attendees permitted per company will be provided after the August 1 abstract submission deadline.

## TUFFP Seeks Additional Research Personnel

Advertisements will soon appear in the *SPE Journal of Petroleum Technology* and the *AIChE Chemical Engineering Progress Journal* for post-doctoral and Ph.D. positions in TUFFP and related contract projects. Applications should arrive throughout the summer and will result in a pool of qualified candidates. Additional research personnel will be needed for TUFFP, GRI, and/or the proposed wax deposition project.



## TU Announces New Summer Business Hours

The University of Tulsa will close at noon on Fridays during the summer. This policy is becoming increasingly popular among institutions in the United States and will include the TUFFP technicians and administrative secretary. These hours are in force May 9, 1994, through August 12, 1994, and could affect the ability of TUFFP members to contact us on Friday afternoons.

## 1994 Questionnaire Scheduled

The 1994 TUFFP Questionnaire will be sent to member companies following the Advisory Board meeting in September. Results from the questionnaires that are returned will be tabulated and included in the November newsletter.

## 1994 TUFFP Members

Amoco Production Company	INTEVEP
Arabian Oil Co., Ltd.	JGC Corporation
ARCO Oil and Gas Company	Japan National Oil Corporation
Baker Jardine & Associates	Marathon Oil Company
British Gas Corporation	Mobil Research and Development Corporation
BP Exploration	NKK Corporation
Chevron Petroleum Technology Company	Norsk Hydro
Chiyoda Corporation	Pertamina
Conoco, Inc.	Petrobras
ECOPETROL/Instituto Colombiano del Petroleo	Petronas
Elf Aquitaine	Phillips Petroleum Company
Exxon Production Research Company	Saudi Arabian Oil Company
Institut Francais du Petrole	Shell Internationale Petroleum MIJ B.V.
Institute of Oil & Gas Production	Simulation Sciences
Technology Oil & Natural Gas Commission	Texaco
Instituto Mexicano Del Petroleo	TOTAL
	UNOCAL

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# Research Progress

## R E P O R T S

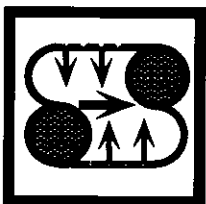


### Downward Two-Phase Flow in Inclined Pipes

The downward simultaneous flow of gas and liquid is often encountered in hilly terrain pipelines and injection wells. Most of the methods for predicting pressure drop in gas-liquid two-phase flow in pipes have been developed for either vertical or upward inclined flow. The objective of this project is to study, experimentally and theoretically, two-phase flow in downward inclined pipes. The first phase concentrates on downward, co-current, intermittent flow in inclined pipes.

A series of two-phase intermittent flow experiments were conducted in a 2-in. diameter, 65-ft.-long PVC pipe installed on a structure that is inclinable from horizontal ( $0^\circ$ ) to vertical downward ( $-90^\circ$ ). The fluids used were air and kerosene. Liquid holdup and pressure drop measurements were taken for the entire range of downward inclination angles from horizontal ( $0^\circ$ ) to vertical downward ( $-90^\circ$ ) at different flow conditions.

Experimental characteristic parameters include liquid holdup in the slug body and the trailing film, pressure drop along a slug unit, slug length, and slug translational velocity. New translational slug velocity and liquid slug holdup correlations were developed based on the acquired data for different inclination angles. All the results will be presented at the next Advisory Board Meeting.



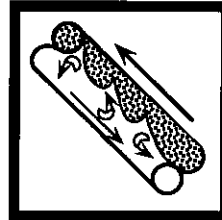
### Flow Behavior in Horizontal Wells

Horizontal wells can have very complex flow geometries, in part due to interaction between the main flow stream and the influxes along the wellbore, and also due to completion type.

A survey of the literature reveals that no experiments have been conducted for relatively low Reynolds numbers, including the laminar flow region, in perforated horizontal pipes with fluid injection. The objective of this project is to investigate, experimentally and theoretically, flow behavior in horizontal wells.

A new friction factor expression for horizontal well flow will be developed using the principles of conservation of mass, momentum, and energy. The design of a new test facility has been finished. At present, the construction of the test facility is under-

way. Preliminary test runs will be conducted on a test section comprised of transparent pipe with one side entry. Acquisition and evaluation of preliminary test data will be completed by July 1994.

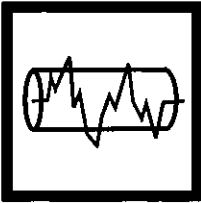


### Investigation of Non-Emulsified Oil-Water Flow Patterns in Inclined Pipes

The need for reliable design methods has been the driving force behind a very large research effort in two-phase gas-liquid flow over the past 30 years. Recently, the industry has turned its attention toward understanding the simultaneous flow of gas-oil-water mixtures. However, the limiting case when no gas phase is present has received inadequate attention and must be addressed before a study of gas-oil-water flow can have a high probability of success. The flow structure of oil-water mixtures in pipes is quite different from that of gas-liquid mixtures. Therefore, gas-liquid flow studies cannot readily be applied to oil-water systems. The objective of this project is to investigate oil-water flow patterns in pipes.

Experiments will be carried out in a 2-in. transparent pipe for 11 different inclination angles from horizontal to vertical. A 16 cp. viscosity oil @  $100^\circ\text{F}$  with a  $34^\circ\text{API}$  gravity was selected among 18 samples considered. The detailed facility design has been completed. Facility construction and development of a data acquisition system are underway and will be finished by mid August. The new facility will be capable of overcoming any potential emulsification problem. A new, efficient three-phase separator with built-in coalescing and hydrophobic elements has been donated by NATCO. The storage tanks will have internal baffles to enhance oil-water separation. The heating/cooling system capacity has been increased. Pumps selected are positive displacement with low rpm, and the use of check valves has been avoided. The maximum mixture velocity being considered is 9 fps due to limitations in separation capabilities. The mixing units will be fully transparent.

A mechanistic approach, based on physical phenomena, will be mainly used to model the oil-water flow pattern transitions. The stratified non-stratified transition will be studied using linear perturbation analysis.



## Transient Two-Phase Flow in Horizontal Pipes

The objective of this study is to experimentally investigate transient two-phase flow phenomena in horizontal pipes and compare the acquired data with predictions of available transient two-phase flow simulators such as OLGA, PLAC, and a TUFFP simplified transient code.

An experimental program has been carried out to acquire two-phase transient flow data on the existing 1,378-ft.-long, 3.068-in.-diameter horizontal pipeline. A new high speed, Macintosh based data acquisition system has been used to acquire and monitor the data simultaneously. Also, a new generation of capacitance sensors has been developed to measure liquid holdup.

The experimental runs comprise gas and liquid flow rate changes, pipeline start-up with different initial conditions, and liquid blow out tests. The initial and final steady-state flow patterns for these transient tests were stratified flow and slug flow. Measured parameters were inlet gas and liquid flow rates, outlet liquid flow rate, absolute and differential pressures, temperature, liquid holdup, and slug lengths and translational velocities.

Preliminary evaluation of the data shows that a change in inlet gas flow rate can create a fast transient, inducing a temporary intense slugging at the pipeline outlet, while transients induced

by a liquid flow rate change at the pipe inlet are slow and smooth. Comparisons of the acquired data with model predictions are currently underway. The results will be presented at the next Advisory Board Meeting.



## Network Upgrade Working

All computers and printers in the TUFFP offices are now talking to each other over a very fast (by comparison with our old AppleTalk) Ethernet. We hope to extend the network to the Technicians Shop and our outlying buildings for more convenient data acquisition and transfer. The extension of the network will also enable students and staff to access E-Mail and server files.

## Faster Server

Our first Macintosh Quadra 700, which is now nearly two years old, suffered an unrecoverable disk failure. We have decided to replace the hard disk with a one gigabyte drive and convert the Quadra into a server. Our old SE/30 server will be moved into the computer room for general use. The larger hard drive on the Quadra will have a much faster access time and enable us to put all our software on the server in keeping with the university's software policy.



## Access to New HP Workstation

TUFFP has purchased a new program called eXodusII™, which enables anyone with a Macintosh to access the new HP Unix Workstation. This program converts the Mac into an X-Station, giving the user full access to the HP. This is a very cost effective method of adding X-Stations to the HP and increases utilization of the more powerful Unix Workstation. Our preliminary trials using eXodusII™ are very favorable.

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