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TUFFP

UNIVERSITY FLUID FLOW PROJECTS NEWSLETTER

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TUFFP's New Computer Resource Manager

By Gerad Gibson

As a native Tulsan, I have always wanted to attend The University of Tulsa. The "large enough to serve you but small enough to know you" attitude has always appealed to me. After familiarizing myself with the first semester demands of studying for a BS in business with an emphasis on MIS and computer science, I decided to run for a commuter's seat in the Student Association Senate and look for a part-time job. I lucked out and found them both!

Jerry Wilson laid a golden opportunity in my lap in mid-February when he offered me the position of computer network manager for TUFFP. This job has enabled me to work for TU during the hours that fit around my class schedule, besides the added plus of gaining hands-on experience in my chosen career field. As the new computer manager, I have gained extensive training in administering networks for Macintoshes, PCs, and HP workstations. My responsibilities are to back up data and make sure that all the computers can "see the world," stay modern, and function properly. I have worked on projects such as recording CDs for data distribution to member companies and am currently revamping the TUFFP and Wax JIP Web sites.

Since joining TUFFP, I have had the honor to work with a quality world-class staff and a host of multi-national students whom I thank for answering all of my "what is it like there!?" questions. When I am not studying or working on computers, I enjoy adventures such as scuba-diving, traveling, and spending as much time as possible outdoors and with my family. The next three years with TU and TUFFP will be exciting and educational; I am looking forward to each and every one of them.

TUFFP Recruits New Research Assistants

Eissa Al Safran from Kuwait has arrived to begin his M.S. degree program in petroleum engineering. Eissa was an outstanding B.S. graduate from The University of Tulsa in 1994. Both his M.S. and Ph.D. degree programs will be fully funded by the University of Kuwait. TUFFP will be funding the research portion of his graduate program. No specific project has been assigned to Mr. Al Safran at this time.

Ryo Manabe of JNOC in Japan has delayed the start of his Ph.D. program in petroleum engineering until next January. A proposal is still being prepared that would permit Mr. Manabe to complete all academic parts of his Ph.D. degree in residence at The University of Tulsa with his research being conducted in the area of slug tracking at a JNOC facility in Japan.

Communications are being established with Ms. Banu Alkaya who is currently attending Istanbul Technical University in Turkey. She has expressed an interest in pursuing an M.S. degree in petroleum engineering at The University of Tulsa. She will be taking the GRE in September and we hope to have her on board in TUFFP as a research assistant by next January.

The advertisement for post-doctoral research associates in various journals this spring also included an advertisement for Ph.D. students. Several potential candidates have applied, and we are in the process of evaluating these at this time.

TUFFP Advertises for Post-Docs

An advertisement for post-doctoral research associates for TUFFP appeared in spring issues of *The Journal of Petroleum Technology*, *Mechanical Engineering*, and the *AIChE Journal*. The advertisement also included an announcement of openings for Ph.D. students. As a result, we have already received more than 40 applications for post-doc positions and more than 10 indications of interest for Ph.D. research assistantships. The application period will soon be over and we will then begin to evaluate all applicants. We anticipate making a decision on the post-doc positions by late August with a successful candidate arriving as soon as possible thereafter.

TUFFP Acknowledges Part-Time Student Work Contributions

Once again, a significant amount of support help on various research projects for TUFFP and the Paraffin Deposition JIP has been provided by students who are hired part time during the academic year and full time during the summer. Typical activities include oilfield roustabout work, electronic wiring, and assisting graduate students and research associates with data acquisition.

TUFFP Announces Staff Changes

Dr. Tom Chen has announced that he will be leaving TUFFP and joining Texaco in late July, 1997. Tom has been a research associate in TUFFP since 1993 and has been very instrumental in the significant advances that TUFFP has made in both modeling and enhancement of test facilities. In addition, for the past two years, he has been the key technical person in the Paraffin Deposition JIP. We commend him on his outstanding service to The University of Tulsa and wish him the best of luck in his new position.

With the resignations of Brandon Land and Liming Zhu from the TUFFP staff in early 1997, it became necessary to search for a new computer resource manager. A decision was made to hire Gerard Gibson, and a feature article on his background appears on the front page.



DON'T FORGET!

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

TUFFP Financial Status Remains Good

TUFFP projected reserve fund balance at the end of 1997 is \$60,000 or nearly the same as the reserve fund balance at the end of 1996. At the present time, only two member companies have not yet paid their membership fees for 1997. As announced at the April 1997 Advisory Board meeting, a decision has been made to retain 1998 membership fees at the 1997 rate of \$27,000. With no change in membership, most of the reserve fund balance will be depleted during 1998. However, our projected growth in members should restore the reserve fund balance, thus, making an increase in membership fees unnecessary.

A detailed report on the TUFFP financial status will be given at the October 2, 1997, Advisory Board meeting. Invoices for 1998 membership fees will be sent to member companies in late October to accommodate those companies who wish to pay 1998 membership fees from their 1997 budgets.

Data and Software Distribution Now Scheduled for July 1997

Mr. A. S. Kaya, a TUFFP research assistant from Turkey, is in the final stage of preparing data and software for distribution to member companies. The documentation manual has been completed and duplicated. A beta version of the compact disc (CD-ROM) that is formatted in ISO 9660 standards will be sent to one member company to confirm that no problems are encountered. The CD will then be duplicated and distribution of the CD and documentation manual is scheduled for early August.

The distribution will include data from five projects and software from five projects completed between 1992 and 1996. All computer programs have been checked for their compliance with TUFFP programming standards and changes were made where necessary.

Slug Tracking JIP Plans Terminated

After careful consideration, a decision has been made to abandon our efforts to establish a joint industry project (JIP) on slug tracking. Although this project has a great deal of technical relevance, efforts to solicit the required level of outside funding have been both unsuccessful and very time-consuming. Five companies have signed a Letter of Agreement to initiate the JIP; however, a minimum of 10 with an ideal target of 15 companies were necessary to formulate the JIP. At one time, 14 companies had indicated interest in the JIP but interest declined when it became clear that high pressure data would not be included in the work scope.

We still consider this project to be of high priority and this feeling has been confirmed in annual TUFFP questionnaires. Consequently, we now plan to pursue an investigation of slug tracking as part of our broader efforts related to multiphase flow in hilly terrain pipelines. Without the funding that would have been generated from the JIP, initial efforts on this topic will of necessity be more modest and of longer term duration. In the coming months, we will formulate a plan that will be presented at future Advisory Board meetings.

TUFFP Seeks Access to Commercial Transient Simulators

TUFFP anticipates having access to three multiphase transient simulators in the near future. An academic license for the use of AEA's PLAC simulator has existed within TUFFP for the past two years. Simulation Sciences will soon provide an academic license to TUFFP for the use of the new TACITE program developed by IFP, Elf, and TOTAL together with a GUI similar to SimSci's PIPEPHASE and NETOPT. ScandPower has requested permission from OLGA owners to grant an academic license to The University of Tulsa for the use of OLGA. Cem Sarica is scheduled to attend a user's course for OLGA on August 18 - 20, 1997, in Houston.

TUFFP Membership on the Rise

At this time, it appears that TUFFP membership could increase in both 1997 and 1998. Marathon Oil Company has rejoined for 1997, and it is likely that PEMEX/IMP and Western Atlas will join for 1998. With the decision to incorporate slug tracking within the TUFFP hilly terrain pipeline scope, we are optimistic that both Statoil and NKK could rejoin TUFFP for 1998. Discussions are also underway with ECOPETROL/ICP and Phillips Petroleum that could result in their rejoining TUFFP for 1997 or 1998.

No companies have informed us of intent to terminate their membership in TUFFP for 1998. A list of 1997 members appears on a following page.

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 in October. He plans to participate in the multiphase transient forum and spend the remainder of the month helping TUFFP research assistants in their modeling problems and design of experimental test facilities.

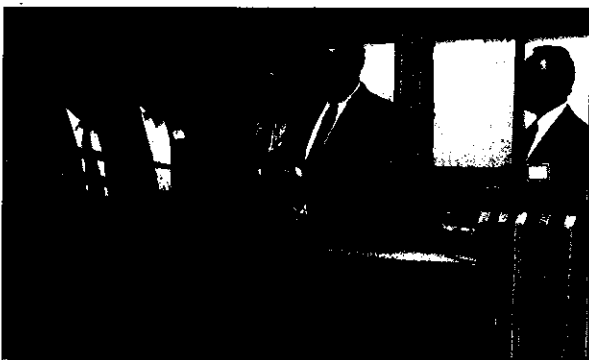
1997 TUFFP Questionnaire

The 1997 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, 1997. Results will be tabulated and summarized in the brochure for the October 2, 1997, TUFFP Advisory Board meeting.

TUFFP Short Course - Another Success

Once again, a successful short course on "Two-Phase Flow in Pipes" was held April 28 - May 2, 1997, in Tulsa, Oklahoma. The course was attended by 23 engineers and scientists, including 20 from 9 TUFFP member companies and 3 from 3 non-member companies. Income from the course was sufficient to pay all expenses incurred. A tentative date of April 27 - May 1, 1998, has been established for the next TUFFP short course.

TUFFP/Wax Facilities Commissioned



Ribbon Cutting Ceremony

Kamran Mirza - Robbins & Myers, John Stava - Stava Building Corp., Cliff Redus - Texaco, Steve Belovich and James P. Brill - University of Tulsa

On April 22, 1997, a commissioning ceremony was held on the North Campus of The University of Tulsa for TUFFP's low-liquid holdup and oil-water flow test facilities and also for both the single-phase and two-phase flow paraffin deposition test facilities for the Wax JIP. Although only the single-phase paraffin deposition facility was fully operational, it was possible to observe the site and plans for the remaining test facilities.

Approximately 75 TUFFP and Wax member representatives, local contractors, and equipment manufacturing companies who had

donated significant amounts of equipment were in attendance. Also attending were several University of Tulsa staff, administrators, and faculty. Following the commissioning ceremony and tour of test facilities, a barbecue dinner was enjoyed by all.



Facilities Commissioning Ceremony

Meetings and Conferences

Future Advisory Board Meetings Schedule

Final plans have been made for the fall 1997 TUFFP Advisory Board and related meetings. An exciting collection of meetings has been scheduled to immediately precede the SPE Annual Technical Conference and Exhibition in San Antonio. All meetings will be held at the Adam's Mark Hotel at Williams Center in downtown 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 Thursday, October 2, 1997, and will adjourn at 4:30 p.m. A pre-meeting reception will be held at the Adam's Mark Hotel from 6:00 - 8:00 p.m. on Wednesday, October 1, and will be joined by those attending the paraffin deposition JIP Advisory Board meeting, which will be held on Wednesday. A tour of TUFFP test facilities will be conducted on Wednesday afternoon from 3:00 to 4:30 p.m.

A summary of the dates for fall 1997, spring 1998, and fall 1998 Advisory Board meetings are shown in the table. The hotel for the spring and fall 1998 Advisory Board meetings has not yet been determined.

TUFFP Advisory Board meeting brochures will be mailed to all members prior to the meetings. 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.

| Month | Year | Meeting Name |
|-----------|------|---|
| September | 1997 | Paraffin Deposition JIP Executive Committee Meeting |
| September | 1997 | Tour of Paraffin Deposition JIP Test Facilities |
| September | 1997 | Paraffin Deposition JIP Advisory Board Meeting |
| September | 1997 | Tour of TUFFP Test Facilities |
| September | 1997 | Joint TUFFP/Paraffin Deposition JIP Executive Reception |
| October | 1997 | TUFFP Advisory Board Meeting |
| October | 1997 | TUFFP Annual Multiphase Flow Workshop Reception |
| April | 1998 | Paraffin Deposition JIP Executive Committee Meeting |
| April | 1998 | Tour of Paraffin Deposition JIP Test Facilities |
| April | 1998 | Paraffin Deposition JIP Advisory Board Meeting |
| April | 1998 | Tour of TUFFP Test Facilities |
| April | 1998 | Joint TUFFP/Paraffin Deposition JIP Executive Reception |
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| September | 1998 | Tour of TUFFP Test Facilities |
| September | 1998 | Joint TUFFP/Paraffin Deposition JIP Executive Reception |
| September | 1998 | TUFFP Advisory Board Meeting |

BHR Group Schedules First Multiphase Conference in North America

BHRG will sponsor their first North American Conference on Multiphase Technology in Banff, Canada, June 9 - 12, 1998. Cosponsors of the conference include TUFFP and NeoTechnology Consultants, Limited. A call for papers has been issued with abstracts required by September 29, 1997. Manuscripts for accepted abstracts will be due by January 17, 1998. The call for papers is enclosed with this newsletter.

TUFFP Schedules Second Multiphase Flow Transient Forum

The first TUFFP Multiphase Flow Transient Forum was held in New Orleans, Louisiana, on September 29, 1994. Thirty seven attendees from 23 companies were present at the forum, which was hosted by Texaco. Thirteen presentations were made covering various interesting aspects of multiphase transient flow. Since then, a considerable increase in utilization of transient flow simulators as a design tool has occurred. It is clear that transient multiphase flow simulators have become one of the standard analysis and design tools used in the transportation of oil-water-gas mixtures.

A common platform to share and discuss experiences gained in the utilization of different transient simulators has proven to be very useful and productive in the past. Consequently, TUFFP announces that the second Multiphase Flow Transient Forum will be held October 3, 1997, at the Adam's Mark Hotel in Tulsa, Oklahoma. The forum will immediately follow Advisory Board meetings for the Paraffin Deposition JIP on October 1 and the Fluid Flow Projects on October 2.

As in the original forum, there will be no minutes, recordings, or publications permitted to enhance the possibility of open discussions and

informal sharing of information. The forum will also be open to non-presenting companies and non-TUFFP member companies to increase the attendance and promote lively discussion.

Anticipated forum topics will include the following:

- Experiences with multiphase transient simulators in comparisons with available field and experimental data.
- Innovative solutions to multiphase flow problems.
- Assessing the adequacy of current transient simulators.
- Discussion of needed simulator improvements.
- Alternative simulation techniques

Persons interested in making a 15-minute presentation should submit an abstract to Cem Sarica by August 7, 1997. Registration forms have been distributed and should be returned by September 15, 1997, to help in planning the forum. A registration fee of \$60 per person will be charged to cover the room, luncheon, audio visual, printing, and mail/fax costs.

1997 Fluid Flow Projects Membership

Ameo Production Company

Arabic Oil Co. Ltd.

Arco Oil & Gas Company

BP Exploration

Beiplo

Chevron Petroleum Technology Company

Conoco, Inc.

IGOPETROL/Instituto Colombiano del Petroleo

Elf Aquitaine

Exxon Production Research Company

Institut Français du Pétrole

INTEVER

Japan National Oil Corporation

Marathon Oil Company

Mobil Research and Development Corporation

Oil and Natural Gas Commission of India

Reemina

Paroslat

Petronas

Saudi Arabian Oil Company

Shell Internationale Petroleum Mij B.V. (SIPM)

Simulation Sciences, Inc.

Texaco

TOTAL

UNOCAL

Paraffin Deposition JIP Update

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 27 domestic and international oil and gas related companies, DOE, GRI, and the U.S. Department of Interior's Mineral Management Service. The JIP is coordinated through five committees chaired by industry members. These committees are: Flow Loop and Deposition Studies; Thermodynamics and Fluid Characterization; Heat Transfer; Operational Issues; and Technology Transfer. 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 October 1, 1997, the day before the TUFFP Advisory Board meeting. The purpose of this update is to describe progress made in the JIP since the last TUFFP Advisory Board meeting on April 23, 1997.

All remaining major modifications to the single-phase flow loop have been completed. A new Moyno progressing cavity

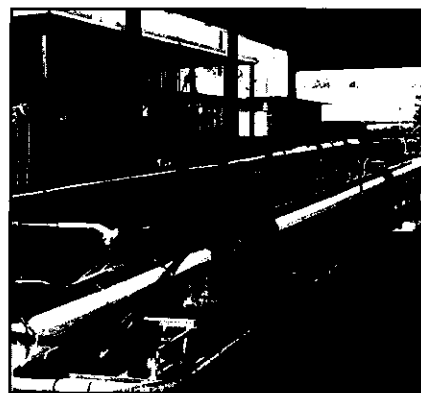


Howard Rettig, Billy Smith, and Chris Weatheril replacing spool piece containing ultrasonic sensor in single-phase flow loop.

pump (75 gpm capacity) and Alan Bradley controls, all donated by Robbins & Myers, was installed. Two impedance heating systems for trimming inlet oil and glycol temperatures were installed. Insulation of the pipeline, oil and glycol feed and return lines, and tanks were upgraded. The piping arrangement for

the glycol cooling system was modified to permit maintaining temperatures anywhere between 20°F and 150°F. Calibration of all Rosemount pressure transmitters was confirmed. All RTDs for measuring oil and glycol temperatures were calibrated.

Final single-phase testing of the South Pelto crude oil began in early July. Initial tests confirmed that excel-



Induction temperature trimming heaters installed in wax single-phase flow loop.

lent control of all variables was possible at higher flow rates. Improved temperature control procedures are being developed for low flow rates. An ultrasonic sensor for confirming and measuring paraffin deposition was successfully tested in the initial single-phase flow tests. The sensor was developed by the Christian Michelsen Research Institute (CMR) in Bergen, Norway, in collaboration with Norsk Hydro and Chevron. A test matrix for conducting final single-flow tests has been developed, and tests will continue throughout the fall.

Design of the multiphase flow loop has been completed. Most

major equipment items have been ordered and are beginning to arrive. Construction of the multiphase flow loop will soon begin with a target of flowing the loop in November and beginning multiphase tests in early January. Single-phase flow tests have yielded invaluable information for improving the multiphase flow loop design and operating procedure.

The final report for the characterization work conducted by Marathon has been reviewed and will soon be distributed to JIP members. The thermodynamic model was completed by Multiphase Solutions Inc. and tested against all data available to the JIP. Component lumping and characterization procedures have been added for heavy hydrocarbons, allowing the model to predict reasonable saturation points and liquid densities without tuning. A Beta version of the program and a final report will soon be distributed to JIP members.



CMR, Norsk Hydro, and Chevron celebrate ultrasonic sensor success!

Three graduate students serve as research assistants on the wax JIP. Bazlee Matzain of Petronas in Malaysia completed his M.S. degree with an analysis of the preliminary single-phase flow tests completed in September 1996 using the South Pelto oil. He is now pursuing a Ph.D. degree working on the multiphase flow deposition part of the JIP. Hans-Jacob Lund and Mandar Apte are both pursuing M.S. degrees in petroleum engineering working on the project. A visiting scholar, Emmanuel Del Casse of France arrived in November to work on the project for a period of 16 months. He is fully supported by Elf Aquitaine. Dr. Tom Chen will serve as the key research associate on the project until his departure later this summer to join Texaco. A complete staff of technicians, student helpers, and a project construction engineer have been involved in preparation of the facilities. Overall supervision is provided by Dr. Brill and Dr. Mike Volk, who serve as the co-principal investigators.

Optimization of Horizontal-Well Completion

A new joint industry project (JIP) titled "Optimization of Horizontal Well Completions" is being established. The JIP will develop a comprehensive model to incorporate the interaction of the wellbore with the reservoir and to provide guidelines for optimizing well performance by controlling fluid influx along the well length. This JIP will be a collaborative effort between reservoir and production disciplines within the Petroleum Engineering Department at The University of Tulsa. The principal investigators are Drs. Erdal Ozkan, Cem Sarica, and Mohan Kelkar.

Available horizontal well models for performance prediction usually neglect flow impairment caused by restricted inflow into a cased or liner completed horizontal well and therefore cannot be used to investigate the influence of the well completion. For a complete description of horizontal well performance, it is essential that: i) the effect of the flow convergence toward small openings on the well surface be incorporated into the reservoir flow models; ii) the additional pressure drop caused by the inflow through restricted openings be incorporated into the wellbore flow models; and iii) flow in the reservoir and in the wellbore be rigorously coupled. Once a complete and rigorous horizontal well-reservoir flow

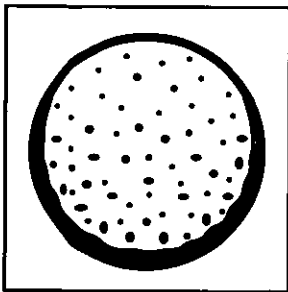
model is developed, it can be used to obtain estimates of well performance under different completion scenarios and to derive guidelines for the design of optimum well completions.

The research goals include modeling of flow around perforations and slots on the surface of the horizontal well and developing correlations to lump the effect of fluid ingress through small openings on the surface of the well into the standard horizontal pipe flow equations. In terms of deliverables, the JIP intends to provide: i) the guidelines to optimize horizontal well completions; ii) a user friendly software to evaluate well performance under various completion scenarios; and iii) a perforation pseudoskin that can be incorporated into the standard deliverability equations and be used in reservoir simulators. An early version of the horizontal-well performance computation program for open-hole completions that incorporates the influences of wellbore hydraulics, selective well completion, and variable skin effect will be delivered to the members at the beginning of the JIP. The budget of the JIP includes membership fees (\$12,000/year/company) of the participating companies for two years, and funding from various federal and state government agencies such as the Department of Energy (DOE) and the Oklahoma Center for Advancement in Science and Technology (OCAST).

The initial concept of the JIP was formulated in March 1997. An introductory presentation of this project was made by Erdal Ozkan at the April 23, 1997, TUFFP Advisory Board meeting. A preliminary proposal has been distributed to representatives of 42 companies. We have received enthusiastic support and verbal commitment from three companies to promote the proposal for final approval. The formal proposal and legal documents were sent to 28 potential member companies in June 1997. Final responses from potential members are expected over the next two months.

To attract federal funds, a preliminary proposal was sent to the Bartlesville Project Office of the U.S. Department of Energy by Mohan Kelkar in March 1997. Based on their positive response to the preliminary proposal, a formal proposal was submitted to the Bartlesville Project Office on June 3, 1997. Support from DOE is expected in the forms of graduate student funding (through the AWU Student Funds) and regular membership. For additional funds, a formal proposal has recently been submitted to OCAST.

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 recent literature and the topic has not been adequately studied. Existing simulation 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 gas pipelines, will be studied. Compressed air and a highly refined oil will be used as testing fluids. Liquid film thickness distribution around the pipe wall will be measured using the newly developed TUFFP capacitance probes. Total liquid holdup and liquid entrainment fraction in the gas phase will be measured using quick-closing valves and a liquid film removal technique, respectively. Pressure drops will also be measured using differential pressure transducers. Based on experimental results obtained, a comprehensive mechanistic model and its closure

relationships will be developed.

Significant progress has been achieved since the last Advisory Board meeting on April 23, 1997. The design of new pipe joints (Collar Type) and a new liquid film removal device have been completed and are currently being manufactured. The preparation of data acquisition programs is nearly completed. The test facility is expected to be operational in August 1997. Modeling studies are also underway.

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. Because of the complex nature of two-phase flow in pipes, the prediction of pressure drop in producing wells was first approached through empirical correlations. The trend has shifted in recent years to the modeling approach. 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 more confidence to flow conditions other than those used for their development.

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.

The Barnea unified model for flow pattern

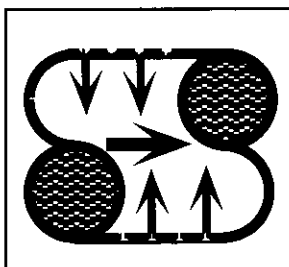


A. S. Kaya

prediction will be thoroughly studied and tested against the expanded TUFFP well databank. The next step is to develop mechanistic models to predict flow characteristics such as liquid holdup and pressure drop for independent flow patterns and test them against the databank.

A deviated well data solicitation form has been prepared and sent to TUFFP member companies and some non-member companies. We expect to complete databank expansion by the end of 1997. Modeling studies have already been started.

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. In the first phase of this project, a new generalized

friction factor expression for a single perforation horizontal well was developed using the principles of conservation of mass and momentum. A simple correlation for the horizontal well friction factor was then developed by applying experimental data to the generalized friction factor expression.

The objectives of the second phase of this project include investigating flow behavior in perforated horizontal wells and horizontal wells completed with slotted liners. Investigation of perforated horizontal well flow behavior has been completed. Experiments for the single slot case have been completed and a total of 277 tests were conducted. Three test sections were designed for the multiple slot case, with different slot distributions and densities. Test section construction has been completed, and 288 data points have been acquired. Data acquisition for the multiple slot case is still underway. These experiments

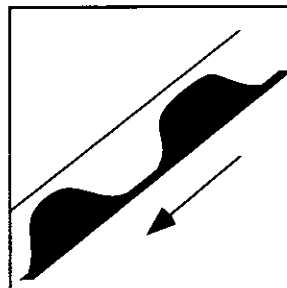


Hong "Jasmine" Yuan

will be completed in July.

CFD simulations of horizontal well flow have been performed using Fluent. It has been concluded that CFD simulators are not capable of properly simulating the complex flow behavior of horizontal wells.

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 dissipation in a hilly terrain pipeline.

A preliminary slug dissipation model has already been developed and presented at the TUFFP Advisory Board meeting on April 23, 1997. Currently, modifications of the existing inclined flow test facility are underway. The upward section, where air and mineral oil are mixed and slug flow is generated, has been modified for this study. Normal commercial steel pipes and transparent PVC-R4000 pipes are used upstream and downstream of the upward inclined section, respectively. Construction of 13 capacitance sensors and the corresponding electric circuits is nearly completed. The capacitance sensors are currently being calibrated statically. A quick-closing valve system for dynamic calibration of the capacitance sensors is also being manufactured. Modifications of the test facility will soon be followed by pre-testing and experimental data acquisition.

**Fluid Flow Projects Advisory
Board Meeting
October 2, 1997**

Two-Phase Flow Calendar

SPE Forum on Multiphase Flow, Aviemore, Scotland

Paraffin Deposition JIP Advisory Board Meeting, Tulsa, Oklahoma

TUFFP Advisory Board Meeting, Tulsa, Oklahoma

TUFFP Multiphase Flow Transient Simulation Forum, Tulsa, Oklahoma

SPE Annual Technical Conference and Exhibition, San Antonio, Texas

International Symposium on Multiphase Fluid, Non-Newtonian Fluid, and Physico-Chemical Fluid Flows '97, Beijing, China

IBC Second Annual International Conference on Controlling Hydrates, Waxes and Asphaltenes, Aberdeen, Scotland

ONGC Limited Round Table Conference on "Controlling Hydrates, Waxes and Asphaltenes," Bombay, India

International Symposium on Liquid-Liquid Two-Phase Flow and Transport Phenomena, Antalya, Turkey

IBC Conference on Controlling Hydrates, Paraffins, and Asphaltenes, New Orleans, Louisiana

ASME Annual Winter Meeting, Dallas, Texas

IFP International Conference on "Production of Reservoir Fluids in Frontier Condition," Rueil Malmaison, France

ASME Energy-Sources Technology Conference and Exhibition (ETCE), Houston, Texas

SPE India Oil & Gas Conference and Exhibition, New Delhi, India

Paraffin Deposition JIP Advisory Board Meeting, Tulsa, Oklahoma

TUFFP Advisory Board Meeting, Tulsa, Oklahoma

TUFFP Short Course on Two-Phase Flow in Pipes, Tulsa, Oklahoma

Offshore Technology Conference, Houston, Texas

First North American Conference on Multiphase Technology, Banff, Canada

Paraffin Deposition JIP Advisory Board Meeting, Tulsa, Oklahoma

TUFFP Advisory Board Meeting, Tulsa, Oklahoma

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