Alternative Technologies to Wet Gas Meters

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Abstract

Hydrate inhibitors are often injected into deep subsea pipelines to reduce the chances of water forming hydrates which can block and damage equipment. Wet Gas Metering is now being used to optimise hydrate inhibitor injections. The accuracy of these types of metering systems are crucial to minimise injection over-dosage. This paper looks at the accuracies of wet gas meters for such a purpose, and an alternative, the Weatherford Red-Eye, which measures directly the concentration of water in aqueous and may reduce some of the over-dosage requirements in chemical injections. Additionally another technique is suggested which would involve using infrared spectroscopy with attenuated total reflectance and may be less susceptible to undesirable flow conditions which affect the Weatherford Red-Eye.

1. Introduction

1.1 Wet Gas Flow

The oil and gas industry uses the term multiphase for a stream containing liquid and gas phases. More specifically this type of flow is two phase flow with multi-component liquids and/or multi-component gases. Commonly the liquid phase contains a mixture of formation water, condensed water and liquid hydrocarbons while the gas phase may contain gaseous hydrocarbons and water vapour. This complex mix is usually a heterogeneous mixture which can be described by numerous flow regimes. Flow composition varies along the cross section of the pipe and with time. Wet gas flow is a subset of multiphase flow. Definitions for wet gas vary. Historically the term wet gas has been used for a multiphase stream with a gas volume flow rate fraction of 90%-95% or higher. However, GVF is based on volumetric flow rates at actual conditions in a pipe, and doesn't account for relative differences in gas and liquid densities. Since this is important in many metering devices the American Petroleum Institute (API RP 85 2003) recommends that a more appropriate definition is that a wet gas has a dimensionless Lockhart-Martinelli parameter less than 0.35. This parameter considers densities and is defined as:

$$LM = \frac{Q_l}{Q_g}\sqrt{\frac{\rho_g}{\rho_l}} \qquad (1)$$

Where Q_l and Q_g are the liquid and gas mass flow rates, and, ρ_g and ρ_l are the densities of the gas and liquid at meter conditions.

1.2 Wet Gas Metering Applications

Metering requirements can be broadly separated into three areas. These are Legislative, Corporate and Operability Requirements. The requirements for different projects can vary significantly. Historically Wet Gas Meters (WGMs) were used for production allocation and reservoir management, which required information about hydrocarbon flows (API 2003). Recently however, WGMs have been used to quantify water flow rates to optimise hydrate inhibitor injections. In many instances this has become the most difficult and important role of WGMs.

1.3 Current Technologies

Metering a wet gas flow is significantly more challenging than metering a single phase gas or liquid flow. Using traditional dry gas metering techniques in a wet gas flow leads to over-readings. Of these dry gas metering techniques the most robust technology with the most repeatable results in wet gas flow has been the differential pressure (DP) meter, which measures a change in pressure across a flow impedance to calculate the flow rate.

Most WGM technologies measure flow rate using a DP meter and attempt to correct for the over-reading by measuring the liquid composition and using other inputted data, such as information about fluid densities and pressures. However; the measurement of the liquid fraction is difficult, stemming mostly from the complex flow patterns that occur in wet gas flow (American Society of Mechanical Engineers 2008). Technologies which are often used to estimate liquid fractions are microwave resonance, gamma densitometry and optical absorption.

1.3.1 Weatherford Red-Eye

The Weatherford Red-Eye is a unique device which offers an alternate method for metering wet gas flows. Rather than estimating flow rates of individual phases, it calculates the fractions of certain components in a flow, including the concentration of water in aqueous. This allows for a direct measurement to optimise hydrate inhibitor injections. This is, in many projects, the role of the wet gas meter which requires the greatest accuracy. This device is relatively new and has not been implemented for such a role.

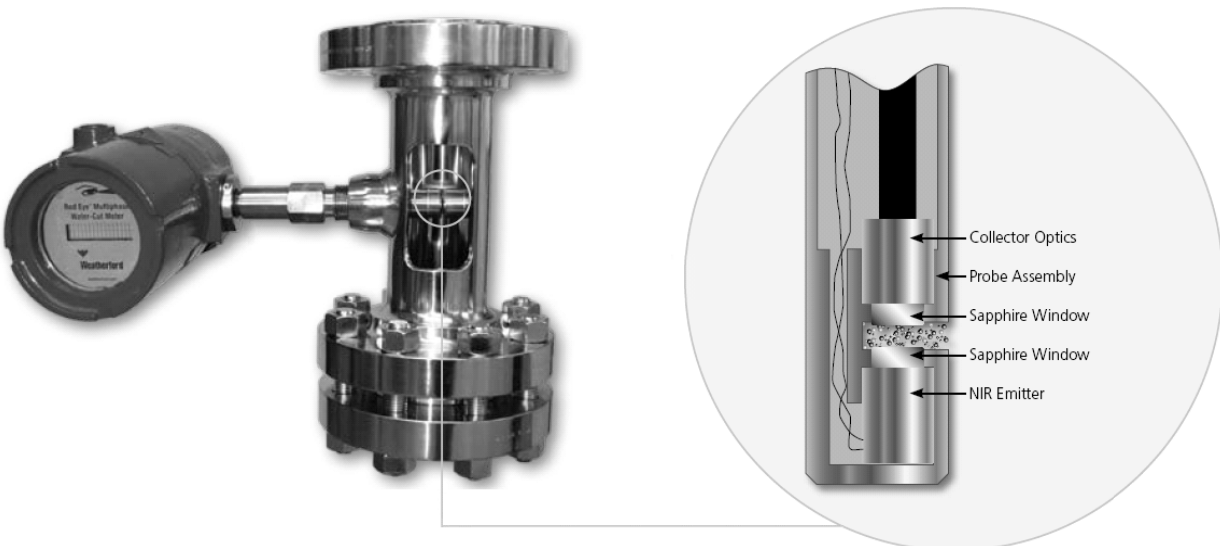

Figure 1. Weatherford Red-Eye (Weatherford 2008)

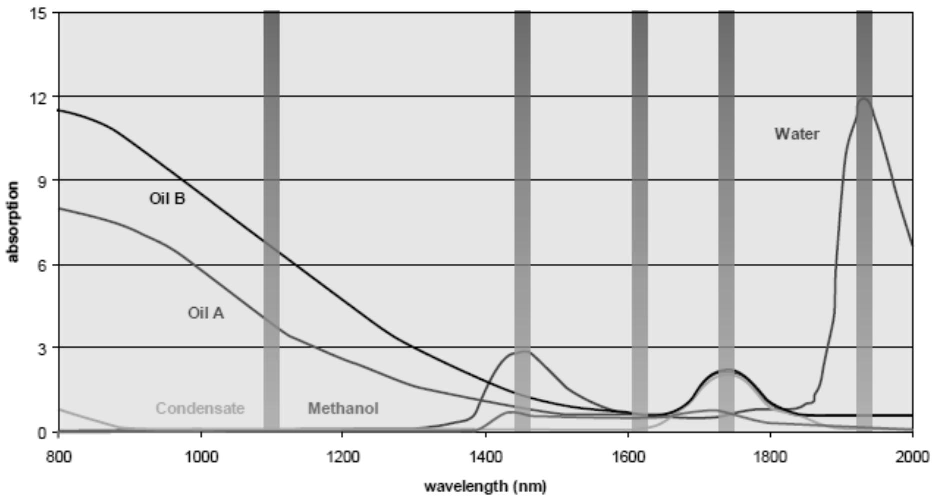

Figure 2. Absorbtion of various components and the 5 wavelengths utilised by the Red-Eye (Weatherford 2008)

Figure 2. shows the near-infrared light absorbance of some common components found in a multiphase stream. The Weatherford Red-Eye measures the absorbance at various wavelengths to calculate the concentration of a multiphase flow.

2. Project Objectives and Investigation Plan

The overall objective of the project is to investigate current WGM technologies and potential alternatives. To investigate current technologies, information was collected, including available test data. From this the limitations of the current WGM technologies were be compared. An investigation into potential alternatives was conducted to determine if any other technologies could be implemented in or replace wet gas meters.

3. Results and Discussion

3.1 Wet Gas Meter Accuracies

An extensive review of WGM test data showed that typical accuracies of WGMs were ±5% relative for gas flow rate measurements. Typical water flow rate accuracies were 0.1% absolute of the total flow. Figure 3 shows some of the typical results of WGMs (For confidentiality reasons individual vendors could not be discussed in this paper).

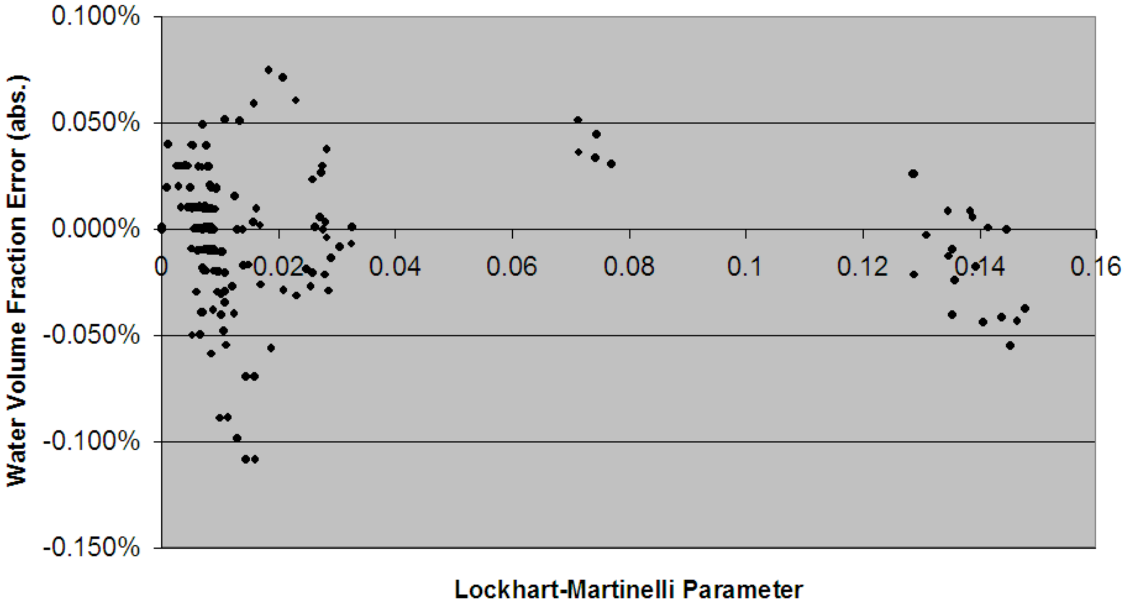

Figure 3. Absolute water volume fraction errors from two WGMs during flow loop testing

3.2 Current Hydrate Inhibitor Injection Over-Dosage Requirements

Over-dosage requirements vary between projects. The Woodside Energy Ltd Sunrise Project is an example of where WGM are being considered for use in hydrate inhibitor injection optimisation. The uncertainties for this project are likely to be:

- Distribution system 15%
- Single phase Inhibitor metering errors 5%
- Inhibitor quality error 6.3%, this is a result from a 2% uncertainty to the concentration of MEG requirements
- Errors from WGMs

Similar uncertainties could be expected for other projects which involve inhibitor injections. A method which measures the concentration of inhibitor to water directly would reduce the over-dosage requirements from inhibitor metering and inhibitor quality errors, effectively reducing the over-dosage requirement by 11.6%.

3.3 Weatherford Red-Eye Analysis

The advantage of the Weatherford Red-Eye in metering for the optimisation of hydrate inhibitor injections is that by measuring the concentration of water in aqueous (C_{wm}) directly, then the over-dosage requirements for inhibitor quality and inhibitor metering are no longer required.

Flow loop tests were conducted by Weatherford at Colorado Engineering Experiment Station Incorporated. The test was conducted with water and methanol in a natural gas and condensate wet gas stream. It was shown that accuracies of within about 10% absolute of the concentration of water in aqueous could be expected. As with other WGMs, as the amount of liquids in a flow decreases, their measurement became less accurate.

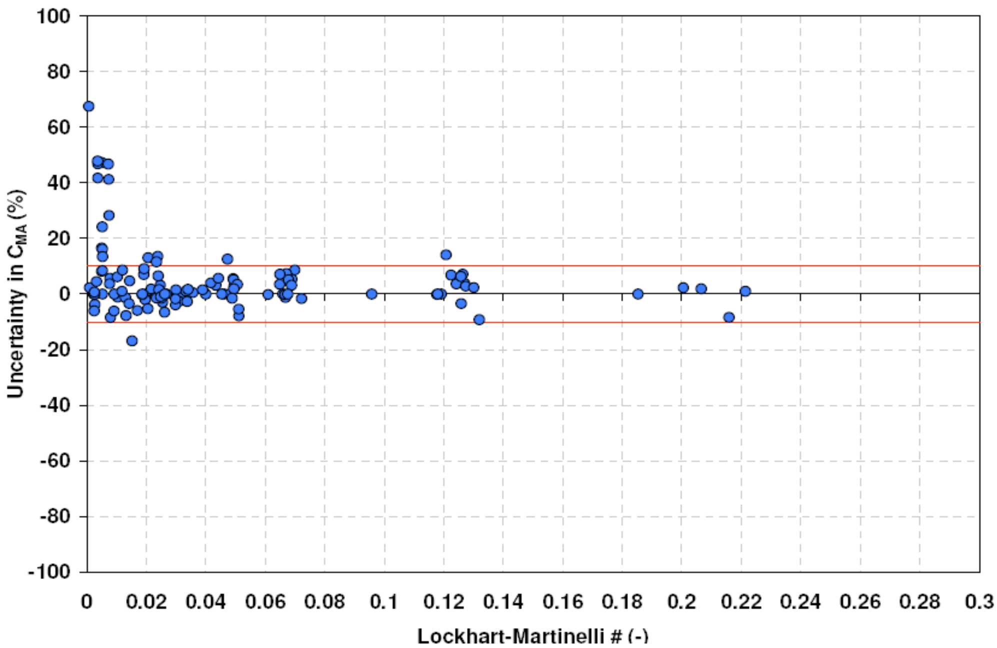

Figure 4. C_{wm} errors during a wet gas flow loop test in CEESI (Ramakrishnan et al. 2010)

This test also showed that the Weatherford Red-Eye was very susceptible to inaccuracies caused by undesired flow conditions, including pressures. This is believed to be a result of insufficient liquids entering the measurement space for analysing.

3.4 Attenuated Total Reflectance Infra-Red for Optimised Inhibitor Injections

An alternate method for the measurement of water to a hydrate inhibitor would be the measurement of a stream with mid-infrared light between the wavelengths of 4000cm^{-1} and 1200cm^{-1}. The relative transmittance of certain wavelengths are dependant on the composition of the fluid. Tests were conducted on mixtures of hydrate inhibitors and water to determine if infrared absorption could be used to determine C_{wm}.

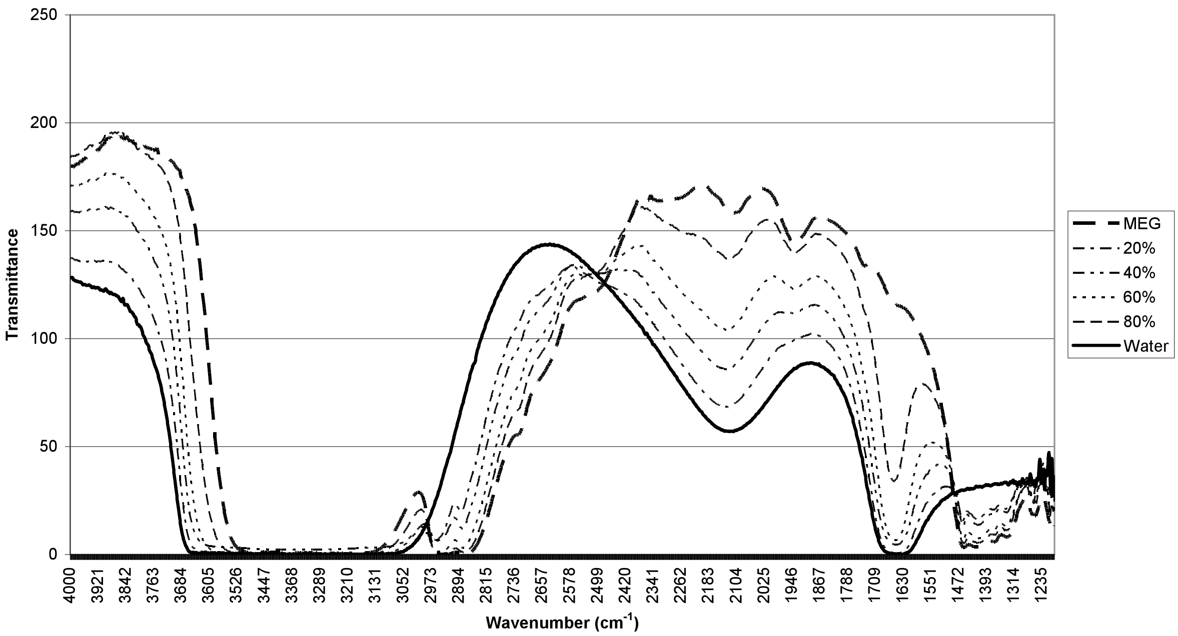

Figure 5. IR transmittance of monoethylene glycol and water mixtures

Figure 5 shows the transmittance of infrared (IR) light at various wavelengths for mixtures of water and monoethylene glycol (MEG), a common hydrate inhibitor. This data indicates that C_{wm} can be determined using mid-infrared range spectroscopy with some accuracy.

One of the advantages of using IR spectrometry is the ability to use attenuated total reflectance (ATR). This method may allow for more versatile liquid sampling, removing the need for a transmitter and absorber – overcoming one of the main limitations of the Red-Eye. ATR requires only the single crystal which can be oriented in a variety of manners about a pipe, e.g. at a pipe wall or as a probe. Further still, multiple measurements can be taken from various positions in the pipe to get an understanding of the flow pattern and concentration gradients.

4. Conclusions and Future Work

The testing of various meters and techniques conducted under different condition has made it difficult for reliable comparisons to be made. As such it would be recommended that independent testing be conducted of the various WGMs and Red-Eye under the same conditions. However, the preliminary results have shown the Red-Eye could increase the accuracies of injection optimisation due to reductions in MEG metering inaccuracies.

The ATR-IR method has been shown to be theoretically viable. However no research has yet been conducted into how this technique would respond when used under different flow regimes within a wet gas flow. Future work could include a computational fluid dynamic model to assess whether it would provide an adequate method of analysing a wet gas flow. Furthermore a prototype could be tested at a flow loop to ensure ATR-IR as a valid technique for Wet Gas Metering.

5. Acknowledgements

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6. References

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