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Technical Paper

Joining efforts between operators within multiphase metering technology

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1. INTRODUCTION

For many years, operators have been using various multiphase and wet gas metering techniques. One of the reasons for implementing multiphase metering solutions were to develop subsea tie-ins, achieve cost reduction and to improve production optimization. More recently the discussion arose that some joint efforts would be valuable in which the operators would

- share and discuss experiences and needs
- combine efforts to improve multiphase and wet gas flow measurement.

The idea to share some information between users was more recently discussed in conferences like the NSFMW. A first meeting was organized during the NSFMW 2015 in Norway between several operators to discuss about needs, technology status and standardization.

Later in 2016, Statoil, Total and Shell decided to start a technical user group and launch some specific initiatives described in this paper.

It is envisaged that the joint user group would have a more effective technical dialog with the suppliers, help to optimize testing efforts, and develop a shared understanding about the needs and performances of the technologies used.

2. LESSONS LEARNED - SUBSEA MULTIPHASE METERING

Numerous subsea multiphase meters are installed and used. Experiences from hundreds of installed multiphase meters show there are some common challenges. Systematic work has been performed over several years to better understand reasons for observed deviations beyond specified measurement performances.

Deviations in subsea multiphase metering can be divided into several categories. In this context, deviation means performance is outside the measurement specification. Typical deviations can be:

- Hardware failures in the multiphase meters or components
- Changes in fluid properties
- Inevitable simplifications in algorithms, software models, configuration data, non-realistic assumptions such as homogenous flow.

Description of typical subsea multiphase metering concepts can be found in [ref 2]. This also include measurement uncertainties of multiphase metering system, calibration against test separator and PVT handling to minimize deviations.

Some technologies show only marginal difference in track record between subsea and topside, while there are considerable differences in track record between different multiphase metering generations. For the earliest versions of multiphase flow meters there are rather a poor track record, while for recent versions of multiphase flow meters have reach a more acceptable track record.

There are several reasons for the improvements:

- Hardware and software in the multiphase meters have been more robust
- More measurement sensors integrated, such as salinity probes, redundant P,T, dP
- Measurement concept with more robustness to changes in compositions
- Integration of multiphase meter to the control system including LivePVT for online updating PVT input to multiphase meters.
- Perform the PVT calculation to standard conditions in the Supervisory metering computer topside to have a more representive PVT calculations with multi stage flashing
- Extending flow testing in flow loops with real fluids and real conditions

However, there are still technology gaps that need to be closed for multiphase flow meters.

2.1 Multiphase metering measurement uncertainty

Measurement uncertainties of multiphase metering systems are more complex to interpret than for more traditional single phase flow meters. For operators using multiphase meters, the measurement of the oil volume rate is often of main interest.

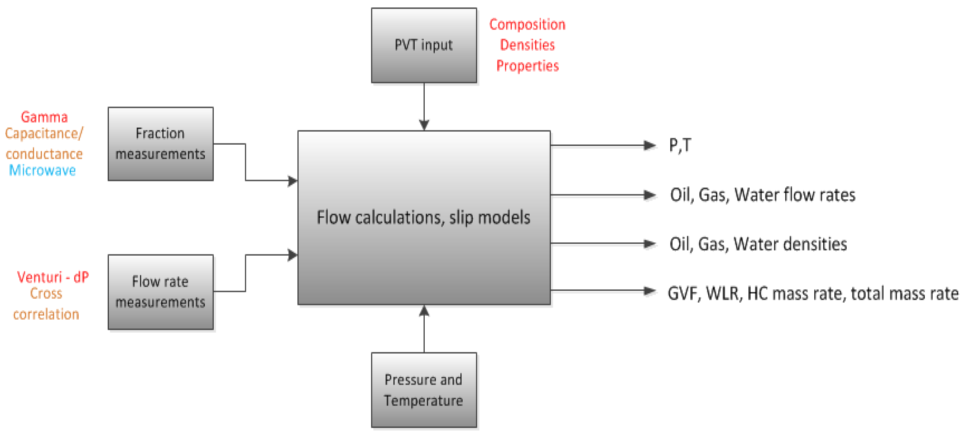

Figure 1. Principle of multiphase meter

Assessments of oil volume rate uncertainties should be based on test results from flow loop testing performed with similar condition to the field, rather than theoretical calculations. In many cases, test results are not meeting theoretical uncertainty specification provided, thus additional field specific uncertainties are needed to be included.

Since specifications typically are provided for liquid volume rates and for water cut, measurement performance specifications for oil volume rate depends on the gas volume ratio and water liquid ratio. Theoretical oil volume rate uncertainty is calculated based on assessments of the production profiles for fields, where typically both GVF and WLR increase during the years. When multiphase meters are used for ownership allocation the HC mass rate is often used.

In verification of multiphase metering systems, it is beneficial to use total mass rate and hydrocarbon mass rate for verification purposes, since total and hydrocarbon mass rates are independent on the conditions, hence, no PVT calculations will be needed. Uncertainties of hydrocarbon mass rate are smaller and have smaller variations than that of oil volume rate.

2.2 PVT related deviations

The PVT related deviations in multiphase meters can be divided into:

- Input to multiphase meters. Properties of gas, oil and water are needed to set up the meter correctly. Measured volume rates and phase densities and the split between oil, gas and water is influenced if properties are changed.

- Calculations of measured flow rates at actual conditions to standard condition. Identical PVT EoS (equation of state), PVT model (number of flashing stages) and composition, as used for the plant is needed to minimize errors in the PVT conversations.

- Calibration of multiphase meters against test separator measurement are performed in most cases at different conditions. Same PVT model is needed ensure same conversion calculation to standard conditions.

By implementing PVT package in the supervisory metering computer these aspects can be reduced by using one common PVT model and one defined well stream composition pr well. Also online PVT corrections due to gas lift or production from different zones can be utilized in the supervisory metering computer.

The input to the multiphase meter can be implemented by using online correction of PVT, for example if there are production from several reservoirs, using gas lift etc. Typical data flow in multiphase metering system using LivePVT is shown in Figure 2.

The meter factor (calibration factor) is based on mass rates in the CM (metering computer) rather than factors in the multiphase meters itself. Those can be stored, and trending is possible. The uncertainty of HC mass rate is lower than the uncertainties of oil volume rate, since the split between oil and gas are avoided. The use of HC mass rate in terms of verifications of subsea meters against topside multiphase meters or test separator is useful, to avoid transformtions to different conditions and thereby reduce errors due PVT calculations.

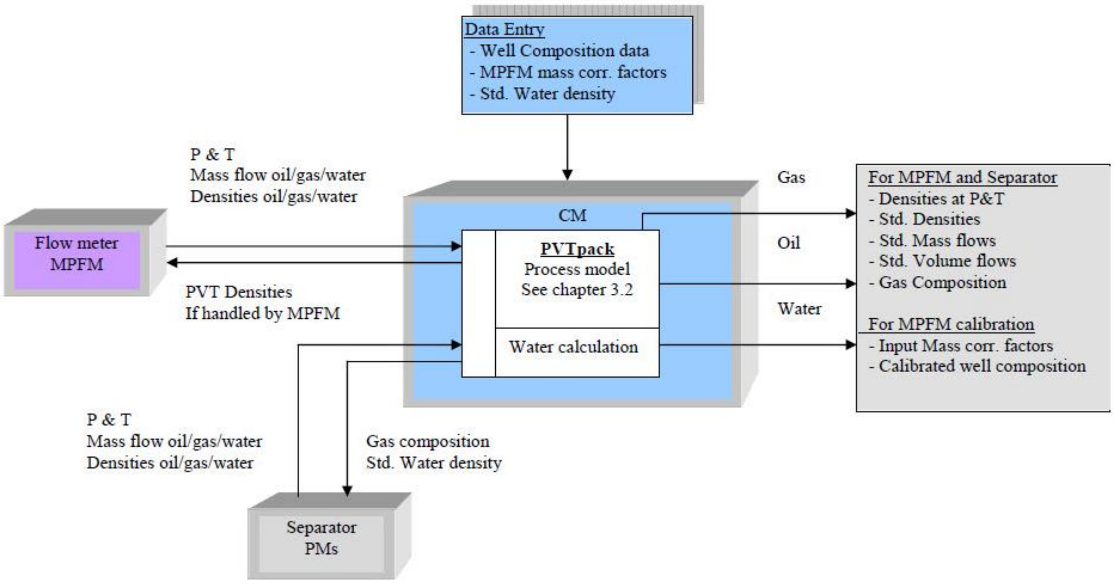

Figure 2. PVT model including LivePVT [ref 1].

3. ONSHORE APPLICATIONS – TYPICAL NEEDS

3.1 Onshore technology needs

For subsea the practice has often been to install one MPFM per well, this is not the case for onshore where number of wells may be more significant and cost per well is significant lower [ref 3].

Conventional topside MPFM are in the 200 / 400 k$ price order of magnitude, the challenges for industry is to offer alternative multiphase metering solution for individual well measurements at significant lower cost.

Reducing costs hould be addressed by simplifying multiphase metering solutions. For onshore, individual well measuring solutions like water fraction meters, WFM, with capability to provide enough information for production optimisation and reservoir monitoring at an acceptable costs are welcome.

An other issue is use of permanent gamma source which require authorization, training & minimum follow up for safety / security reasons. Use of gamma source may limit large deployment of MPFM in some areas.

3.2 Multiphase metering system operations

The way we operate MPFM has considerably been improved recently especially in case of subsea & unmanned situations by using remote monitoring & surveillance for instance [ref 4 and 5].

With remote access to the vendors service-pc, online flow measurements, raw signals, diagnostics data can be analysed online either by internal or external metering experts.

Similar approaches which allow to reduce OPEX shall be applicable to onshore developments or upgrade of existing installations, has shown industry to come up with more cost effective and user friendly systems.

4. User Forum joint efforts

During initial discussions between Total, Shell and Statoil, a list of subjects were identified on which we saw an opportunity to exchange and collaboration on technical aspects.

Technology gaps

The total experiences allow a large view both on field performance, availability and systems at different developments stages. Use of TRL (technology readiness level) is a tool to classify technology. The scope has been focusing on systems we have identified new multiphase metering solutions but also on water fraction measurements systems. The experiences also show there are gaps that need to be closed, this also include bigger diversity of different technological solutions.

Cost reduction initiatives

Clearly, in the current context, this is an issue in which join efforts may help to identify and qualify cost effective technology for different applications.

Flow loop testing / cooperation between Operators

This is certainly one of the first initiative in the technical User Forum took in order to share expertise and efforts to test different technologies and meters. Requirements and flow loop testing, standardization of testing, including system testing, including interpretations of test results are important in this part. Other topics can include:

- PVT handling
- Workshop & meeting between operators
    - Liaison with manufacturers
- Invite to joint industrial projects including flow testing
- Standardization work
- Establish User Groups where experiences can be shared

Based on the experiences for subsea multiphase metering, it is obvious that lesson learned is useful for onshore applications, even the solutions will be simplified. During assessements of proper technology solutions for onshore, the expected measurement uncertainties, reliablilty and PVT handling will be about the same as for subsea.

4.1 Joint testing program 1

The first initiative is the joint testing program called *Non gamma JTP 1* to test to map performances of non-gamma multiphase measurement systems in addition to water fraction measurement systems.

The aim with the test is to identify one or more technologies to be taken further for more testing and qualification work for different applications.

The focus on this first joint testing program is to identify technologies that can be useful for onshore fields, and usages of technologies in regions where use of gamma rays is rather stricted. Technologies that are planned tested is somewhat simpler that normal implemented for subsea. Thus mapping the simplication against an overall need based on field experiences are needed.

The user group has invited a number of vendors initially that are considered interesting to further test. The plan is to run the first test at DnV GL in Groningen with several units in series, later this year. DnV GL is coordinating the activity on behalf on the operators towards the vendors.

For some fields, water cut measurement and salinity measurement technologies can be sufficient, for example to identify water producing zones during production optimization. The joint test program will therefore also include water fraction/cut measurement technology applicable for multiphase flow. Two MPFM without gamma sources and some water fraction meters able to work in multiphase have been considered.

The test setup for this, two multiphase meters and two water cut meters are installed in series, thus the same reference single phase measurements are used for all units. This allow the total test matrix to be run once, without any need to route the flow through different meters, which will be an effective manner to obtain data.

The test will cover extended test matrix covering WLR and GVF between 0 - 100%, two line pressures, two water salinities and a given range in liquid flow rate.

Tests will be carried out following a strict protocol and similar conditions during 2 weeks with confidentiality clauses as well as data ownership conditions fully accepted by suppliers.

Hopefully some results from this test can be shared next year's workshop. The possibility to lauch a JTP 2 in 2018 or later, will be evaluated when new concepts are presented for the user group.

5. Conclusions and WAY FORWARD

Up to now, the cooperation and exchange between our companies have been excellent and useful.

The purpose of our joint efforts have been to share information within multiphase metering experiences, but also working together to further develop technology.

The User Group and annual workshops between Operators has been an area to discuss experiences, technology gaps, and future projects.

This initiative has allowed to define some short term and long term actions that can improve multiphase metering technology, contribute to develop technologies that better meet the industry needs and close gaps.

New activities is suggested to be launched in order to meet the objective with this initiative, such as

- Annual workshop between operators
- Other joint industrial projects
- Standardization alignment
- Cost reduction initiatives
- PVT handling
- Technology readiness evaluation

The Joint testing program launched is one of the first significant initiative which will allow to test multiphase meters and water cut meters, and standardise test protocoles, tests agreements and also reference measurements.

Further develop multiphase metering technology to close gaps and do multiphase metering systems more reliable over time are needed. Better understanding how multiphase metering system are working, better training of users and more openess of different technologies are working is obviously an objective with this initivative.

Abbreviations

RMM: Remote Metering Monitoring
MPFM: Multiphase Flow Meter
WGFM: Wet Gas Flow Meter
WFM: Water fraction meter

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