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Introduction

From 91 to 96, TotalFinaElf supported and tested multiphase meter prototypes. These were qualified on onshore fields.. Since 1997 multiphase meters are considered by projects and installed for direct multiphase flows both for well metering and field metering . Several multiphase meters are now in operation in TotalFinaElf operated units both on onshore & offshore locations This technology is also subsea deployed in high water depths developments

The key issues are for such a new technology to get acceptance by projects but also to develop long term confidence from users compared to conventional technology

Through the description of two different operational experiences within TotalFinaElf , this paper brings users , designers and manufacturers some guidelines to apply successfully multiphase metering on field .

Four years experience with a meter 1997 - 2001

General

In this first application , the field layout comprises wells that are clustered on a wellhead platform. The production is sent on shore through a 40 Km line. After separation, the oil is metered before custody transfer, which yields an excellent reference measurement.

The platform is unmanned. It has minimum facilities: Production manifold, test manifold and the multiphase flowmeter. The local operator interface of the meter is housed in the electrical room. The readings from the meter are also available on shore, through a low baudrate communication that carries all the control signals for the platform. The valves of the test manifold are not equipped with actuators.

Multiphase meter system

The decision to use a multiphase meter was made back in 1994/1995.

The multiphase meter is a Fluenta MPFM 1900VI, which consists of a capacitance sensor, an inductive sensor, a gamma densitometer, a venturimeter and a flow computer. The velocity of the flow is determined both by cross-correlation between different electrode pairs in the capacitance sensor and by the venturi *meter,* which extends the range of the multiphase meter to cover single phase liquid and annular flow, and also add redundancy to the velocity measurement in the intermediate range of gas velocity *flow (GVF).* The meter is basically an instrumented pipe section, approximately 1.4 m long, and with an internal diameter of 3".

The meter has been supplied as skid mounted, complete with inlet and return piping, and drain, vent and drip tray for ease of calibration.

In order to limit any potential for clogging by wax, etc. within the meter itself, or in the pressure and differential pressure impulse lines, the complete instrumented pipe section has been heat-traced and lagged.

The measurement principle is first to measure the density of the flow using a gamma densitometer. In oil-continuous flow (i.e. up to approx. 60 – 70% water cut), the density measurement is combined with a measurement of the dielectric constant of the flow using the non-intrusive, surface plate, and capacitance sensor. At higher water cut, when water is the continuous liquid phase, the mixture conductivity is measured using an inductive type sensor.

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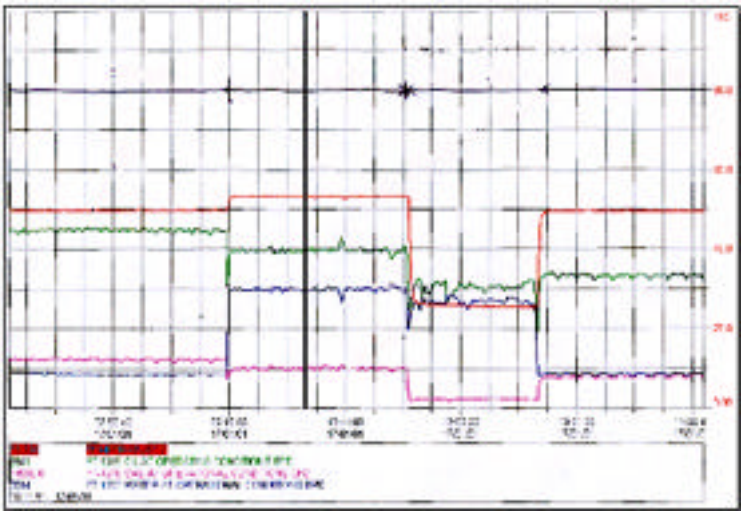
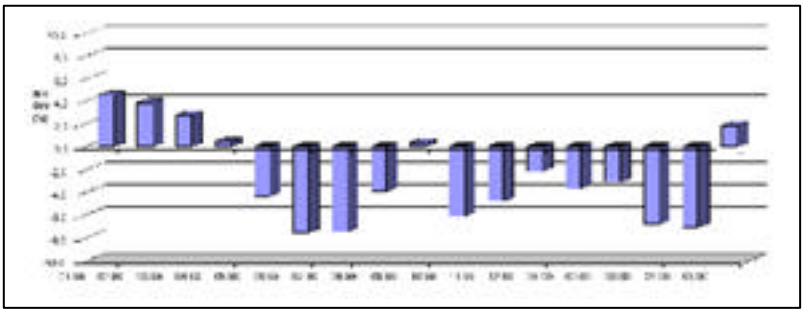
Operational experience gained so far

- The MPFM 1900VI was offshore commissioned in early 1997. with assistance from manufacturer and in-house specialists, ***especially for fluid parameters (oil & water density) determination***. The duration of the commissioning / start up phase was about 10 days including training for the operators.

- As no test separator was available on the offshore platform for testing and verification; *a static calibration procedure* has been defined and implemented. This has been successfully applied to the meter to check the meter and make diagnostics. The procedure involves isolating the meter, emptying it and filling it with air, oil & seawater. Since the fluid properties are known, this makes it possible to check the static response and calibration of the capacitance sensors, inductance sensor and gamma meter.
- The MPFM is continuously in operation. During the weekly visit, wells to be tested are switched through the meter. A well test takes about one hour, and all the tests are validated before being entered into the database.
  In between weekly visits, the MPFM is left under flowing conditions with one well producing through the meter.
  The man machine interface allows simple operation of the system; operators have been very satisfied by the simplicity of use.
- No systematic maintenance is carried out under normal operation; verification of performance is done through regular follow up and comparison between well figures and total production.
  The manufacturer has been called out one times a year for calibration and replacement of a display monitor and an electronic card on the inductive sensor. In 4 years time, 3 interventions have been carried out by the manufacturer, mainly for capacitance & inductance sensors calibration.
- The system has been operated successfully during 4 years without any problem. No failure has been recorded on sensors. The availability has been 100 % since the start up. The meter has been used during a short period of time only for liquid and gas measurements; this was due to a bias in the water cut measurement generated by incorrect water cut setting. This indicates that care must be taken when calibrating MPFM with field measurements, which are not necessarily representative. This also indicates that even in such a case, the system still continues to provide data before reconfiguration or recalibration of some sensors.
- The meter has been used for continuous recording of flowrates, gas fraction, and water hold up of wells for well behavior monitoring or for individual well test for reservoir management.



Accuracy of the meter has been checked by both daily and monthly comparison with terminal figures. MPFM figures for oil and water have been in good agreement (average less than +/-5 % for oil, and +/-10 % relative for water) with fiscal figures.
Yearly figures show a difference of less than 1% between reference figures and multiphase meter figures.



A step towards multiphase metering standardization in offshore West Africa 1998 - 2000

Applications

Six multiphase meters are now in operation on recent Congo offshore well platform both for well testing (4 wellhead platforms) and also for field metering (2 platforms) .

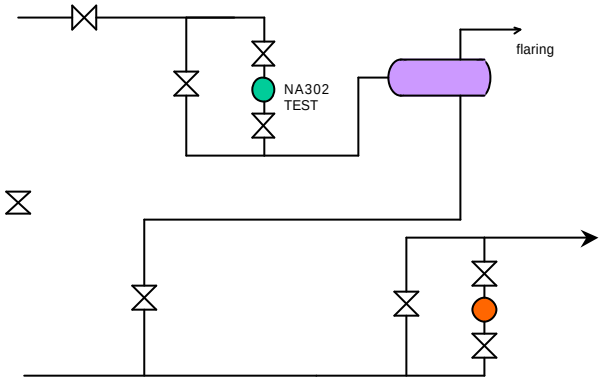
Each wellhead platform is unmanned. Most of them have a simplified design with minimum facilities: production manifold, test manifold , multiphase flowmeter for well testing and in some cases a multiphase meter to measure the total production of each platform

Multiphase meter system

The multiphase meters concepts which have been selected are based on the MFI technology with a very limited number of components ; the measuring part consists basically on microwave sensors and a gamma densitometer. The velocity of the flow is determined by cross-correlation in the microwave section of the meter .(Only one meter among the six was equipped with a redundant flowrate measurement based on a venturi meter)

The meters are very small (0.6 m long) ; they are installed in a vertical (internal diameter of 2 " and 3”)

They have been installed to by passed in order to do some static checks if necessary .



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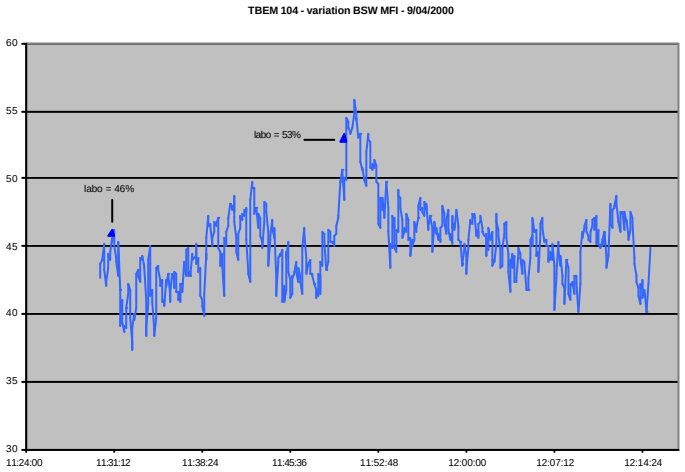
Operational experience gained so far

- Well tests are started from a Digital Control System based on each platform
- In the first months of operation , differences have been noticed between water cut measured by multiphase meter and laboratory results ; this problem has been solved both by implementation of accurate values for water conductivity .



After configuration with correct conductivity figures obtained in laboratory , agreement between water cut determined from multiphase meter and sampling has been found satisfactorily (90.5 % for MPFM compared to 91% for sampling)

- Cross correlation has been found to be inoperable for a limited number of wells with GVF < 10 % , flow rate cannot be determined ; one solution was to test the wells in combination with high GVF wells (up to 90 %) . it has to be pointed out that even if flowrate is not available , instantaneous water and Gas fractions are still measured and displayed .
  In such a case , a venturi should extend the range of the multiphase meter to cover single phase liquid and annular flow, and add redundancy to the cross correlation velocity measurement in the intermediate range of gas velocity flow (GVF)

Benefits

- Multiphase meters without flow conditioning systems have been applied to multiphase streams with water cut up to large range of flow conditions : WLR up to 90 % and GVF up to 90 %

- Monitoring of the multiphase flow at the wellhead eliminates the need for dedicated test lines from remote wellhead completions, as well as the need for a dedicated test separator at the processing facility. The meter replaces a test separator in its functionality.

- Multiphase meters can be used successfully for total field metering of a multiphase flow with an acceptable accuracy

- A MPFM at the wellhead allows improved well control, and hence better reservoir monitoring and well performance management. Extra information can be gained from the instantaneous feature of the measurement. For example, water slugs and gas slugs appear clearly in the readings of the remote wells.
- Continuous readings, instead of accumulated quantities given by test separator, will allow diagnostics of well behavior, and total recovery would probably be increased.
- The high CAPEX savings have been evaluated for each platform to something around 800KUS$, compared to a test separator solution. In this application, the main savings came from the fact that the device saved the flare: the platform has no vessels to blow down.

- This device helps in cutting OPEX as well. Despite the manually operated valves of the manifolds, it is possible during a one-day visit to test 2 or 3 wells, thanks to the short stabilization time of the meter. When leaving, the operator launches a « long » test that will last until the next visit. A remote display allows for further analysis of the behavior of a given well.
- The Fluenta design multiphase meter has already demonstrated a high reliability (good operation during 4 years without failure) ; no failures apart humidity influence on high frequency connectors have been recorded on the MFI meters themselves
- From a maintenance point of view, the meter themselves are generally low maintenance cost item as compared to a test separator..

Improvements & recommendations

- Due to the specificity (" high tech ") of multiphase meters , it is sometimes required to have a specific maintenance contract with the manufacturer rather than with a general maintenance contractor

- Detailed fluid and flow characteristics knowledge is required to select the appropriate design and implement the good parameters in the software

- In house resources are often necessary for detailed determination of fluid parameters and dedicated training of users .

- Environment (saline humidity) has to be considered ;technology shall be made insensitive to such influences .

- Installation of MPFM in order to be able to carry static checks brings a lot of information (diagnostics) in case of " troubles " ; it can be used also for periodic validation .

- Standardization is not easy ; each case can be different ; they are " easy cases" and " difficult cases"

- Good communication between specialists , users ,project people and manufacturer is mandatory

- Investment cost is not so critical , life cycle cost including maintenance and different assistance to operations has to be considered

Conclusions

Compared to the results we are used to getting from a test separator, the figures, which are delivered by this equipment, are in the same range of accuracy. for most of GVF (< 90 %) and WLR (< 80%) . Nevertheless higher water cut require a good

knowledge of water properties (conductivity) and subsequent follow up of water salinity is required Furthermore , the detailed analysis of the gas/water/oil fraction distribution allows better knowledge of the flow conditions in the gathering system and in the flowlines. During transient operations (mainly start-up operations), the increase of the watercut allows us to improve our understanding of the well near the well bore.

Implementation of multiphase meters on field export allow to meter multiphase field production for allocation .

This experiences demonstrates that the MPFM can be reliable solutions for well testing , well monitoring and field metering

Four and a half years life time without failure for some meters shows that multiphase metering is now compatible with very demanding subsea and high water depths applications:

These first success in our company have been possible through a positive **involvement of all people (project people, specialists, users) from design and detailed studies to operations**. But further standardization do require repeatable successfully cases and .a strong confidence of users based on a number of various applications .

In TotalFinaElf , we try to develop such confidence through a rigorous selection of technology and applications . Long term reliability , simplicity and operability including understanding are mandatory

Support of manufacturers and common understanding of problems will also be critical

Acknowledgements

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