Hydrate Blockage Formation: Restart Investigations

The experimental work will be performed in the University of Tulsa’s Hydrate Flow Loop Testing Facility with the objective of developing a better understanding of hydrate blockage risk factors. The work consists of three tasks supported by 60 experimental runs with the hydrate flow loop and 100+ runs in the jumper facility. These tasks are:

**Task 1: Risk assessment of hydrate plugging during steady-state operations**
- Steady-state flow with hydrate experiments (6 months)
  - Variables of interest: Gas-Oil Ratio, flow rate, flow pattern prediction, superficial mixture liquid velocity, no-slip Holdup, diffusion coefficient for gas components, Interfacial tension between hydrocarbon and aqueous phases, fugacity between hydrocarbon and aqueous phases, gas-liquid interfacial area, Water droplet size distribution, onset temperature, cooling rate, fluids viscosities, brine concentration and liquid loading.
  - Simulation of past experiments will be performed with TU-PVTSim based simulation tool to derive experimental hydrate formation rates and correlate the results as a function of operating conditions.

Note: The 30 hydrate experiments in the Hydrate Test Loop can be thought of as numbers of experiments that can be allocated depending on need during matrix evaluation from the variable set mentioned above from collaboration of working committee, the University of Tulsa, and project champions.

**Task 2: Risk assessment of hydrate plugging during restart operations**
- Experimental studies with transient flow facilities (18 months)
  - Effect of liquid loading, water cut, flow velocity
  - Examination of difference between gas and liquid dominated systems during inhibitor displacement and during restart operations in the jumper test facility.
  - Feasibility studies on low-pressure hydrate formation in the restart tests conducted in the jumper test facility.

**Task 3: Hydrate Plug Characteristics**
- Formation of plugs & measurements of plug characteristics (6 months) by measuring pressure drop for permeability and fluid displacement and gamma densitometer measurements for porosity.
- Evaluation of dissociation methods (18 months) compared to plug dissociation simulation tools and compare pressure dissociation with chemical dissociation with MEG.

Desired Results from this work include:
- Develop a Risk Matrix for hydrate blockages (both transient and steady state operations) to enable application of the study results to actual project work.
- Identify testing Oils by important physicochemical properties rather than field terms. This will help in the identification of analogue oils and understanding the differences in test results correlated with fluid properties.
- Perform more experiments with high liquid loaded systems while maintaining low GOR (<500 SCF/BBL). This will aid in completing the data set obtained from prior experimental work.
Activity Summary & Accomplishments:

Task 1: Risk assessment of hydrate plugging during steady-state operations

- Documentation of the work on rate constants continued. The steady state test matrix was finalized and modification of the test facility to return it to its steady state testing mode was begun.

Task 2: Risk assessment of hydrate plugging during restart operations

- Phase I of the experimental study is complete. Documentation of the results began.

- The preliminary Phase II test matrix for the liquid displacement experiments with thermodynamic inhibitors was discussed and reviewed with the Project Champions. According to the information provided, field procedures of jumper flushing are normally accomplished at low inhibitor rates. For this reason an additional data point of 0.25 ft/s for liquid superficial velocity was incorporated into the experimental program.

- Preliminary heat transfer calculations in the Pyrex jumper indicate that we may not be currently able to achieve cooling into the hydrate domain, due to limited coolant flow rate, temperature, and radiation effects, especially when the outside temperature is above 70 F.

- A 4-ft section has been ordered to demonstrate the feasibility prior to committing to the order of all the Pyrex sections required.

Task 3: Hydrate plug characteristics

- The final experiments for plug characterization and dissociation studies with a low spot/leaky valves configuration have been completed – totaling 19 experiments. In the last experiments, a measurement technique to accurately measure dissociation times using plug density profiles was developed and dissociation data is being compared with TU’s dissociation model and CSMPlug. Experiments for plug formation with different subcoolings have been conducted; subcooling was varied by changing salinity, temperature or both. A last series of four tests was aimed at comparing dissociation techniques: heating, depressurization, nitrogen and MEG injection. Data is currently being processed. Heating and depressurization show radial dissociation of the plugs as expected, while dissociation with MEG does not occur radially but seems to depend on plug
porosity, permeability and contact with the inhibitor. Feasibility of dissociation with nitrogen was confirmed for the selected operating conditions; the dissociation with nitrogen was found to be very slow (very low injection rate) and progressing from one end of the plug to the other and leaving a clean pipe behind.

- Work was initiated on a modeling concept for inhibitors
- Dissociation simulations of the low-spot tests using CSMPlug are being compared to the experimental dissociation times

### Activities Planned Next Period:

- Continue working with Champions Creek, Estanga, and Hernandez on details of test matrix and alternatives for hydrate formation in the test loop.
- Development of a technical proposal for the study of water inhibition and liquid displacement in a jumper type configuration using MEG and methanol. The scope of this project will be to evaluate the efficiency of hydrate prevention strategies currently used in the field and propose improved design of inhibitor injection and restart procedures from the technical and economic standpoints.
- The construction of the new jumper facility that can be cooled with glycol is still in progress. Work in underway to find out the optimum range of glycol circulating velocity and temperature to assure adequate heat transfer conditions between the cooling fluid flowing in the annulus and the working fluids moving inside the inner pipe.
- Liquid displacement tests using MEG and MEOH will begin.
- Data processing of the hydrate plug characterization experiments will continue. The flow loop will be reset to original configuration with the multiphase pump to either conduct additional plug experiments in pumping mode or the steady-state experiments.
- Continue modeling dissociation tests to determine what parameters, if any, must be changed to bring the predictions in line with the experimental dissociation times. Targeted parameters are the dissociation temperature, porosity, and heating rate.
- Documentation of the work on formation rate constants will continue.
- Simulation of past flow loop experiments will continue to aid planning and understanding as we go forward.
- Begin steady state test program.

Percent Complete: 70 %