TUFFP NEWSLETTER

A Semiannual Publication of the Tulsa University Fluid Flow Projects

February 1989 Volume 3, Number 1

Directory

Director: Dr. J. P. Brill

Assoc. Director: Dr. O. Shoham

Research Assoc.: Dr. Y. Taitel

Administrative Secretary:
Rosa Jackson

Technicians: C. Ingle
D. Robinson

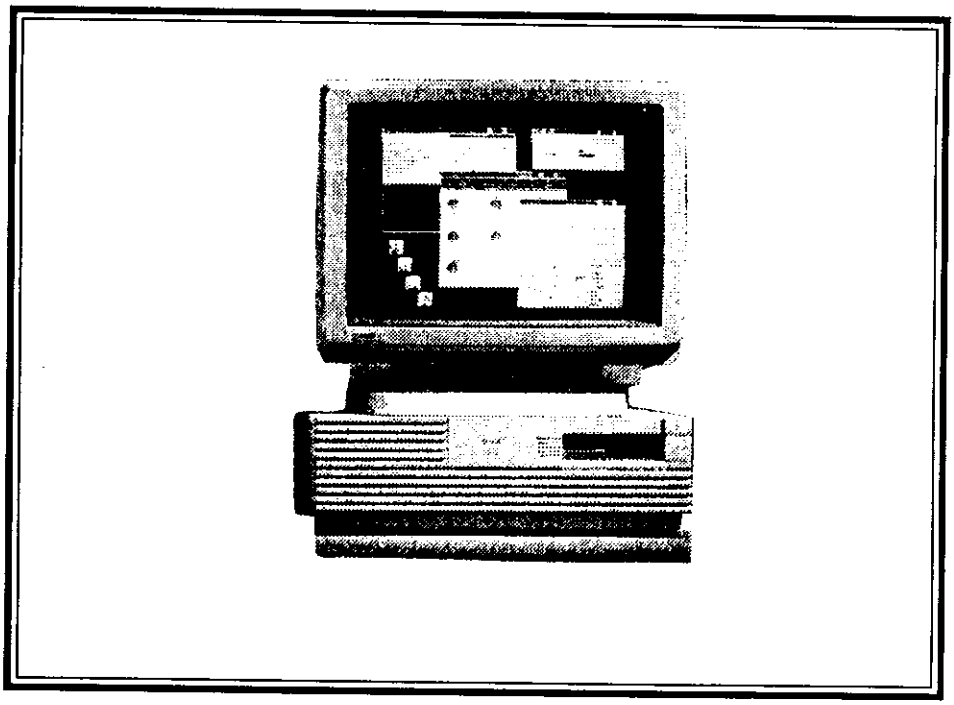
Research Assistants:
I. Alves C. Daza
K. Minami S. Arirachakaran
C.Sarica M. Gokdemir
G. Zheng J. Xiao
F. Jansen D. Papadimitriou

Computer Resources:
Lorri Jefferson - Manager
Luis Ahumada - Asst. Manager

Secretaries:
R. Minami & N. Arirachakaran

600 South College Avenue
Tulsa, Oklahoma 74104
918-631-3040
Telex: 747135 Fax: (918)-631-2167

TUFFp Talk



Apollo Donates Computers to TU

We were delighted to learn in early November, 1988 that Apollo Computer, Inc. had agreed to donate eight of their DN3550 computer workstations to the Petroleum Engineering Department. Each of the computers has eight megabytes of memory, a floating point accelerator, full eight plane color, a 348 megabyte hard disk, and is valued at over $35,000. The total magnitude of the gift was $305,000. TUFFP will receive three of the nodes, and the Petroleum Engineering Department will receive four of the nodes with the remaining node going to the Drilling Research Projects. These state-of-the-art workstations will dramatically increase computing capabilities for all research conducted in Petroleum Engineering. In particular, the three new nodes in TUFFP will permit modernization of our already sophisticated Apollo network.

(continued on p. 2)

(Apollo donation continued from p. 1)

Engineering departments at The University of Tulsa have standardized their technical computing use with Apollo computers. Six separate but interconnected token ring networks involving over 30 Apollo workstations have now been established. The College hopes to purchase 10 nodes during 1989 for an undergraduate laboratory. In addition, another proposal has been submitted to Apollo requesting a donation that includes a DN10020. This would provide super minicomputing capabilities to the College for use in research projects involving well test analysis, reservoir simulation, transient two-phase flow, finite element applications and many others.

TUFFP Announces Dates for Advisory Board Meetings

The next two Advisory Board meetings will be held May 9-10, 1989 and November 7-8, 1989. The May meeting will be held at the Sheraton Kensington Hotel in Tulsa, Oklahoma. Consideration is being given to holding the November meeting at the Doubletree Hotel in Tulsa. Request for Information forms will be mailed to member companies approximately 6 weeks prior to each meeting to determine attendance. The forms will be accompanied by information pertaining to hotel reservations and accomodations to and from the airport.

The Advisory Board meetings will begin at 8:30 a.m. and will adjourn at 4:30 p.m. A pre-meeting cocktail party will be held at the Sheraton Kensington Hotel 5:30-7:30 p.m. on Tuesday, May 9 and at the hotel selected for the meeting on Tuesday, November 7. Tours of the TUFFP test facilities will also be held on Tuesday afternoons from 3:00-4:30. The above meeting dates were selected to accomodate those member companies who also attend Advisory Board meetings of other cooperative research programs at The University of Tulsa. The following is a summary of these meetings for May, 1989.

- Erosion/Corrosion Monday, May 8
- Reservoir Exploitation Monday, May 8
- Drilling Research Tuesday, May 9
- Fluid Flow Projects Wednesday, May 10
- Artificial Lift Projects Thursday, May 11

TUFFP Advisory Board meeting brochures will be mailed to all members prior to the meetings. They will contain sufficient information to enable each attendee to 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 meetings but will not be mailed to members.

TUFFP Personnel Present Papers at Technical Meetings

Dr. J. P. Brill and Dr. O. Shoham represented TUFFP at the SPE Annual Fall Meeting in Houston, Texas October 2-5, 1988. Dr. Brill presented a paper titled, "Dynamic Simulation of Slug Catcher Behavior". Dr. Shoham presented a paper titled, "Prediction of Dispersion Viscosity of Oil-Water Mixture Flow in Horizontal Pipes." Both papers were based on research projects completed by TUFFP.

Mr. S. Arirachakaran, a Ph.D. student in TUFFP, will present a paper at the SPE Production Operations Symposium in Oklahoma City March 12-14, 1989. The title of his talk will be "An Analysis of Oil-Water Flow Phenomena in Horizontal Pipes". This paper is a summary of M.S. theses completed at TUFFP on oil-water flow in 1975 by Malinosky, in 1979 by Oglesby, and in 1983 by Arirachakaran.

Mr. I. Alves presented a paper titled, "Modeling Annular Flow Behavior for Gas Wells" at the ASME Annual Meeting in Chicago, November 27-December 2, 1988. The paper was based on his M.S. thesis work completed at the Universidad Federal de Ouro Preto in Brazil.

Dr. Shoham, Dr. Brill and Dr. E. Caetano of Petrobras will attend the BHRA Fourth International Conference on Multiphase Flow in Nice, France in June. Both Dr. Brill and Dr. Caetano were on the organizing committee for the conference. Dr. Brill will serve as a Session Chairman and Dr. Caetano will present two papers based on his Ph.D. research at TUFFP on modeling two-phase flow through a vertical annulus.

Calendar for Two-Phase Flow Technical Meetings

Several conferences are scheduled for 1989 which include technical sessions involving multiphase flow in pipes. A calendar of these events is given below.

March 12-14	SPE Production Operations Symposium - Oklahoma City, Oklahoma
May 10	TUFFP ABM - Tulsa, Oklahoma
May 11	TUALP ABM - Tulsa, Oklahoma
May 22-26	TUFFP Short Course - Tulsa, Oklahoma
June 12-16	TUFFP Short Course - London, U.K.
June 19-21	BHRA Fourth International Conference on Multiphase Flow - Nice, France
October 8-11	SPE Annual Fall Meeting - San Antonio, Texas
October 19-20	PSIG Meeting - El Paso, Texas
November 5-1 0	AIChE Meeting - San Francisco, California
November 8	TUFFP ABM - Tulsa, Oklahoma
November 9	TUALP ABM - Tulsa, Oklahoma

TUFFP Adds Two New M.S. Students

Mr. Metin Gokdemir, an M.S. student funded by the Turkish Government, has been selected to work on a new TUFFP research to develop a model for predicting wellbore phase separtion phenomena when wells are shut in at the surface to conduct pressure buildup tests. Metin began his Graduate program in January 1988.

Mr. Dimitri Papadimitriou, a self supported M.S. student from Indonesia, has also been selected to work on a TUFFP research project to develop a mechanistic model for predicting bottomhole pressures in pumping wells. This project was initially an independent study that has been expanded into a thesis topic. Dimitri has been in the M.S. program for over a year and is scheduled to complete his research by Fall 1989.

Lorri Jefferson began her graduate program in Computer Science in January 1989 following completion of deficiency work during the Fall term 1988. Lorri has worked for TUFFP for over a year managing our increasingly complex computer network.

TUFFP Upgrades Macintosh Computers

A decision was made in 1988 to increase the memory of all TUFFP Macintosh Plus and Macintosh SE computers. In January, eight of these machines were upgraded from 1MB to 2.5MB memories, and one machine was increased to 4MB of memory. In addition, an AppleShare Network using the 4MB Macintosh Plus as a server has been implemented. This will give all students and staff enhanced capabilities in the areas of word processing, spreadsheets, data bases and some graphics and technical computing. In addition, an electronic mail system has been installed.

Membership Outlook Continues to Improve

Simulation Sciences, Inc. has officially joined TUFFP for 1989. In addition, it still appears that YPF from Argentina will join during 1989. These two companies, together with Schlumberger, who renewed its membership for 1989 after a lapse of two years, would permit us to achieve our budgeted membership income goal. Strong indications of interest in joining TUFFP have also been received by the National Iranian Oil Corporation (NIOC), the Oil and Natural Gas Commission of India, and AGIP.

TUFFP Students Pass Ph.D. Qualifying Examinations

Three TUFFP Ph.D. students successfully passed their Ph.D. Qualifying Examinations in January 1989. These students were Ibere Alves, Kazu Minami, and Guohua Zheng. Reaching this stage of their Ph.D. programs officially makes them candidates for the Ph.D. Degree. Each student is nearing completion of the course work preparation stage of their programs and will soon devote full-time to conducting research. All five Ph.D. students in TUFFP have now achieved this status.

TUFFP Short Courses Scheduled

Final details have now been completed in scheduling the TUFFP Short Courses for 1989. An updated version of the standard TUFFP Short Course, "Two-Phase Flow in Pipes", will be held again in Tulsa, Oklahoma May 22-26, 1989 at the Sheraton Kensington Hotel. The course will also be taught at the Sheraton Heathrow Hotel in London, England June 12-16, 1989. The London course is scheduled the week prior to the BHRA meeting in Nice, France. Both courses will again be taught jointly by Dr. Brill and Dr. Shoham.

The purpose of these courses is to give participants a well grounded understanding of the fundamentals of two-phase flow through pipes and restrictions. Completed and current research projects permit teaching the latest techniques for designing multiphase flow piping systems. Upon completion, the participants will be able to apply knowledge gained to design fluid flow conduits encountered in petroleum, natural gas and chemical engineering operations.

As a result of having to cancel the TUFFP course in 1988, a decision was made to eliminate the free enrollment to TUFFP members. Rather, a pricing structure has been established that will permit member companies to enroll two people for nearly the same cost as two enrollments in past years. Following is the pricing structure for both the Tulsa and the London courses. Brochures describing the course were mailed to members and other potential participants in mid February.

TULSA:

Member's first enrollee: $750
(if enrolled one month before course: $695)
Member's subsequent enrollees: $600 each
Non-member enrollees: $995 each
(if enrolled one month before course: $950)
Non-member subsequent enrollees: $800 each

LONDON:

Member's first enrollee: $995
(if enrolled one month before course: $950)
Member's subsequent enrollees: $850 each
Non-member first enrollee: $1,150
(if enrolled one month before course: $1,095)
Non-member subsequent enrollees: $995 each

Some of the significant improvements that have been made in the short course include: a comprehensive mechanistic model for predicting two-phase flow in vertical wells; an improved method for predicting temperatures in flowing wells; and, new material on treating the flow behavior of oil-water emulsions as non-Newtonian fluids.

We urge member companies to enroll engineers as soon as possible. If an insufficient number of enrollees are obtained by mid-April, it will again be necessary to cancel the courses.

Lorri Jefferson Prepares Newsletter

Lorri Jefferson

Design of the TUFFP Newsletter was performed by Lorri Jefferson using the PageMaker desktop publishing application. She also prepared all artwork for icons and diagrams of the TUFFP computer systems and test facilities. MacVision was used to prepare photographs.

Distribution of Magnetic Tape and User's Manual

Preparation of the magnetic tapes and users' manuals continues to be a logistic nightmare. We now anticipate distribution will take place in late March. Two 9-track, 6250 bpi, ASCII tapes will be mailed to all TUFFP members. We are in the final stage of mounting files on master tapes. Copies of the tapes will be sent to two TUFFP members to identify any tape reading problems before duplication and distribution can occur. Following is a summary of files planned for the tapes.

- 22 of the 24 files distributed previously to requesting TUFFP members and listed on pg 21 of May 14, 1986 Advisory Board meeting brochure. GPA*SIM files will not be included.
- Fortran programs and data files based on Dutta-Roy, Caetano, Scott, and Vierkandt research reports.
- New CORE programs (GRAD87, PVT87, MATH87) with revisions to correct any errors found during 1988 and addition of Ansari models to GRAD87.
- Updated TUFFP well data bank and user programs.
- Prudhoe Bay data and user programs.

A concurrent mailing to TUFFP members will include the following:

- Users Manual for the Scott program.
- Users Manual for Prudhoe Bay data.
- Errata for TUFFP CORE Software Users Manual distributed to members in 1988 and a listing of the files added to GRAD87 for the Ansari report.

Dr. Shoham Receives Research Contract from Lumus-Crest

A contract research project has been funded by Lumus-Crest on behalf of AGIP, Chevron and Texaco. The project will involve determining the rheological behavior of oil-water mixtures using oil from a field in the South China Sea. The TUFFP oil-water flow test facility is being modified by technicians Charles Ingle and Doug Robinson. Modifications include adding a 0.5 in. test section, heating capabilities, improved electronics and venting of oil vapors.

Charles Ingle

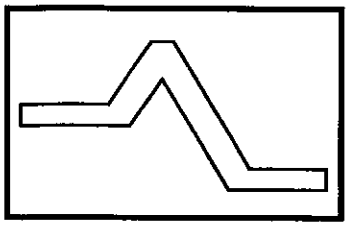
Doug Robinson

Graduate Seminars Continue

Numerous TUFFP Graduate Seminars have been held since the August Newsletter and several more are scheduled for the remainder of the Spring term 1988. Some of the seminars were presented by invited distinguished lecturers. Following is a summary.

TIME	SPEAKER	TOPIC
August 12	Dr. Y. Taitel Distinguished Lecturer	*Two-Phase Flow:* Modifications of Severe Slugging Model
August 26	Kazuioshi Minami	*Two-Phase Flow:* Gas Flow Through Stagnant Liquid in Inclined Pipes
September 16	Steven Vierkandt	*Oral Presentation:* Stability of Severe Slugging in Pipeline-Riser Pipe System
September 30	Dr. O. Shoham	*SPE Fall Meeting Presentation:* Prediction of Oil-Water Dispersion Viscosity
November 4	Trevor J. Hill Distinguished Lecturer	*Two-Phase Flow:* Two Phase Flow Research Activities in SE Forties Field
November 18	Ibere Alves	*ASME Winter Meeting Presentation:* Modeling Annular Flow Behavior in Gas Wells
December 2	Asfandiar Ansari	*Oral Presentation:* Comprehensive Mechanistic Model for Upward Two Phase Flow
January 20	D.G. Wood Distinguished Lecturer	*Two-Phase Flow:* The Effect of Inclination on Flow Regime Boundaries and Slug flow Characteristics
February 3	Dr. O. Shoham	*Well Testing:* Wellbore Separation Phenomena in Pressure Buildup Tests
February 10	Dr. Alan Baker Distinguished Lecturer	*Two-Phase Flow:* PIPESIM Development and Use in Two-Phase Flow Design
March 3	J. Kikani Distinguished Lecturer (Stanford)	*Reservoir:* Application of Boundary Element Method to Reservoir Engineering Problems
March 3	S. Arirachakaran	*SPE Production Operation Symposium:* An Analysis of Oil-Water Flow Phenomena in Horizontal Pipes
March 17	G. Zheng	*Two-Phase Flow:* Review of Creare Model (Part 1)
March 24	J. Bailey, P. Weaver Distinguished Lecturers	*Computer:* Use of PANET for On-Line Literature Searching
April 7	G. Perez	*Computer:* Apollo System Administration School Summary SR 10
April 28	Dr. S. Scott Distinguished Lecturer	*General:* Ekofisk Subsidence Problem

Research Projects

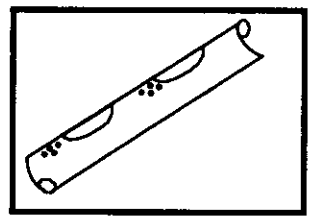


Two-Phase Slug Flow in Hilly Terrain Pipelines

G. Zheng

This project represents the first step in an on-going effort in TUFFP towards a comprehensive analysis of two-phase flow in hilly terrain pipelines. In this project, the effect of pipe inclination on slug characteristics in upward, shallow inclined pipelines is being examined both experimentally and theoretically. A long, versatile test facility has been fabricated which enables inclination angles from -1° to +5° from the horizontal. The test facility can also be modified easily for later studies of hilly terrain configurations. Extensive instruments, including nine ring capacitance sensors and eight pressure transducers were installed for two-phase flow measurements. A microcomputer based data acquisition and control system is being utilized.

The model outlined in the November 1988 Advisory Board meeting is now being evaluated. Following this, an interim report will be prepared and distributed. Another two ring capacitance sensor is already being assembled which will be utilized in a new observation station upstream from the separator. The station is necessary to study the overall effect of an upward inclined pipe and a downcomer on slug flow characteristics in a long horizontal pipeline. Additional experiments will be conducted from March through May when weather conditions become favorable. The new tests will include data for a pipe inclination of -1° from the horizontal, and are intended to cover a broad range of slug flow conditions.



Slug Flow in Directional Wells

Ibere Alves

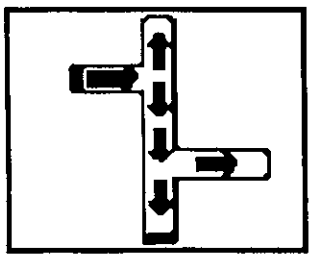
This project consists of an experimental and theoretical study of slug flow in upward inclined pipes. Slug flow is one of the most common flow patterns in wellbores and pipelines, occurring over a wide range of flow rates.

Design and construction of the experimental test facility for the project are underway. The previous test facility and metering section used by Caetano (1985) were removed. The previous instrumentation building was replaced with the building used by Kouba (1986). This new building is more suitable for housing the computer based data acquisition system.

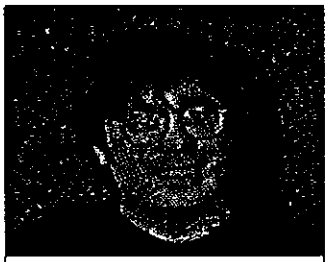
A new metering section will have two sets of orifice meters to measure the gas flow rate. For metering the liquid phase, three turbine meters are needed to cover the entire liquid flow rate range. The flow rates through the metering section will be controlled by two electrical needle valves placed downstream of the meters.

The test section consists of two legs. The first leg is 2 in. PVC R-4000 transparent pipe. This section is approximately 50 ft long and will allow visualization of the flow behavior. All instrumentation required for measuring the flow characteristics will be placed in this leg. The second leg is the first part of the return line.

The data acquisition system is based on a Turbo-Tech PC-AT (IBM compatible) using LABMASTER. The system is presently installed on a small scale facility to help in the development of some of the software that will be needed to run the system.



Slug Flow Splitting Phenomena in Side-Arm & Impacting Tees



S. Arirachakaran

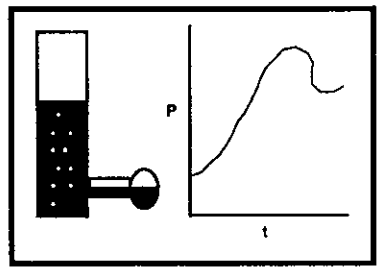
Slug flow splitting at a regular horizontal side-arm tee and elbow effects on slug flow splitting at a regular horizontal impacting tee are the two primary objectives of this study. Models which describe preferential liquid movement through these pipe tees will be developed, and verified with the acquired and published experimental data.

The gas and liquid flow meters of the experimental facility have undergone extensive calibrations, and are now ready for conducting experimental tests. The remainder of the test facility was completed by the November, 1988 Advisory Board meeting.

Most instruments have been interfaced to the PC data acquisition unit, with the exception of the capacitance sensors, which are still being modified and assembled. Some electronic problems were encountered during the calibration process of the modified air-water circuit for the 2-in. capacitance sensor prototype which warranted further investigations. These are being remedied, and should be corrected by the end of February, when the experimental system would be fully operational.

Some technical problems were also encountered during the testing of controlling software routines developed for this data acquisition system. These problems are due to the different assignment numbers of hardware calling routines between the PC Design AT and the IBM PC-AT. Actions are being taken to debug these second-generation acquisition routines, and should be accomplished by early March.

Due to the limitation of the A/D converter channels available on the two acquisition boards, the data acquiring process has been divided into two sessions. The first session will serve as the preliminary step, and will involve stabilizing the flow, and collecting the pertinent data on slug characteristics. These data will be analyzed by Carlos Daza. The second session will concentrate on collecting data pertaining to the splitting of the slug flow at the tee junction. The two session process will also allow a longer testing period for each session without filling up all the available memory of the computer unit.

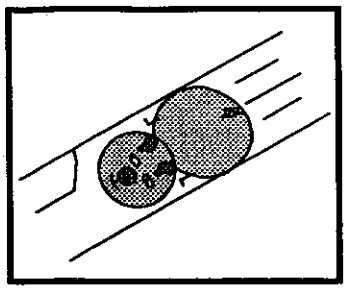


Wellbore Phase Separation Phenomena in Pressure Buildup Tests

Metin Gokdemir

Surface shut-in of wells for pressure buildup tests can cause phase separation in wellbores which produces an increase in bottomhole pressure. This increase results in a pressure "hump" in the pressure buildup curve which makes the interpretation of buildup test data difficult. A study of the phase separation phenomena will permit more accurate interpretation of pressure buildup curves.

The objective of this study is to investigate the effect of phase separation on bottomhole pressure behavior using a mechanistic modeling approach. The first part of the study is to consider the wellbore alone, isolated from reservoir influences.



Modeling Pigging Dynamics in Two-Phase Pipelines

K. Minami

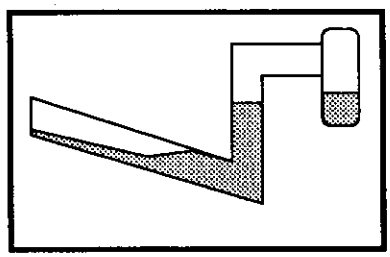
Complex transient phenomena occur when two-phase pipelines are pigged. Immediately after a pig is introduced in a pipeline, a relatively fast transient takes place, with rapid changes in liquid holdup and pressure. After the pig has exited the pipeline, a much slower transient then follows, characterized by a gradual buildup of liquid along the line.

The objective of this project is to investigate theoretically and experimentally the dynamics of pigging operations. The knowledge of the flowing characteristics will enable proper design of wet-gas pipelines and liquid handling facilities.

The theoretical part will include the development of models for predicting pressure, liquid holdup and velocity along the pipe. The experimental part will include collecting transient flow and pigging data on the 1400 ft long, 3 in. diameter pipeline with or without hills, using a kerosene-air mixture.

The pigging model will consist of separate models for each of the flowing sections present in a pigging operation, namely, undisturbed two-phase flow section, liquid slug section, gas flow section, and finally, a redeveloping two-phase flow section. For the last two sections, the simplified transient model developed by Taitel et al. has been found to be suitable, and will probably be used with modifications (such as different numerical schemes, inclusion of mass transfer, etc.). Efforts to develop a model for the liquid slug section ahead of the pig are currently underway.

The first set of experimental transient flow data in horizontal flow is scheduled to be taken this summer. The data will be used to evaluate the simplified model.



Elimination of Severe Slugging in a Pipeline Riser Sytem

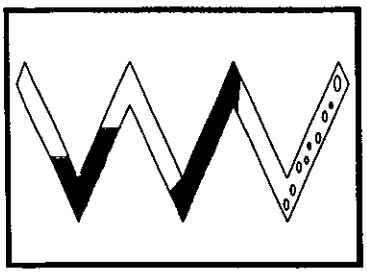
Finn Erik Jansen

Research conducted in this project is a continuation of the work completed earlier by Vierkandt on the same facility. The new project will focus on the elimination of severe slugging by the three most common methods, namely; choking, gas injection and increased back pressure. Various modifications of the test facility are required for this study.

One problem of the original facility was the placement of the gas flow control valves relative to the orifice meters. The valves were placed upstream of the orifice meters and provided no damping when pulsating flow occurred in the system. The pulsations from the slugging caused the flowrate readings from the orifice meters to vary considerably. The placement of the orifice meters relative to the valves has now been changed and the orifice meters are now placed 12.5 in. upstream of the valves.

Additional changes currently in progress are the installation of a pressure transducer upstream of the valve and a capacitance sensor on the riser. The capacitance sensor for measuring liquid fallback in the riser is necessary because fallback is an important part of the severe slugging model. In the previous study by Vierkand, fallback was arbitrarily set to be a constant fraction of 0.1.

The final task will be to evaluate the Taitel severe slugging model against the collected data and, if necessary, develop modifications. In addition, results from the revised model will be compared to any field data that can be obtained from TUFFP members.



Two-Phase Flow in Low Velocity Hilly Terrain Pipelines

Cem Sarica

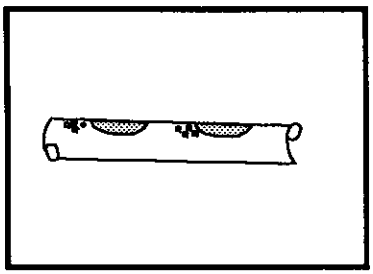
The primary objective of this study is to investigate two-phase flow in low velocity hilly terrain pipelines. This includes development of a model to predict the complex nature of the flow in such systems, in particular the development of steady or unsteady flow conditions in the pipeline. The model will be the basis for a computer simulator suitable for design purposes. Finally, since the model is based on physical principles, it can be used to check available more general elaborate numerical schemes.

Hilly terrain pipelines with low flow rates of gas and liquid are often encountered in offshore fields. The flow in these pipelines is gravity dominated. Thus, pressure distribution and both liquid and gas distributions in the pipe are governed by gravity. Liquid tends to accumulate in the lower sections or valleys, with gas flowing above it. The flow behavior of such low velocity pipelines can be complex, even for constant input flow rates. Possible unsteady conditions may develop in the upward inclined sections (risers) due to accumulation of compressible gas upstream.

The only study considering low velocity pipelines has recently been presented by Taitel et al. (1988). This study represents an extension of the severe slugging model to the general hilly terrain case. The model can predict the complex behavior of the gas and liquid in a pipeline.

The Taitel et al. model presents fundamental concepts and analysis of low velocity hilly terrain pipelines. However, the model is not complete and further studies are required in order to develop a more generalized model.

Progress of this project has been hindered since the last Advisory Board Meeting due to personal reasons. The main accomplishment since the last meeting was the study of the new developments in severe slugging (Vierkandt 1988) and the possibility of their implementations in the hilly terrain model.



Evaluation of Slug Flow Models for Horizontal Pipes

Carlos Daza

Since the November 1988 Advisory Board meeting, most of the work on this project has concentrated on installation of instrumentation and calibration of measurement devices in the test facility. This work can be summarized as follows:

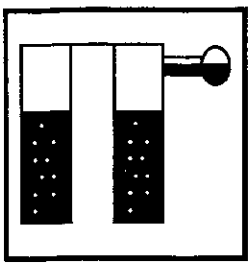
1. The gas orifice meter was calibrated for orifice plate sizes of .25, .375, .500, and .625 in. Also, the orifice calculation computer program was revised and updated.

2. Calibration of the gas flow provers located at the discharge point to the atmosphere was completed. Orifice plate diameters of .375, .500, .625, and .75 in. were tested and calibrated.

The available theoretical models for slug flow in horizontal pipes are currently being studied. The models under review are the classical Hubbard and Dukler model (1975), and other simplified models. New phenomena such as drift velocity are also being considered.

The Prudhoe Bay data, which serve as a basis for the study of the slug flow characteristics in large diameter pipes, have been accessed through the Apollo computer network, and the information is being organized for proper analysis. The database from the TUFFP 3 in. diameter air-kerosene system is also being recompiled for this project.

Initial experiments in the test facility are expected to be conducted in late February after the calibration of the capacitance sensors is completed.

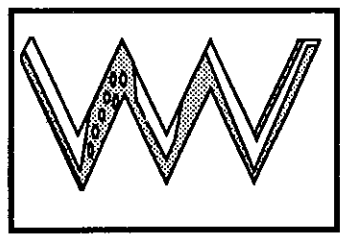


A Mechanistic Model for Annulus Gradients in Pumping Wells

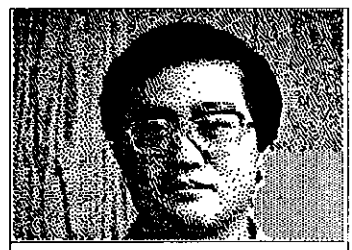
D. Papadimitriou

The determination of bottomhole pressure in pumping oil wells is essential for a proper design of the pumping facility. The pressure is usually determined from the casing liquid column level obtained with acoustic well sounders. However, the presence of gas flowing in the casing - tubing annulus complicates the determination of the bottomhole pressure, due to the existence of a type of two-phase flow. The normal approach to compensate for the amount of gas present in the annulus is to use the Gilbert "S" curve. Experiments were conducted by Schmidt at al. (1980) to verify the Gilbert correlation. They found that fluid physical properties, which were not taken into account in the original correlation, have a definite influence on the pressure gradient.

The objective of this study is to develop a mechanistic model for the prediction of bottom hole pressures in pumping wells. The model will take into consideration recent developments in two-phase flow, such as flow through an annulus configuration. Also, it will account for all important parameters, such as geometry, PVT properties and flow rates.



A Comprehensive Mechanistic Model for Two-Phase Flow in Pipelines

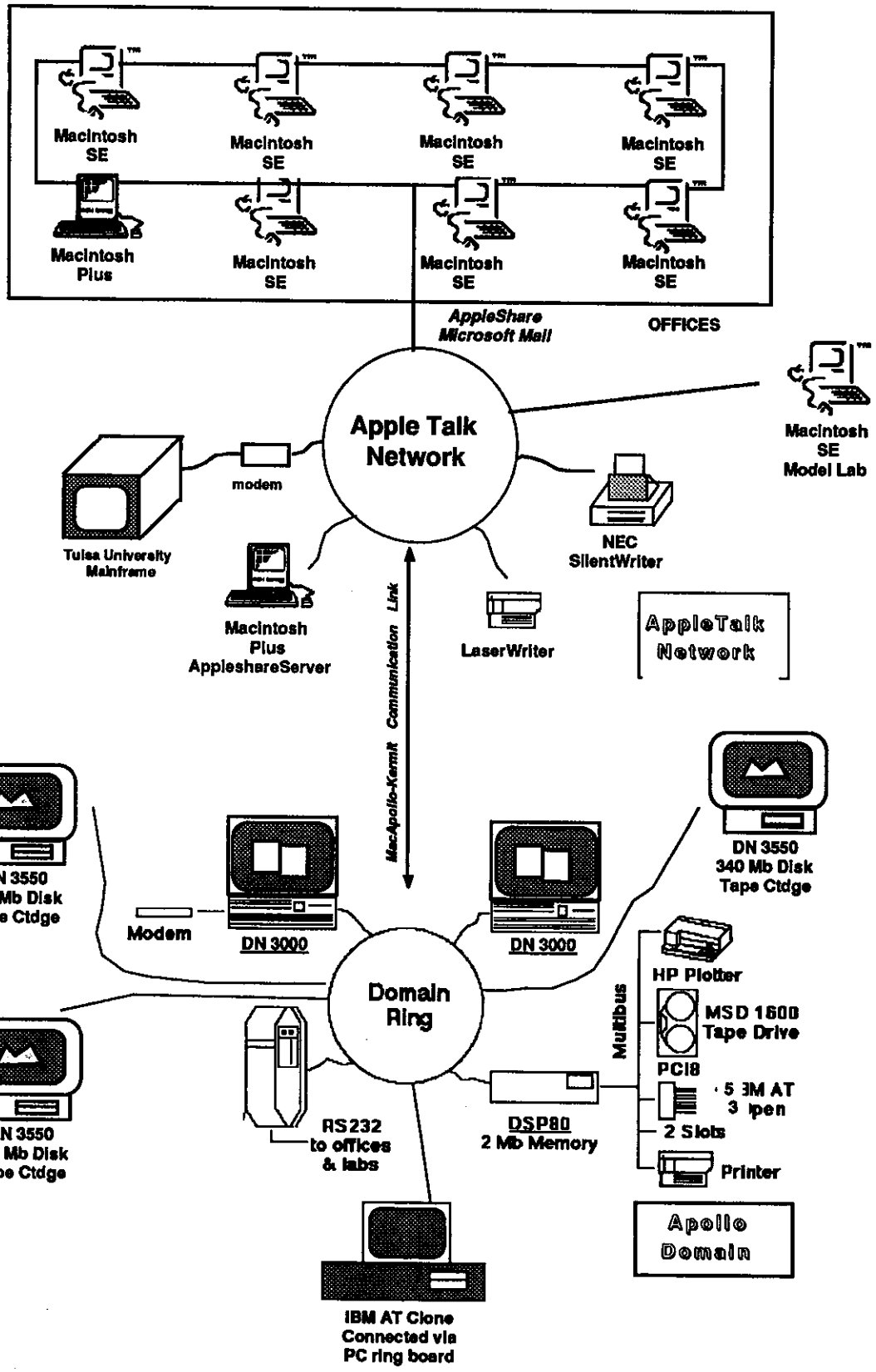


J. Xiao

The model anticipated from this study includes a flow pattern prediction model and pressure and holdup prediction models for each individual flow pattern: stratified flow, annular flow, dispersed bubble flow and slug flow. For flow pattern prediction, the Taitel-Dukler model will be used, but several modifications have been made based on recent developments in this area. Various stratified flow models already exist in the literature. However, uncertainties about the interfacial friction factor still remain and will be examined in this study. Although there have been many studies for vertical annular flow, horizontal annular flow has been addressed by only a few investigators due to the difficulty in modeling the asymmetric flow geometry. Available methods are the classical triangle relationship treatment, the two-fluid model and the latest approach to include the effect of a secondary flow. These methods will be evaluated to develop a model for horizontal annular flow. The homogeneous model is believed to work well for dispersed bubble flow. The slug flow model to be used by TUFFP will be recommended by Daza. Final selection of models will also be influenced by analysis of the models suggested in the Creare study for the A.G.A Pipeline Research Committee. Preliminary computer programs for all flow patterns, except slug flow, have already been completed.

A data bank will be used to evaluate the mechanistic model and the most commonly used correlations. Since the reliability of the A.G.A. data bank has been questioned by NKK (1985), an attempt to obtain more data from other sources such as TUFFP member companies will be considered.

Our ultimate objective will be to develop an accurate computer simulator with a user friendly interface and the ability to provide graphic interpretation of results.



TUFFP Computer Network Systems

1989 TUFFP Members

Amoco Production Co.
Arabian American Oil Co.
Arabian Oil Co., Ltd.
ARCO Oil and Gas Co.
British Gas Corp.
British Petroleum International Ltd.
Chevron Oil Field Research Co.
China National Oil & Gas E. & D. Corp.
CHIYODA
Conoco, Inc.
Exxon Production Research Co.
Instituto Mexicano del Petroleo
Intevep
JGC Corp.
Japan National Oil Corp.
Kerr-McGee Corp.
Mobil Research and Development Corp.
Nippon Kokan K.K.
Norsk Hydro
Pertamina
Petrobras / Cenpes
Phillips Petroleum Co.
Schlumberger
Shell Internationale Petroleum MIJ B.V.
Simulation Sciences, Inc.
Statoil
Texaco
Texas Gas Transmission Corp.
Unocal Corp.
YPF

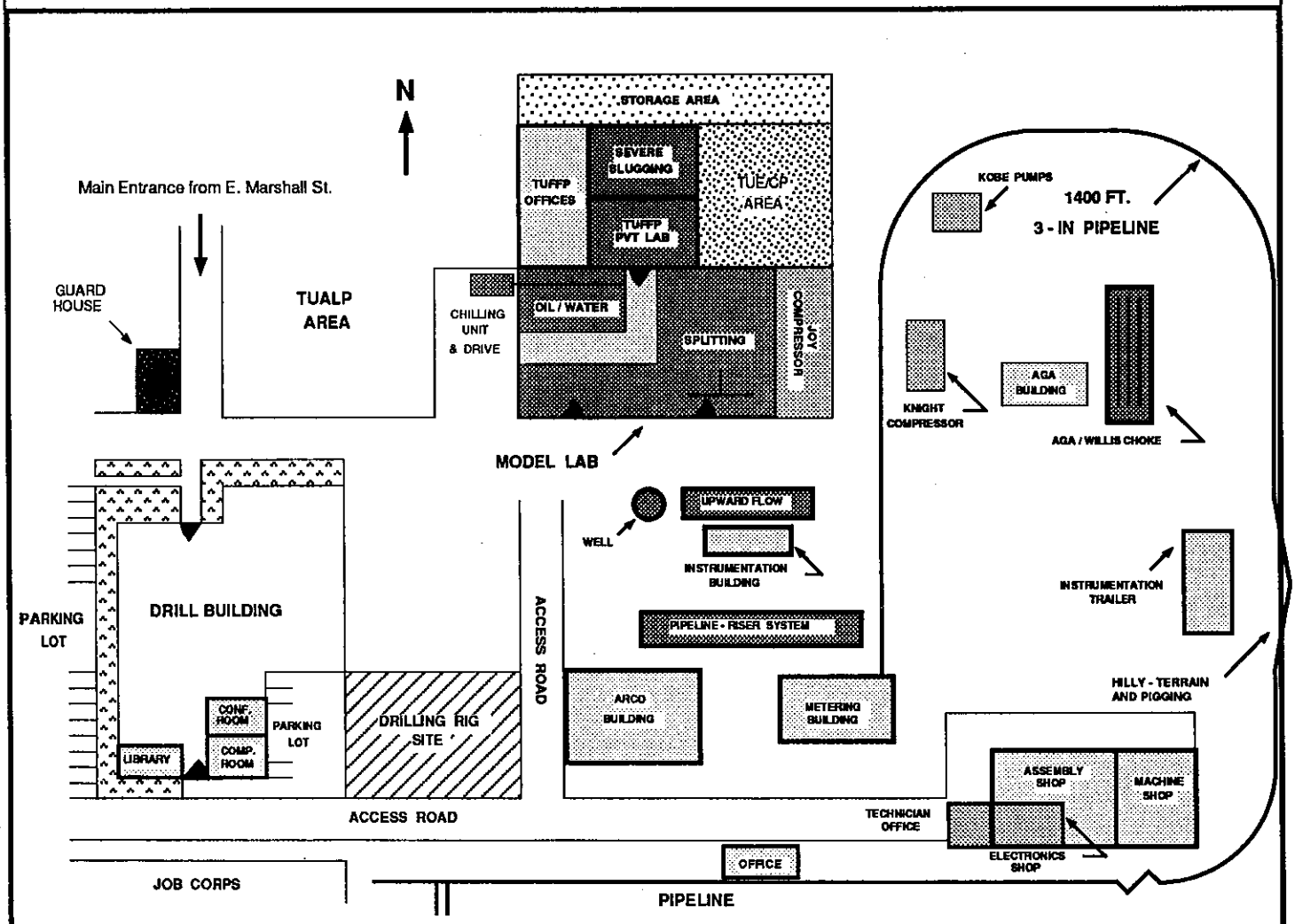


Illustration of TUFFP Test Facilities