TUFFP

NIVERSITY FLUID FLOW PROJECTS NEWSLETTER

July 1998 A Semiannual Publication Volume 12, Number 2

Holden Zhang presents seminar to TUFFP Staff

Holden Zhang joins TUFFP as Research Associate

Following an extensive advertisement and search for new Post-Doctoral Research Associates for TUFFP and the Paraffin Deposition JIP, a decision was made to hire Dr. Holden Zhang from Tianjin University in the People's Republic of China. Holden has B.S. (1982) and M.S. (1985) degrees in Thermal Energy Engineering from Xi'an Jiaotong University. His Masters thesis was an experimental study involving multiphase flow and heat transfer, including the use of Laser Doppler Velocimetry (LDV) techniques. His Ph.D. (1988) degree in Fluid Mechanics was from Tianjin University and involved both experimental and numerical research. Holden also served as a lecturer and Associate Professor at Tianjin University where he taught experimental techniques in fluid mechanics, turbulence, and computational fluid dynamics. In 1993 and 1994 he was an Alexander von Humboldt Research Fellow at the prestigious Max-Planck-Institute of Fluid Mechanics in Göttingen, Germany and at a German aerospace research firm also in Göttingen.

During his employment at Tianjin University, Dr. Zhang published several articles in various fluid mechanics journals. His knowledge of fluid mechanics, numerical methods and experimental techniques will be put to excellent use in TUFFP research projects. Holden arrived in Tulsa in mid-May and will be joined in Tulsa later this summer by his wife and daughter. His initial primary responsibility will be on the Paraffin Deposition JIP and he is already actively involved in becoming familiar with the multiphase flow test facility being constructed.

Sarica Scheduled to Leave TUFFP

Cem Sarica

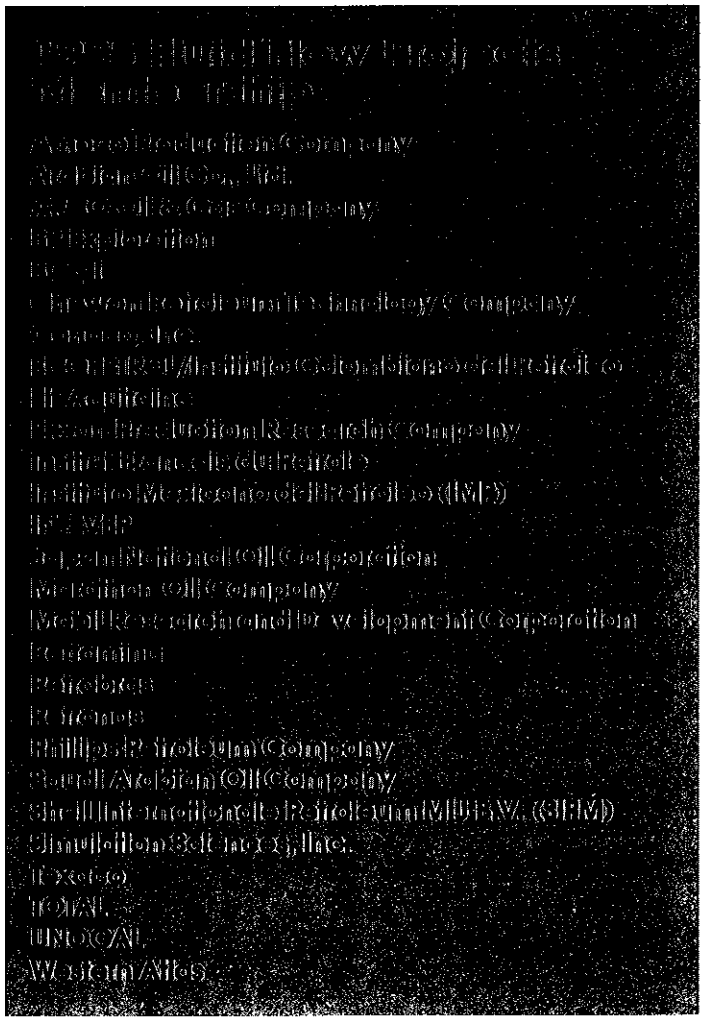
Following an incredibly productive six year period as a Research Associate and more recently as Associate Director of TUFFP, Dr. Cem Sarica has resigned to accept a faculty position as Associate Professor of Petroleum and Natural Gas Engineering at Pennsylvania State University. Dr. Sarica's contributions to TUFFP have been enormous and he will be very difficult to replace. Every effort will be made to pursue collaborative research with Cem after he becomes settled at Penn State. A search is underway for a successor and we anticipate hiring somebody by early 1999.

New TUFFP Research Assistants Will Soon Arrive

We are pleased to confirm that Mr. Ryo Manabe of JNOC in Japan will begin his Ph.D. program in Petroleum Engineering in August. His Ph.D. program will involve satisfying the academic portion in residence at The University of Tulsa and the research portion at JNOC's Kashiwazaki test facility. A proposal to accomplish this unusual arrangement has been submitted to JNOC and Mr. Manabe would conduct his research in the area of slug tracking in hilly terrain pipelines.

Mr. Gonzalo Olivares from Pemex also anticipates beginning his Ph.D program in Petroleum Engineering at The University of Tulsa in August, 1998. Gonzalo holds B.S. and M.S. degrees in Petroleum Engineering from the Universidad Nacional Autonoma de Mexico (UNAM) in Mexico City. At present, he is working hard to satisfy his English proficiency requirements. A research project has not yet been assigned to him.

Discussions are still under way with CIED/PDVSA in Venezuela to sponsor a Ph.D. student at TUFFP beginning in 1999. Discussions are also underway with an outstanding Ph.D. applicant from China who is targeted to begin in the Fall 1999.



TUFFP Provides Summer Jobs for Several Petroleum Engineering Undergraduates

Significant construction activity and maintenance of tests facilities are underway at TUFFP this summer. Much of this work will be performed by several petroleum engineering undergraduate scholarship recipients. This will give entering students an opportunity to learn more about petroleum engineering and also become familiar with experimental methods. Included are the following students: Leozarin Morshidi, a senior, James Nonongan, a sophomore, Roy Brashears, a freshman, and three incoming freshmen for the Fall term, Michael Coates, Eric Nelson and Richard Tallant.

Richard Tallant, Eric Nelson, and Michael Coates assisting Howard Rettig

TUFFP Financial Status Remains OK!

TUFFP's projected reserve fund balance at the end of 1997 is $172,575 with newly projected expenditures for 1998 of $753,924 and projected income of $729,000. We now anticipate a decrease in the reserve fund to approximately $147,651 by the end of 1998. Projected income and expenditures for 1999 confirm that the reserve fund balance would be totally depleted by the end of 1999 without an increase in membership fees. Accordingly, a decision has been made to increase the 1999 membership fees to $30,000. This is consistent with our past history of adjusting rates approximately every three years.

At the present time, 5 member companies have not yet paid their membership fees for 1998. Efforts are underway to contact these companies and prompt payment would be appreciated.

A detailed report on the TUFFP financial status will be given at the September 23, 1998 Advisory Board meeting. Invoices for 1999 membership fees will be sent to member companies in late October to accommodate those companies who wish to pay 1999 membership fees from their 1998 budgets.

1998 TUFFP Questionnaire

The 1998 TUFFP Questionnaire was distributed to the official Advisory Board representative with this newsletter. Members were asked to express their relative interest on existing and possible future research projects. A request was made that the questionnaire be returned by September 1, 1998. Results will be tabulated and summarized in the brochure for the September 23, 1998 TUFFP Advisory Board meeting.

TUFFP Short Course Another Success!

Once again, a successful short course on "Two-Phase Flow in Pipes" was held April 27 – May 1, 1998 in Tulsa, Oklahoma. The course was attended by 17 engineers and scientists, including 10 from 8 member companies and 7 from 5 non-member companies. Income from the course was sufficient to pay all expenses incurred. A tentative date of May 10 - 14, 1999 has been established for the next TUFFP short course.

Yehuda Taitel Again Returns to TUFFP

Dr. Yehuda Taitel, Professor of Mechanical Engineering at Tel Aviv University will once again spend a period of one month at TUFFP from mid-September to mid-October. He plans to formalize all research activity plans pertaining to the slug tracking research proposal from Tel Aviv University. He will also devote time helping TUFFP research assistants in their modeling problems and design of experimental test facilities.

TUFFP to Fund Slug Tracking Software Development at Tel Aviv University

A proposal of cooperation with Tel Aviv University dealing with slug tracking in hilly terrain pipelines will soon be approved. The proposal was developed by Yehuda Taitel, Dvora Barnea and Lev Shemer from the Department of Fluid Mechanics and Heat Transfer at Tel Aviv University. Included will be an investigation of the behavior of slugs in hilly terrain pipelines and completion of a slug tracking computer program. The research will be completed over a period of two and one half years. Some experimental work will be conducted on an existing test facility at Tel Aviv to investigate slug initiation and slug length distribution near the entrance of a hill. Total funding will be $25,000 in 1998, $50,000 in 1999 and $50,000 in 2000. The project will begin in October, 1998 and will end in April, 2001.

TUFFP Membership Remains Stable

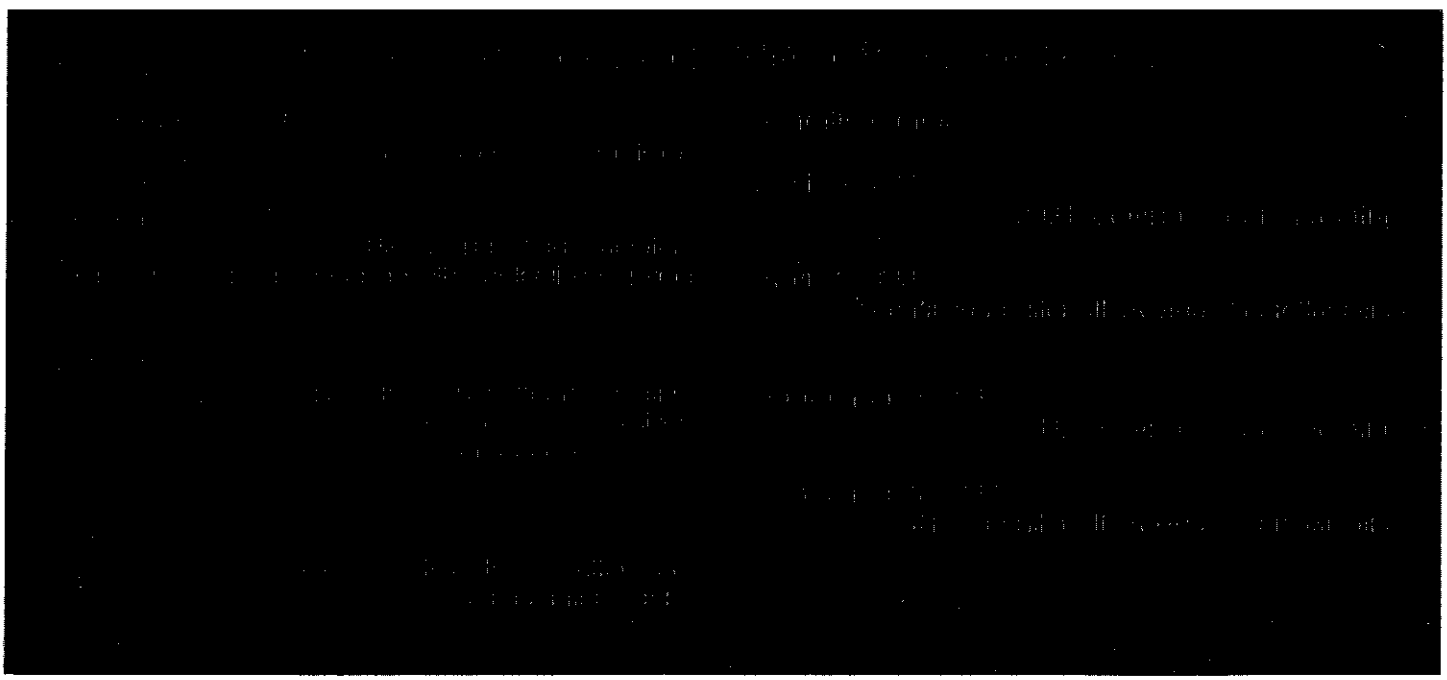
At this time, it appears that TUFFP membership will remain the same for 1999. Petronas has announced that the Asian financial crisis will necessitate terminating their membership in TUFFP for 1999. No other terminations are expected for 1999. We anticipate that the U.S. Department of Interior's Minerals Management Service (MMS) will join TUFFP in either late 1998 or for 1999. Other excellent possibilities for membership include Statoil and NKK, both of whom are very interested in our slug tracking research activity. A list of 1998 members appears on the preceding page.

Future Advisory Board Meetings Scheduled

Final plans have been made for the Fall 1998 TUFFP Advisory Board and related meetings. These will be scheduled to immediately precede the SPE Annual Technical Conference and Exhibition in New Orleans. All meetings will be held at the Marriott Southern Hills Hotel in South Tulsa. 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 meetings should complete the form and return it to us as soon as possible. The TUFFP Advisory Board meeting will begin at 8:30 a.m. on Wednesday, September 23, 1998 and will adjourn at 4:30 p.m. A tour of test facilities for persons attending the TUFFP Advisory Board meeting but not staying for the Paraffin Deposition JIP Advisory Board meeting will be held at 3:00 p.m. on Tuesday, September 22, 1998. Following the Advisory Board meeting on Wednesday there will be a reception at the Marriott Southern Hills Hotel from 6:00 to 8:00 p.m. and TUFFP members will be joined by those attending the Paraffin Deposition JIP Advisory Board meeting that will be held the following day, September 24, 1998. Immediately following the Paraffin Deposition JIP Advisory Board meeting there will be another tour of test facilities at 5:30 p.m. followed by a Barbecue dinner on the North Campus at 6:30 p.m. This arrangement should permit everybody to tour all TUFFP and Paraffin Deposition JIP test facilities during the meetings. On Friday, September 25, 1998 there will be a workshop held in Zink Hall on the Main Campus of The University of Tulsa to plan future Paraffin Deposition JIP activities. The current JIP is scheduled to finish on June 30, 1999. This workshop will be open to all current and possible future JIP members.

A summary of the dates for Fall 1998, Spring 1999 and Fall 1999 Advisory Board meetings are shown in the following table. The Spring and Fall 1999 Advisory Board meetings will probably also be held at the Marriott Southern Hills Hotel.

TUFFP Advisory Board meeting brochures will be distributed at the meeting and will be mailed to all members after the meeting. The brochure will contain sufficient information to help each attendee actively participate 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 but will not be mailed to members. Consideration is being given to making both the brochure and slide copy available on the TUFFP web page which is currently under construction.



BHR Group's First Multiphase Conference in North America a Resounding Success

BHRG sponsored their first North American Conference on Multiphase Technology in Banff, Canada on June 10 – 11, 1998. A technical program of 30 papers over the two-day period was enjoyed by over 135 registrants. Co-sponsors of the conference included TUFFP and Neotechnology Consultants, Ltd. It is likely that the success of this conference will result in this becoming a biannual event, alternating with the biannual conference in Cannes, France.

A Call for Papers has been issued for the 9th International Conference, Multiphase '98 scheduled for June 16 – 18, 1999 in Cannes, France. A copy of the Call for Papers is distributed with this newsletter.

Alistair Muir - BHRg, Garry Gregory - Neotechnology Consultants, Inc., and Catherine Cox - BHRg

Planning Underway for ETCE '99 Conference

The ASME Energy Technology Conference and Exhibition (ETCE) will again be held at the Sheraton Astrodome Hotel in Houston, February 1 – 3, 1999. A concerted effort is underway to develop several technical sessions on multiphase flow within the Petroleum Production Technology Symposium. At the present time, we anticipate approximately 30 technical papers on a variety of subjects, many of which will be on multiphase flow through pipes, meters and pumps. Similar to ETCE '98, an accelerated peer review process will occur that will permit manuscripts submitted by early August to appear in the March 1998 ASME Journal of Energy Resources Technology (JERT). TUFFP members are urged to participate in this growing technical conference and also to consider subscribing to the JERT where an increasing number of multiphase flow articles are being published.

TUFFP Recognizes Charter Members

To celebrate TUFFP's Silver Anniversary, commemorative plaques were presented at the April 23, 1998 Advisory Board meeting to charter companies that joined TUFFP in 1973 and had continuous membership for the ensuing 25 years. Companies qualifying were Amoco, ARCO, Chevron, Intevep, Mobil, Texaco and Unocal. In addition, a Silver Anniversary paperweight was distributed to all attendees and mailed to Advisory Board representatives that could not attend.

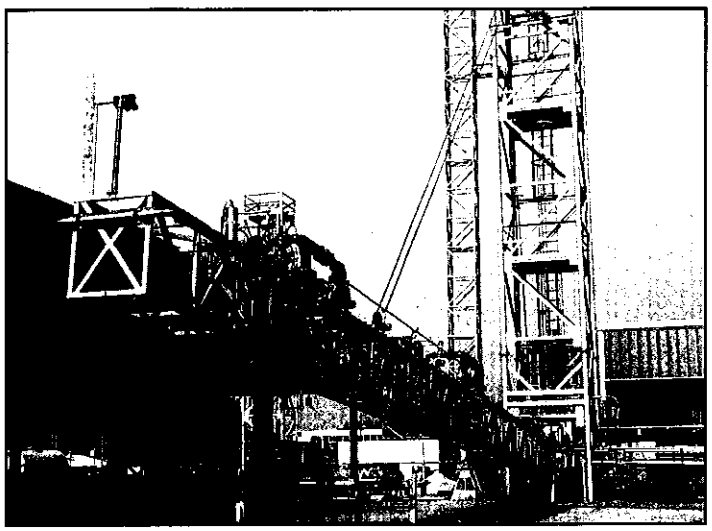
Fluid Flow Projects Advisory Board Meeting September 23, 1998

Paraffin Deposition JIP Advisory Board Meeting September 24, 1998

Please send in your Request for Information form and hotel reservations for the upcoming Advisory Board meetings as soon as possible.

See you there!

Paraffin Deposition JIP Update



Elevated test section for multiphase deposition loop.

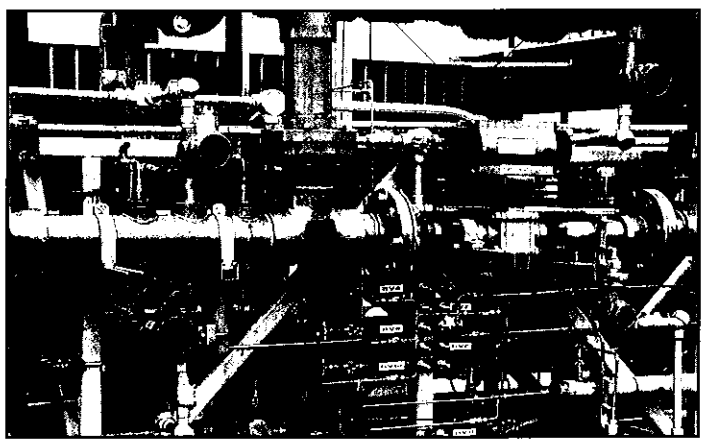
A large Joint Industry Project (JIP) was initiated at The University of Tulsa on May 1, 1995 to investigate paraffin deposition under both single phase liquid and multiphase flow conditions in pipelines and wellbores. This $4 million, four-year project is funded by membership fees from 33 domestic and international oil and gas related companies, DOE, and the US Department of Interior's Minerals Management Service. The JIP is coordinated through five committees chaired by industry members. Deliverables in the form of literature searches, computer programs, experimental data, and reports describing models for predicting deposition phenomena are scheduled throughout the four-year study.

Monitoring of progress in the JIP is accomplished through frequent committee meetings and semi-annual Advisory Board meetings. The next Advisory Board meeting will be held in Tulsa on September 24, 1998. On September 25, 1998 there will be an industry workshop at Tulsa University to discuss future use of the TU test facilities to conduct research on paraffin deposition and remediation. This workshop will be open to all interested companies.

Analyses of the single phase wax deposition data using South Pelto crude oil and Garden Banks condensate are now complete. These data have been distributed to JIP members on a CD. Analyses of the data yielded accurate calculations for deposition thickness as a function of location, time, inlet bulk oil temperature, inlet coolant temperature and Reynolds number. Deposition thickness was calculated based on both pressure drop and heat transfer measurements. HTGC analyses of deposits yielded new information for predicting trapped oil concentration in the deposits. Analyses of the data suggest that molecular diffusion cannot account for all of the deposition phenomena observed. Paraffin deposition is a very complex process that will require significant basic research to fully understand the many phenomena involved. Additional mechanisms that must be considered include: the role of viscosity of a colloidal dispersion in the boundary layer region; the relative roles of mass and thermal diffusion; the size of paraffin crystals being formed; the role of a gelled oil layer, including the affect of shear stress and yield strength in sloughing or creeping flow; growth or reorganization of paraffin crystals and the corresponding mechanism of deposit hardening; and, the role of heat transfer in the deposit in accelerating the aging or hardening process.

Development of an initial multiphase flow deposition computer program is nearing completion. The program development will combine the following: modern multiphase flow mechanistic models for wells and pipelines; a state-of-the-art solid-liquid-vapor equilibrium module (from Multiphase Solutions Inc.); a broad range of multiphase flow heat transfer options (from Oklahoma State University); and, multiphase flow deposition models based on the preliminary TU tests. A user-friendly GUI for the program is being developed by Multiphase Solutions Inc. Improved deposition models will be added later based on more extensive multiphase flow tests.

Construction of the multiphase flow deposition loop is nearing completion. Single phase testing with the multiphase flow loop will begin in late July, with the objectives of developing operating procedures and verifying results obtained with the single phase flow loop. Piping of the gas system is underway and should be completed by late August, permitting the start of preliminary two-phase tests in September. It is likely that some modifications to the flow loop and



LD-LD axial deposition system

operating procedures will be identified during the preliminary two-phase flow tests. The overall testing program for the two-phase flow study includes:

- single phase deposition tests to verify reproducibility with tests conducted on the single phase flow loop
- develop flow pattern maps for horizontal, vertical and inclined flow in a non-deposition environment
- refine operational procedures in a two-phase deposition environment
- conduct two-phase horizontal deposition tests
- conduct two-phase vertical deposition tests
- conduct two-phase uphill and downhill deposition tests.

The two-phase test conditions will utilize one inlet bulk oil temperature, one inlet coolant temperature, and flowing South Pelto crude with natural gas at pressures of 500 psia. The duration of the test program will be approximately seven months ... one month for preliminary tests and six months for remaining two-phase flow tests. The two-phase test program will consist of 16 to 22 tests in order to investigate all flow patterns. This includes 6 to 10 tests in a horizontal loop, 4 to 6 tests in a vertical loop, 3 tests in an uphill loop, and 3 tests in a downhill loop.

Bazlee Matzain examining Rosemount transmitters

Optimization of Horizontal-Well Completion Joint Industry Project

A Joint Industry Project (JIP) was initiated on January 19,1998 to provide completion guidelines for horizontal wells and to develop software to be used in the design of optimum well completions. The project will be completed by January 2000. Completion optimization will provide members of the JIP with a low cost or no-cost means of increasing the economic benefit expected from horizontal wells. During the kick-off meeting an early version of the horizontal-well performance computation algorithm for open-hole completions that incorporates the influences of wellbore hydraulics, selective completion, and variable skin effect was delivered to the members.

Significant progress has been made since the kick-off meeting.

- Analytical modeling of the flow towards a slotted liner completed well is currently underway.
- An experimental facility has been prepared for the experiments.
- Ten different test sections have been designed, and are currently being constructed.

Future tasks include:

- Data acquisition and development of friction factor correlations for different completion geometries.
- Complete development of the analytical model of flow toward small openings on a horizontal well surface.
- Development of general well computation software, and a horizontal well completion pseudo-skin expression.
- Preparation of horizontal well completion guidelines.

The membership status has improved significantly since the kick-off meeting. Currently, the JIP has 5 members. The JIP members are Phillips, Amoco, Unocal/Sprit 76, the Minerals Management Service, and the Department of Energy. Membership is expected to increase when 1998-research budgets of prospective companies become available. The current membership fee is $24,000 for the duration of the project.

Efforts are underway to prepare a web page for the JIP. The web page will help the JIP to communicate with member and prospective member companies better. The address of the web page is: http://www.ee.utulsa.edu/~gsatish/interesmang.htm. Members and non-members are invited to visit our web site to monitor the progress of the JIP.

Comprehensive Mechanistic Modeling of Two-Phase Flow in Deviated Wells

The objectives of this project are to develop and evaluate a comprehensive mechanistic model for predicting two-phase flow behavior in deviated wells and to expand the current TUFFP well databank. The fundamental postulate of the modeling approach is the existence of flow patterns. Various mechanistic models have been developed to predict flow patterns. For each flow pattern, separate models were developed to predict flow characteristics like holdup and pressure drop. By considering basic fluid mechanics, the resulting models can be applied with confidence to flow conditions other than those used for their development.

Early modeling efforts were concentrated on vertical wells. Ozon et al.(1987), Hasan and Kabir (1988), Ansari et al. (1988), Chokshi et al. (1994) and Tengesdal et al.(1999) are the comprehensive mechanistic models developed strictly for vertical upward two-phase flow. Although one can use vertical flow models for deviated wells by simply applying an inclination angle correction to the gravity component of the pressure gradient equation, the results should be scrutinized, and not be expected to reflect the actual flow behavior. Therefore, it was recognized that additional studies were needed to improve predictions for deviated wells.

A comprehensive mechanistic model for both vertical and inclined upward flows has been developed for flow pattern and flow characteristic predictions. The model considers five flow patterns: bubbly, dispersed bubble, slug, churn and annular flows.

The flow pattern prediction incorporates models by Ansari, et al. (1988) for annular flow, Taitel, et al. for dispersed bubble flow, and new transition models for churn flow based on the drift flux approach and for bubbly flow. When compared to six other transition criteria, the new churn flow transition criterion gives the best results based on Shoham's (1982) churn data.

The mechanistic models consist of a homogeneous model for dispersed bubble flow, a new model for bubbly flow, a modified Chokshi et al. model for slug flow, the Ansari et al. model for annular flow, and the Tengesdal et al. model for churn flow.

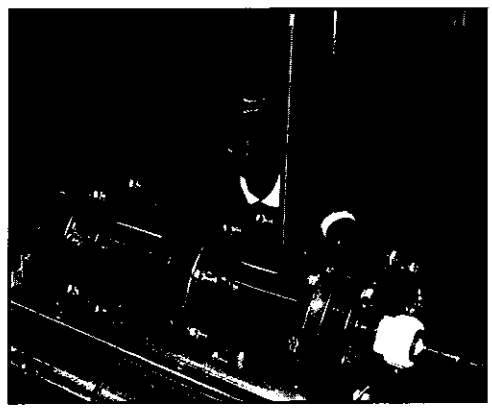
Verification of the comprehensive model is accomplished by comparing the model's performance against the TUFFP expanded well databank containing 2052 well cases from field and laboratory experiments. The model was also compared with two correlations and four mechanistic models. Comparisons show that the model performs the best.

Preparation of the final report is currently underway.

Low Liquid Loading Two-Phase Flow In Near-Horizontal Pipelines

Gas-liquid two-phase flow with a small amount of liquid is frequently encountered in natural gas pipelines. Even when single-phase gas enters a pipeline, condensate traces can be formed by retrograde condensation. The presence of these traces of liquid can lead to a significant increase in pressure loss over that for single-phase gas flow. Despite numerous theoretical and experimental investigations into gas-liquid pipeline flow, only a few studies on low liquid loading two-phase flow have appeared in the recent literature and the topic has not been adequately studied. Existing models do not predict the flow characteristics of gas-condensate mixtures in natural gas pipelines with sufficient accuracy.

The objective of this project is to investigate, experimentally and theoretically, low liquid loading two-phase flow in near-horizontal pipelines. Both stratified-wavy and annular flows, the most common flow patterns encountered in wet gas pipelines, are currently being studied.



Significant progress has been achieved since the last Advisory Board meeting on April 23, 1998. The designed tests were completed. The data acquired include liquid flow rate, gas flow rate, liquid film flow rate, deposited liquid flow rate in a short piece of pipe, the pressure gradient and liquid film height. The superficial gas velocities ranged from 5 to 25 m/sec and superficial liquid velocities ranged from 0.001 m/s to 0.053 m/sec. Correspondingly, the liquid loadings are from 40 to 10,600 m3/MM3 (from 7.12 to 1,888 BBL/MMSCF). At high superficial gas velocity, an increase in liquid flow rate decreased the liquid film flow rate and liquid holdup. The liquid droplets were observed to entrain in the gas core just after roll waves were generated. The droplet diameters were very small near the liquid entrainment onset point. The droplet size was large when the gas flow velocity was high. Some of the tests were videotaped. Data processing and

Two Phase Flow in Hilly Terrain Pipeline

Hilly terrain pipelines are inevitable in field operations. Both offshore seafloor and onshore land exhibit hilly terrain configurations. The prediction of flow behavior for hilly terrain pipelines is important to properly manage hydrocarbon recovery. Hydrodynamics slugs generated in uphill sections may or may not decay in following downhill sections, causing uncertainties in pressure behavior. Such configurations can also result in terrain induced slugs that are much longer than those normally encountered in horizontal pipelines. These long slugs often cause operational problems, flooding of downstream facilities, severe pipe corrosion, and structural instability of the pipeline, as well as production loss and poor reservoir management due to unpredictable wellhead pressures.

In this study, two phase flow in hilly terrain pipelines will be investigated experimentally and theoretically. The objectives of this project are four fold:

- Investigate slug initiation and evolution in general.
- Determine slug length distributions at several locations along the 1,370-ft long TUFFP flow loop.
- Develop a constitutive relationship for slug initiation for slugs generated at the bottom elbow of a pipeline.
- Generate data to evaluate the developed model for various hill and valley configurations.

An existing TUFFP facility, 420 m (1,370 ft) long and 77.9 mm (3.068 in) diameter flow loop, will be significantly modified to conduct the experimental part of this study. Significant progress has been made since the last Advisory Board meeting on April 23, 1998. The flow loop design has been completed. A 2-in. diameter test pipe is planned to be used in this project due to the availability of 2-in. diameter capacitance sensors from the slug dissipation study. A single hilly terrain unit will be simulated with 70-ft long uphill (downhill) and 70-ft long downhill (uphill) sections. The inclination angles will be ± 2° and ± 0.5° from horizontal. The test section modification and construction are already underway. Near future tasks include installing the 2 in. pipe, construction of the trapping section and mounting measurement instruments on the test section. A detailed progress report will be presented at the Fall 1998 Advisory Board meeting.

Slug Dissipation in Downward Flow

Slug flow is a common occurrence in hilly terrain pipelines. The standard engineering method has been to divide a pipeline into various sections of constant slopes, and apply steady state flow models to simulate flow behavior in each section, without considering the interaction between upward and downward sections. An important consequence of this interaction is carryover of large slugs into downhill sections that were created in uphill sections, even though modern flow pattern prediction models indicate that stratified flow should exist in the downhill sections. The objective of this project is to conduct an experimental and theoretical study to investigate slug flow dissipation in downward inclined pipes as encountered in a hilly terrain pipeline.

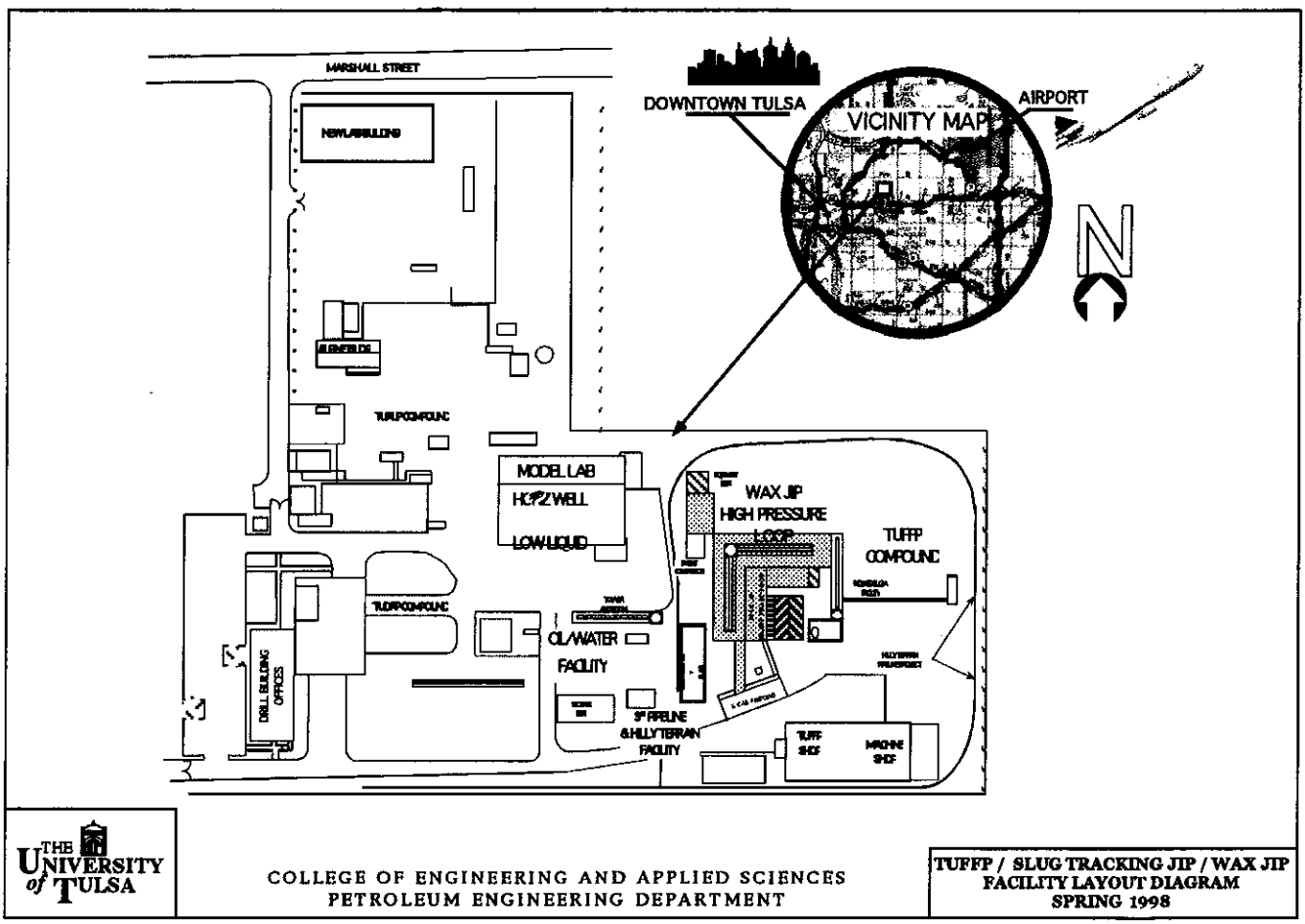
The data acquisition has already been completed. A total of 135 tests were conducted with downward inclination angles of 1°, 2°, 5°, 10° and 20° and superficial oil and gas velocities ranging from 0.5 to 5 ft/sec and 1 to 15 ft/sec, respectively. Preliminary data analysis has revealed four different phenomena with regard to slug dissipation in downward flow. A model to determine the slug dissipation region has been developed. Analysis of the data is continuing to determine the effect of inclination angle on slug dissipation velocities and distances.

Oil - Water Flow Patterns in Slightly Inclined Pipelines

A systematic research program has been underway at TUFFP since 1992 to investigate oil-water flow in wellbores and pipelines. Trallero completed a study on oil-water flow patterns in horizontal pipes and classified the flow patterns based on both his experimental data taken at the TUFFP Oil-Water Flow Facility, and data from several other sources. A new mechanistic model was developed based on a rigorous two-fluid model and a force balance between gravity and turbulent fluctuations normal to the main flow. Comparisons of the model with data from his research and from several other studies show that the Trallero flow pattern model performs very well for horizontal pipelines. In a recent study by Flores, oil-water flow was investigated for the inclination angle range from 45° to 90°. Flow patterns for vertical and deviated flows were identified and models for vertical upward flow were developed.

Although there are no perfectly horizontal pipelines, research on the flow of oil-water mixtures in slightly inclined pipelines is almost nonexistent. The objective of this project is to develop mechanistic models to predict the transitions of oil-water flow patterns for slightly inclined pipelines by using experimental data that will be obtained at various flow conditions and inclination angles, using mineral oil and water.

A comprehensive review of the literature has already been completed. Facility modifications and a new test section design are currently underway. Facility modifications, and construction of the new test section are expected to be completed by Jan. 1, 1999. A detailed progress report will be presented at the Fall 1998 Advisory Board meeting.



Two-Phase Flow Calendar

1998

September 13 - 18	SPE Forum Series in Europe, Technical Solutions for Offshore Field Life Extension, Aviemore, United Kingdom
September 23	TUFFP Advisory Board meeting, Tulsa, Oklahoma
September 24	Paraffin Deposition JIP Advisory Board meeting, Tulsa, Oklahoma
September 25	Paraffin Deposition JIP Deposition and Remediation Forum, Tulsa, Oklahoma
September 27 - 30	SPE Annual Technical Conference and Exhibition, New Orleans, Louisiana
October 20 - 21	Ohio University Erosion/Corrosion Advisory Board meeting, Athens, Ohio
October 20 - 22	SPE European Petroleum Conference, The Hague, The Netherlands
November 1 - 4	SPE/CIM International Conference on Horizontal Well Technology, Calgary, Alberta, Canada
November 2 - 6	SPE International Oil and Gas Conference and Exhibition in China, Beijing, China
November 15 - 20	1998 ASME International Congress and Exhibition (IMECE 98), Anaheim, California (session on Multiphase Flow Phenomena in Combustion and Chemical Processes).

1999

February 1 - 3	ASME Energy Technology Conference and Exhibition, Houston, Texas (several sessions on multiphase flow as part of Petroleum Production Technology Symposium)
March 14 - 18	AIChE Spring National meeting, Houston, Texas (symposium on wax thermodynamics and deposition)
April 20 - 21	Ohio University Erosion/Corrosion Advisory Board meeting, Athens, Ohio
April 28	TUFFP Advisory Board meeting, Tulsa, Oklahoma
April 29	Paraffin Deposition JIP Advisory Board meeting
May 3 - 6	Offshore Technology Conference, Houston, Texas
May 10 - 14	TUFFP Short Course on Two-Phase Flow in Pipes, Tulsa, Oklahoma
June 16 - 18	Multiphase '99, Cannes, France
August 15 - 17	33rd National Heat Transfer Conference, Albuquerque, New Mexico (session on Experimental Study of Multiphase Flow)
September 29	TUFFP Advisory Board meeting, Tulsa, Oklahoma
September 30	Paraffin Deposition JIP Advisory Board meeting, Tulsa, Oklahoma
October 3 - 6	SPE Annual Technical Conference and Exhibition, Houston, Texas

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