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Designing A Multi-Phase Flow Loop

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Summary

Due to the complexity of multi-phase flow (MPF) phenomena research in this area is largely based on experimentation using laboratory scale test loops. The design of multi-phase flow test facilities is quite involved and requires careful attention. First, the test rigs have to produce results that are valid or can be scaled to actual full scale systems. This demands that the system geometry and dimensions, the flow drivers (pumps and compressors), flow controls (flow meters, pressure regulators, etc.) and the flow measurement sensors (pressure, temperature, velocity, ..etc) have to be selected so that a wide range of flow conditions can be tested. For example, Jepson and Taylor (1993) stated that in order to mimic the flow mechanisms observed in large diameter pipes the size of the test pipe should be at least 7.5 cm (3") in diameter. Frequently, more than one size of the same device is used to ensure accurate reading and reduce the adjustments in control. For example, low, medium and high flow rate flow meters of the same type me be used and similarly for other devices such as pumps or pressure transducers.

There are few large scale multiphase flow loops around the world and they serve in the research and development process and in testing different multiphase flow devices used in oil fields. An example of these flow loops is the inclinable large scale flow loop built by the SINTEF group in Norway that has 1000m pipe length, 4, 8, 12 inch pipe diameters, maximum liquid and gas rates are 450 and 1580 m^3/h, respectively, with a maximum pressure of 90 bar. The SINTEF group built also a medium scale flow loop that has 200m pipe length, 69 cm pipe diameter, 55 m^3/h and gas capacity of 875 Nm^3/h with 7.5 bar pressure at the outlet. Another example of medium multiphase flow loop is the TUV-nel multiphase flow loop with its 60 m horizontal pipeline length and 10 m vertical pipeline length, maximum liquid and gas flow rates of 100 m^3/h and 1500 m^3/h, respectively, at a maximum pressure of 10 bar. The Norsk Hydro Multi Phase Flow Loop is a high pressure flow loop in which the pipe is 200 m long and 3 inch in diameter, and the maximum operating temperature and pressure are 140 ˚C and 110 bar absolute, respectively.

In addition to the large scale flow loops, small laboratory scale multiphase flow loops have been also used to study multiphase flow. These flow loops are attractive because of their relatively low cost, small space required and ease of operation. Their main drawback is the limited experiment test time which is affected by the generally smaller storage tanks of the single phase fluids. This drawback can be

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solved through a data acquisition card that collects data from all sensors and stores it automatically and thus saving time otherwise spent in collecting data manually.

Regardless of the increase demand on constructing multiphase flow loops, there are no specific standards for constructing multiphase flow loops. The presentation will focus on design steps that should be followed in order to design a reliable, multiphase flow loop that is suitable for the user objectives.