T U P D P

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Dear Members,

This is our first quarterly progress report presented in a “Newsletter” format. This format of reporting has been used in the Tulsa University Fluid Flow Projects (TUFFP) since the early 1980’s. With this format, we not only present a short summary of the quarterly progress on each research project, but also provide additional relevant information and news about paraffin deposition and related projects. We appreciate your comments and suggestions.

Progress on each research project is given later in this Newsletter. A brief summary of the activities is given below.

Single-Phase Studies (Project-1) Task-1 (Model Review) continued with activities in software improvements including the addition of various models and correction of minor bugs. The MSI-TUWAX program is being updated for the revisions as an intermediate step prior to the development of TUWAX software based on Microsoft VB/ Excel. Task-2 (Model-Validation) continued with comparisons of the model with Garden Banks data. Task-3 (Single-phase Model Enhancements) has focused on the design of a small scale laboratory device with which wax deposition conditions can be varied and observed to better understand the physical mechanisms of deposition and shear stripping/prevention.

As part of Multiphase Studies (Project-2) Task-1 (Two-Phase Gas-Oil Deposition Model Enhancements) improvements in the single-phase model are currently being incorporated in the multiphase model. As an intermediate solution, it is planned to have the MSI TUWAX GUI updated to reflect the improvements prior to the development of TUWAX software based on Microsoft VB/Excel. Task-2 (Two-Phase Oil-Water Deposition Enhancements and Development) continued with the review of the existing oil-water deposition data and the re-commissioning of the small scale facility.

Based on our initial results on Pigging studies (Project-3) Task-2 (Feasibility) an inquiry was sent to TUPDP members asking whether to continue the pigging studies. Outcome of the inquiry mandated further detailed feasibility study before starting any experimental or modeling study. Currently, efforts are being concentrated on more detailed analysis of the existing studies. Moreover, data collection attempts are underway. The pigging data collected from ChevronTexaco Humble facility were made available to TUPDP for the consortia purposes. These data are currently being analyzed.

Project Coordinator Leaves

Wendy Fusselman, the Project Coordinator in TUPDP and related projects has resigned effective December 1, 2004 to assume a position with William Communications. We wish her well in her future endeavors. Project Coordinator position will not be filled at this time. Linda Jones, Project Assistant with TUPDP and related projects, has assumed the responsibilities of the project accounts.

Howard Rettig Retires

Mr. Howard Rettig, a Mechanical Technician with TUPDP and related projects, has recently retired after over seven years of service to The University of Tulsa in different capacities. He will be remembered by all of us for his dedicated service to TUPDP and TUFFP. Craig Waldron has assumed his job responsibilities.

Guilherme Couto

Congratulations to Our Recent Graduate

Guilherme Couto, a Research Assistant in TUPDP, has successfully completed his MS degree requirements in Petroleum Engineering. He has recently accepted a position with PETROBRAS in Brazil. We wish Guilherme well in his future endeavors.

TUPDP Membership

Phase 3 of the Tulsa University Paraffin Deposition Projects (TUPDP) began on April 1, 2004. We currently have 15 members and are having continuing discussion with JNOC and Pemex regarding membership. Invoices for the 2005 membership fees will be sent in February 2005.

TUPDP Members

Baker Petrolite
BG
BHP Billiton
BP
ChevronTexaco
ConocoPhillips
DOE
ExxonMobil
Marathon Oil Company
Nalco
Petrobras
Shell
Statoil
TOTAL
Unocal

Emerson Process Management Makes Equipment Donation

The Emerson donation valued in excess of $24,000 includes Rosemount compact orifice flowmeters, pressure transmitters, RTDs and temperature transmitters. This equipment will be used within TUFFP and TUPDP to provide petroleum engineering students a working knowledge of basic instrumentation and process measurement and control.

We would like to thank Pat Gibson and Pam Smith of Emerson Process Management for their help in arranging these donations.

Meetings/Conferences

Spring 2005 Advisory Board Meetings

Plans have now been finalized for the Spring 2005 Advisory Board meetings. A tour of the test facilities will be held on Tuesday, March 29th at 3:00 p.m. Following the tour, there will be a joint TUFFP/TUPDP BBQ between 5:00 - 7:00 p.m. The TUFFP Advisory Board meeting, the TUFFP/TUPDP reception, and the TUPDP Advisory Board meeting will all be held at the Doubletree Hotel at Warren Place. The TUFFP Advisory Board meeting will begin at 8:30 a.m. on Wednesday, March 30th and will adjourn at 5:00 p.m. Following the TUFFP meeting, there will be a joint TUFFP/TUPDP reception from 6:00 - 9:00 p.m. The TUPDP Advisory Board meeting will be held on March 31st. The meeting will begin at 8:00 a.m. and will adjourn at 5:00 p.m. The TU Hydrate JIP (TUHFP) Advisory Board meeting will be held on Friday, April 1st at The University of Tulsa in the President's Lounge in the Allen Chapman Activity Center. A social function is planned for Thursday evening, March 31st also to be held in the President's Lounge. The Request for Information form and hotel information will be placed on the web page soon. All persons from your company that plan to attend the Advisory Board meetings, should complete and return these forms as soon as possible to help us plan the meetings. Information on the Advisory Board meetings can also be found on our web site at www.tupdp.utulsa.edu/abminfo.htm. You can then follow the links for the Request for Information form. TUPDP Advisory Board meeting brochures will be available for members at the meeting and a concerted effort will again be made to have the combined brochure and slide copy available for downloading from the web site at http://www.tupdp.utulsa.edu/abmbrochures.htm shortly before 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.

BHRg's Multiphase Production Technology 05 to Be Held in Barcelona, Spain

BHR Group's Conference on Multiphase Production Technology '05 is scheduled to be held between 25-27 of May 2005 in Barcelona, Spain. Multiphase Production Technology '05 will benefit anyone engaged in the application, development and research of multiphase technology for the oil and gas industry. Applications in the oil and gas industry will also be of interest to engineers from other industries for whom multiphase technology offers a novel solution to their problems. We strongly encourage our members to participate in this conference. It is expected that the conference will benefit anyone engaged in the application, development and research of multiphase technology for the oil and gas industry.

The conference is being structured into themes that will be introduced by one or more Review Papers that describe aspects of: "*Today's Technology*". These will be followed by the traditional accepted technical papers that feature new developments, new applications and hitherto unpublished work: "*Tomorrow's Technology*". Finally, throughout the Conference, delegates will be invited to post their views on a notice board as a contribution to the debate on the technology gaps and the needs for the future: "*Next Week's Technology*". These will be discussed during the Closing Technology Review. There will be five themes in the Multiphase Production Technology Conference: 1. Laboratory and Field Measurement 2. Process, Measurement and Control Equipment and Analysis 3. Production Chemistry 4. Modeling and Simulation 5. Thermal Management. The detailed information about the conference can be found on BHRg's web site www.brhgroup.com.

TUFFP Short Course

The 30th TUFFP "Two-Phase Flow in Pipes" short course is scheduled to be taught May 9-13, 2005 in Tulsa by Dr. Sarica and Dr. Brill. The course covers the most current, up-to-date-research performed at the Tulsa University Fluid Flow Projects (TUFFP) and Tulsa University Paraffin Deposition Projects (TUPDP). This five-day course is focused on the fundamentals of two-phase flow in piping systems encountered in the production and transportation of oil and gas. The short course will include a half-day session on paraffin deposition in pipes. For this short course to be self sustaining, at least 10 enrollees are needed. We urge our TUFFP and TUPDP members to let us know soon if they plan to enroll people in the short course. Information regarding the short course can be found at www.tupdp.utulsa.edu/calendar.htm.

Upcoming ABM's

March 29, 2005

TUPDP/TUFFP Facilities Tour
The University of Tulsa North Campus
2450 East Marshall
Tulsa, Oklahoma
3:00 - 5:00 p.m.

TUPDP/TUFFP Barbeque
The University of Tulsa North Campus
2450 East Marshall
Tulsa, Oklahoma
5:00 - 7:00 p.m.

March 30, 2005

TUFFP Advisory Board Meeting
Doubletree Hotel at Warren Place
6110 South Yale Avenue
Tulsa, Oklahoma
8:00 a.m. - 5:00 p.m.

TUFFP/TUPDP Reception
Doubletree Hotel at Warren Place
6110 South Yale Avenue
Tulsa, Oklahoma
6:00 - 9:00 p.m.

March 31, 2005

TUPDP Advisory Board Meeting
Doubletree Hotel at Warren Place
6110 South Yale Avenue
Tulsa, Oklahoma
8:00 a.m. - 5:00 p.m.

TUHFP Reception
Charleston's Restaurant
6839 S. Yale
Tulsa, Oklahoma
6:00 p.m.

April 1, 2005

Hydrate JIP Advisory Board Meeting
The University of Tulsa
Allen Chapman Activity Center
Tulsa, Oklahoma
8:00 a.m. - 5:00 p.m.

Progress Updates

Project 1 - Single Phase Studies

Hong Chen

Task 1 - Model Review

Model Development

The task of revising the TUWAX software was completed on schedule. The following improvements were made:

- The Singh et al. (2000) model was added to the TUWAX software to predict the deposit aging process. Users have the option of selecting this aging model or inputting a constant oil fraction in the deposit without considering the aging effect.
- The Matzain et al. (1999) and Venkatesan (2003) models were added to TUWAX software to predict the shear stripping/prevention effect on the deposition process. Users are able to choose between these two different shear stripping/prevention models or inputting a user defined stripping coefficient for the prediction of the shear stripping/prevention effect.
- The Maxwell correlation for predicting deposit thermal conductivity was added to TUWAX software. The correlation predicts deposit thermal conductivity based on the wax content of deposit, the thermal conductivity of oil and the thermal conductivity of pure solid wax. Users have the option of using the correlation or a user defined ratio between the thermal conductivity of deposit and oil.

Other software improvements are:

- The current explicit algorithm has been replaced with an implicit algorithm resulting in a more accurate transient wax build-up prediction.
- A bug which could cause discontinuity of the wax thickness profile by using the film mass transfer model was identified and fixed.

Graphical User Interface (GUI) Modifications

Modifications to the original MSI-TUWAX GUI are being made by MSI to include all of model improvements mentioned above. A revised MSI-TUWAX for single-phase wax deposition will be available for download from TUPDP web site in January 2005.

Future Work

Incorporate the revised TUWAX model into a Microsoft EXCEL based environment.

Gladys Sucre

Task 2 -Model Validation

Database Development

The objectives of Task 2 are to develop a validation database and test the revised TUWAX model. A database was developed and presented at the last Advisory Board Meeting. This database currently consists of data from various tests conducted at The University of Tulsa. The comparison of the revised model with South Pelto data from the database is complete and the Garden Banks data comparisons are underway.

Gladys Sucre

Task 3 - Single-Phase Model Enhancements

The objectives of Task 3 are to define the improvement areas of the model, design and implement the future research and test the improved model with a database. Construction of a laboratory scale facility is planned to directly observe the paraffin deposition process especially under turbulent flow condition which includes shear prevention/shear removal and aging effects. The studies utilizing this facility are expected to result in a better understanding of the mechanisms involved with wax deposition for future model improvements. The facility will allow direct observations of the process visually or with the aid of an apparatus like a microscope or a camera, and the sampling of the deposits will be performed with minimum or no disturbance to the deposition process.

A rectangular duct shaped test section is proposed. Two side walls and the upper wall will be transparent (acrylic) plates, and the lower wall will be an aluminum plate that will be cooled to establish the temperature difference between the bulk oil and the bottom cold plate. Clear waxy model oil will be used to observe the deposition process on the cold bottom plate through the transparent side walls or the upper wall.

Hydrodynamic and thermal similarities of rectangular duct flow with normal circular pipe flow need to be addressed. Friction factors defined based on hydraulic diameter could be used for rectangular ducts using a correction factor that varies with aspect ratio, the correction is lower with higher aspect ratios and Reynolds numbers[1,2]. Nusselt Number correlations defined with hydraulic diameter such as Dittus-Boelter, Colburn, and Sieder-Tate can be used to calculate heat transfer within a rectangular pipe. Maximum deviations between symmetric and asymmetric heating are 7.5%. The difference between symmetric and asymmetric heating diminishes with the increase of Prandtl number[3,4]. Simulations with CFD software FLUENT have been made to corroborate the findings in the literature, and to find a minimal aspect ratio to achieve appropriate shear, temperature and velocity profiles.

Fluent Simulations

Fluent simulations were performed for a rectangular pipe flow with different aspect ratios (ratio of width to height of the pipe). An aspect ratio of 3:1 was selected considering the size of the facility, flow velocity and temperature profiles. After this aspect ratio was determined different flow rates were used in simulations to see the changes of profiles with variations of flow rate. Figure 1 shows a typical velocity profile with an axial developing region. Figure 2 shows a fully developed cross-sectional temperature profile. It is noted that the temperature disturbance caused by corners of rectangular pipe is insignificant.

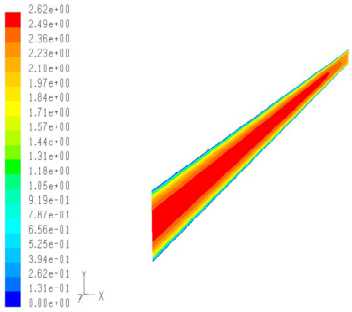

Figure 1 - Velocity Symmetry View with RE: 6500, Height: 1cm, Width: 3cm, Length: 50cm

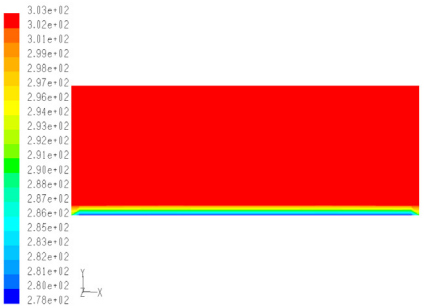

Figure 2 - Temperature front view with RE: 6000, Height: 1cm, Width: 3cm

Future Work

Design and setup of a small scale lab device with which wax deposition conditions and shear could be varied and observed to better understand the physical mechanisms of wax deposition and shear stripping/prevention for future model improvements.

References

1) O. C. Jones, Jr, An improvement in the calculation of turbulent friction in rectangular ducts, J. Fluids Engineering 98, 173-181 (1976)

2) N. T. Obot, Determination of incompressible flow friction in smooth circular and noncircular passages: A generalized approach including validation of hydraulic diameter concept. (Clarkson Univ) Source: American Society of Mechanical Engineers (Paper), 1988.

3) Sparrow, E., Cur, N., “Turbulent heat transfer in a symmetrically and asymmetrically heated flat rectangular duct with flow separation at inlet”, journal of heat transfer. Vol. 104. pp. 82-89, 1982

4) M. Kostic and J.P. Hartnett, Heat transfer to water flowing turbulently through a rectangular duct with asymmetric heating. Int. J. Heat Mass Transfer 29, 1283 (1986).

Project 2 - Multiphase Studies

Task 1 - Two-Phase Gas-Oil Deposition Model Enhancements

Hong Chen

Improvements in the single-phase model are currently being incorporated in the multiphase model. As a temporary solution, the multiphase GUI developed by MSI will be updated to incorporate those improvements and be used until the new Excel/Visual Basic software is developed.

Antonio Bruno

Task 2 - Two-Phase Oil-Water Deposition Model Enhancements and Developments

A preliminary oil-water model was developed by generating look-up tables for physical properties of the oil-water mixture and then running TUWAX to obtain the deposition rate. This model was verified by the cold finger data[1].

Review of the existing two-phase oil-water experimental data from cold finger tests and the small-scale test loop was completed. Problems in some experimental data such as depletion of the wax, abrupt fluctuations in DP measurements and disagreement between wax thickness obtained by DP method and boroscope were identified. Possible solutions to these problems were proposed and are under investigation.

The small-scale test loop has been re-commissioned for future testing.

Future Work

Upgrade MSI GUI for the multiphase to incorporate those improvements in the single-phase model.

Test improved two-phase deposition model with the existing data.

Develop a program which could generate look-up tables of oil-water mixture properties automatically. Look-up tables generated by this program could then be used by TUWAX to obtain the deposition rate of oil-water flow.

Improve the small-scale test loop to solve those problems identified in previous tests.

Design a preliminary test matrix for new experiments of oil-water using the small-scale test loop.

Reference

1) Guilherme Hartenbach Couto, 2004, “Investigation of Two-Phase Oil-Water Paraffin Deposition”, MS Thesis, The University of Tulsa, Tulsa, Oklahoma.

Project 3 - Pigging Studies

Qian Wang

Task 2 - Feasibility

The original objectives of this project are the assessment of existing pigging models and the development of a new pigging model if necessary. The initial findings presented at the last Advisory Board meeting indicated that wax transportation force rather than wax breaking force was the dominant factor in determining the requirements of a pigging operation. Based on these findings, an inquiry was sent to TUPDP members asking whether to continue the pigging studies. The outcome of the inquiry is given in Table 1.

Table 1: Inquiry Results for Pigging Studies

Continue	Discontinue	Neutral	No Response
8	2	1	3

The outcome of the inquiry indicates that pigging studies need to be continued. Further comments received with the ballots indicated that a more detailed feasibility study should be conducted before starting any experimental or modeling study. Therefore, our efforts concentrated on more detailed analysis of the existing pigging models.

Hovden[1] suggested that Pedersen/Rønningsen[2] model to calculate the wax slurry viscosity and transportation force. This model was developed based on the experimental data for the crude oils with the weight percentage of solid wax content (Wt %) less than 8.0%. From the 24 hour long single-phase wax deposition test data acquired in TUPDP, the wax content in the deposits varied from 8 to 54 Wt % depending on oil properties and flow conditions. The Pedersen/Rønningsen model needs to be verified for the range of Wt % of wax greater than 8%.

Many slurry rheology studies based on bench scale experimental setups have been identified in various disciplines. These studies are mostly experimental and inherently limited with the testing fluids and conditions. Therefore, the applicability of any slurry model identified needs to be verified with the experimental and/or field data.

The data collection has been started. The pigging data collected from Humble facility through DeepStar pigging project were made available to TUPDP by ChevronTexaco. The data are currently being analyzed. Efforts continue to collect additional field data.

References

1) Hovden, L., Xu, Z. G., Rønningsen, H. P., Labes-Carrier, C. and Rydahl, A., 2004, “Pipeline wax deposition models and model for removal of wax by pigging: comparison between model predictions and operational experience”, BHR Group 2004 Multiphase Technology.

2) Pedersen, K. S. and Rønningsen, H. P., 1999, “Effect of precipitated wax on viscosity-A model for predicting non-Newtonian viscosity of crude oils”, Presentation at AIChE Spring National Meeting, Houston, TX, March 14-18, 1999.

Relaxing after the ABM in Houston!!

Calendar of Events

2005

February 2 - 4	International Symposium on Oilfield Chemistry-The Woodlands Waterway Marriott Hotel and Convention Center-Houston, Texas
March 12 - 15	Middle East Oil & Gas Show and Conference (MEOS)-Bahrain International Exhibition Centre-Kingdom of Bahrain
March 29	TUPDP/TUFFP/TUHFP Tour of Facilities and Barbecue-The University of Tulsa North Campus-Tulsa, Oklahoma
March 30	TUFFP Advisory Board Meeting-Doubletree Hotel at Warren Place-Tulsa, Oklahoma
	TUPDP/TUFFP Reception-Doubletree Hotel at Warren Place-Tulsa, Oklahoma
March 31	TUPDP Advisory Board Meeting-Doubletree Hotel at Warren Place-Tulsa, Oklahoma
April 1	TU Hydrates JIP Advisory Board Meeting-The University of Tulsa-Allen Chapman Activity Center-Tulsa, Oklahoma
April 3 - 7	NACE Corrosion-2005, George R. Brown Convention Center-Houston, Texas
April 10 - 14	AIChE 2005 Spring National Meeting-Hyatt Regency-Atlanta, Georgia
April 16 - 19	SPE Production and Operations Symposium-Cox Business Services Convention Center-Oklahoma City, Oklahoma
May 2 - 5	Offshore Technology Conference-Reliant Center at Reliant Park-Houston, Texas
May 9 - 13	Fluid Flow Projects “Two-Phase Flow in Pipes” Short Course-College of Engineering and Natural Sciences Harvard Center-Tulsa, Oklahoma
May 25 - 27	Multiphase Production Technology ‘05-Barcelona, Spain
June 20 - 23	Latin American and Caribbean Petroleum Engineering Conference (LACPEC)-Intercontinental Hotel-Rio de Janeiro, Brazil
July 17 - 22	ASME Heat Transfer Conference ‘05-Westin St. Francis Hotel-San Francisco, California
September 6 - 9	Offshore Europe 2005-Aberdeen Exhibition and Conference Centre-Aberdeen, United Kingdom
October 9 - 12	SPE Annual Technical Conference and Exhibition (ATCE)-Dallas Convention Center-Dallas, Texas
November 21 - 23	International Petroleum Technology Conference (IPTC)-Qatar International Exhibition Centre-Doha, Qatar