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THREE PHASE METERING IN SUMATRA USING THE STARCUT METER: AN EXAMPLE OF A PERFECT FIT TO A SPECIALIZED NICHE

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1. SUMMARY

Matching of multiphase meter (MPM) capabilities with field conditions has allowed exceptional performance in applications in Indonesia. Texaco's Starcut microwave sensor is unique in its ability to provide very accurate and stable WaterCut determination (<0.3% rms. error) at very high watercuts (>90%) even when some gas is present in the fluids and salinity is varying. Accuracy, stability and rapid transient response derives from slip stream sampling, small size, dual channel construction, bonded ceramic and steel components and heat exchange jacketing using production fluids. The system performs continual automatic calibration based on on-line estimates of fluid density and salinity. When combined with various options such as orifice meters STARCUT also provides accurate flow rate measurement (<1% rms. error). The above described production niche is not addressed by MPM manufacturers but is critically important to Texaco. In this niche most other MPMs are insufficiently accurate to provide useful well management data.

2. INTRODUCTION:

The name STARCUT refers to Texaco's patented microwave based oil, water and gas fraction measurement technology. This technology has proven to be very versatile and is incorporated into several multiphase metering contexts from full range gas volume fraction (GVF) cases to low and zero GVF applications. STARCUT is composed of microwave control and computational electronics and a dual channel microwave waveguide fluid sensor. The STARCUT sensor construction and operation is well documented in several reports, 1, 2. This fluid fraction sensor technology is unique in the industry in several ways, each of which contribute to its versatility, exceptional accuracy and long term stability.

The sensor is actually two identical sensors in one steel block. The sensors are microwave waveguides composed of ceramic bonded to steel fired at 1000 degrees Fahrenheit and coated with 3 mils of aluminum oxide. Geometry of the sensor is manufactured to .001 inch tolerance and is currently calibrated over 32 to 310 degrees Fahrenheit and pressure tested at 10,000 psi. These sensors are jacketed with a heat exchanger using the production fluids. During meter operation therefore both sensors are at the same temperature but one contains a stationary reference fluid and the other receives a portion of the production flow from a 1/4 inch diameter main line slip stream. Microwaves at 10,000 megahertz are alternately passed completely through first the reference sensor and then the production sensor at up to several hundred times a second. Extreme sensitivity and high signal to noise ratio are achieved through continual differential measurement allowing common mode rejection of electronic noise, aging effects of electronics, transmission line effects and both effects of electronic and sensor temperature. Data collection from the sensor pair consists of temperature, microwave attenuation, microwave phase shift. These basic data are processed statistically using pattern recognition methods and are referenced to stored laboratory data consisting of tables of properties of pure oils , brines and gas as well as families of mixing curves, all as a function of temperature. These laboratory data combined with field data allow continual and on-line prediction of dry crude oil API gravity, pure field water salinity, gas fraction and finally WaterCut. At preset intervals of seconds to minutes , internal calibration is automatically reviewed relative to oil density , water salinity and gas fraction. Changes in fluid conditions immediately provokes automatic re-calibration. Fraction and density determinations are then used in overall MPM rate computations.

Total fluid rates are determined in a variety of ways depending on the application and the accuracy requirements. Many of our applications require higher accuracy than is possible using MPMs which take the entire flow stream through one sensor tube. We have developed two basic designs suited to our needs:

3. LOW GAS FRACTION DESIGN

The STARCUT Low Gas Three-Phase Meter is a design (<.15 GVF) which consists of the STARCUT sensor in parallel with an orifice plate flow meter . The orifice meter equation is continually updated using the fluid fraction data, API gravity and water salinity. This particular application was installed, tested, proven in the Minas oil field in central Sumatra. Figures 1, 2 and 3 present data used to prove the STARCUT application. The STARCUT Three Phase Meter is currently in portable use in Sumatran well testing operations.

4. ALL GAS FRACTION DESIGN

The STARCUT Full Range Multiphase Meter design recognizes that metering accuracy rises greatly when some fluid separation is allowed. Secondly we recognize that no separator performs a complete phase separation. Some gas always remains in the liquid legs of the separator. STARCUT gas insensitivity makes it the choice for accurate determination of WaterCut in this liquid portion of the MPM. We therefore have combined the STARCUT Low Gas Three-Phase Meter in series with a small, passive fluid conditioning device, the Gas Liquid Cylindrical Cyclone (GLCC) deliberately undersized to allow up to 0.15 GVF to pass out the liquid leg and emphasizing a dry gas stream. STARCUT, in parallel with an orifice meter in the liquid leg, is easily able to determine fluid fraction data. An orifice meter is also present in the gas leg to complete the design. The GLCC was design was aided with software provided by the University of Tulsa , Separation Technology Project. Meter testing is underway.

5. FIELD TESTING - AT LOW GVF

The STARCUT meter design for the Minas Application is of the Low Gas Three-Phase Meter design and is portable and operated from a truck battery. This STARCUT THREE PHASE METER has successfully passed accuracy and survival evaluation for portable use in the hilly , jungle environment of Minas well testing operations, Northern Area. Current and projected reservoir development in that area consists of 100s of wells whose production niche is characterized by low Gas Oil Ratio (GOR), very high temperatures , high WaterCut, variable and low salinity, multiple zone production , sand production and high flow rate ranges. During the test phase STARCUT was evaluated relative to separator data where facilities were available and by manual sampling. STARCUT demonstrated WaterCut measurement agreement with reference data with +- 0.3%, average deviation from reference, regardless of operating pressure and in the presence of up to 0.10 GVF estimated from empirically derived crude oil Pressure , Volume , Temperature (PVT) data , figure 1. Flow rate accuracy of 1% average deviation from reference, from 3000 to 16000 Barrels/day of produced fluid has also been demonstrated, figure 2. For a single well, 3D86, downstream pressure was varied over time to demonstrate WaterCut measurement stability at different GVF, figure 3 a. b. c. Figure 3c. indicates well head pressure set by closing downstream valves against the down hole ESP driven flow. Changes in well head pressure affect GVF negatively as seen in Figure 3a. Watercut of production fluids was monitored using STARCUT and separator testing (Tank Test). STARCUT watercut estimate, separator data indicate close agreement over the GVF indicated, figure 3b. Uncompensated reading of watercut demonstrate that without STARCUT gas detection and compensation the watercut errors would have been over 6% in that case.

This portable system replaces a portable coriollis-based WaterCut meter and gas orifice meter which required a perfectly functioning truck mounted two-phase separator. The physical principle of the STARCUT dual measurement microwave sensor is inherently more accurate than the density based coriollis method by a factor of 10 to 100 under the low GOR , high WaterCut Minas Northern area conditions.

STARCUT is licensed to Jiskoot AutoControl of England and distributed and supported in Southeast Asia by Matco Asia.

6. DISCUSSION

Full bore non-intrusive MPMs have not demonstrated sufficient accuracy's for high water low gas production well testing. Major improvements in MPM accuracy are possible using the STARCUT Microwave System in conjunction with various configurations using minimal and partial liquid gas separation. Drawbacks to partial separation are primarily related to footprint and weight however new concepts in separator design combined with STARCUT Gas insensitivity have allowed design of highly accurate portable compact MPMs with footprints of 3 feet by 5 feet and weighing less than 1200 pounds. Texaco EPTD engineers have filled a multiphase metering niche in which STARCUT has demonstrated high accuracy at low cost . Not only does the niche of high water, high temperature and low gas operations currently represent a significant portion of Texaco production in Indonesia, future trends for world wide oil production are also in the direction of higher watercuts and lower gas fractions. Few, if any, other instruments are focused in this niche even though there is a critical need.

7. ACKNOWLEDGEMENTS

We wish to recognize the contributions of past and current members of the Texaco EPTD Multiphase Pumping and Metering Team and the staff of the EOR

Project for the Minas field for their exceptional effort in supporting the Starcut Three Phase Meter project.

8. REFERENCES

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9. FIGURES

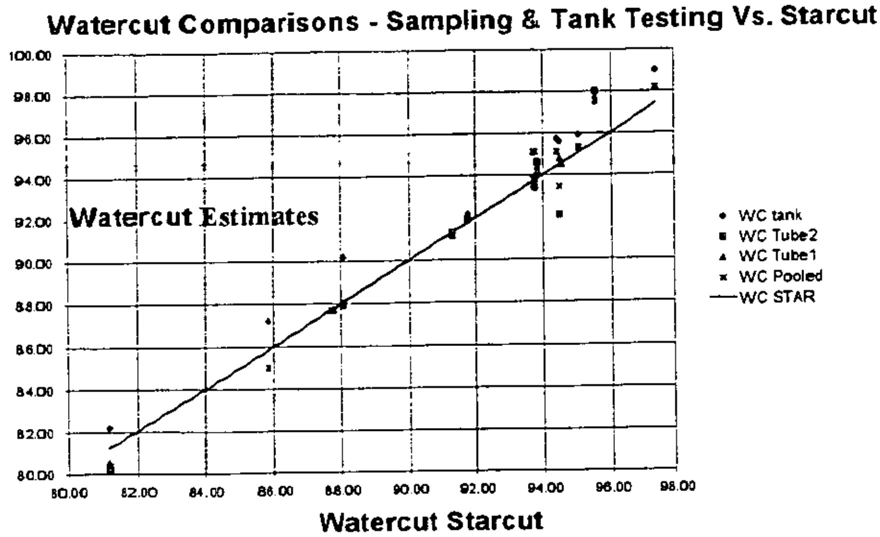

Figure 1 - Comparison of Watercut Obtained by Three Phase Separation, Sampling (Tube cuts) and Measurement by STARCUT

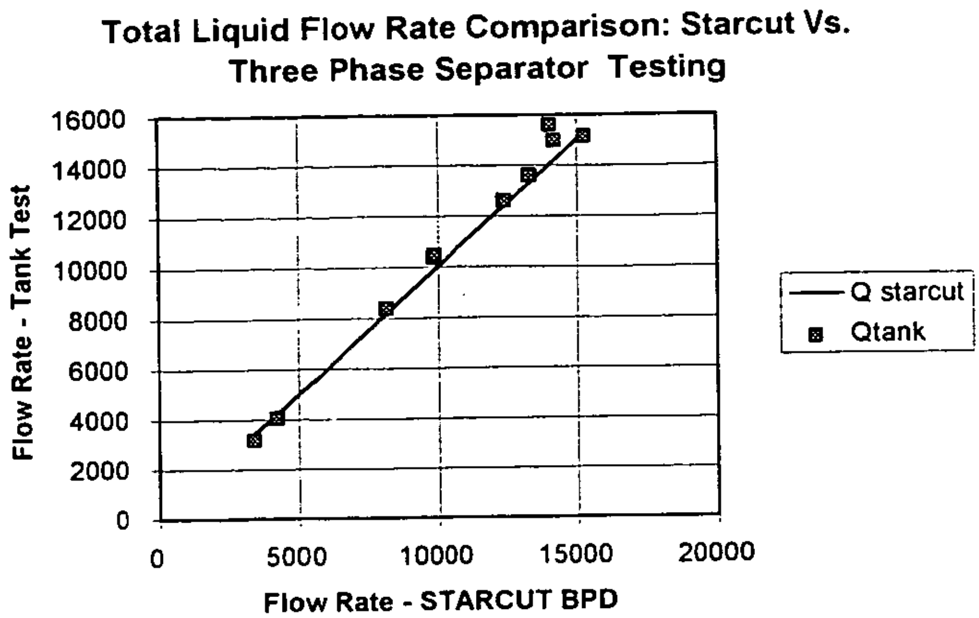

Figure 2: Total liquid flow rate as determined by STARCUT Meter versus three phase separator (Tank) results.

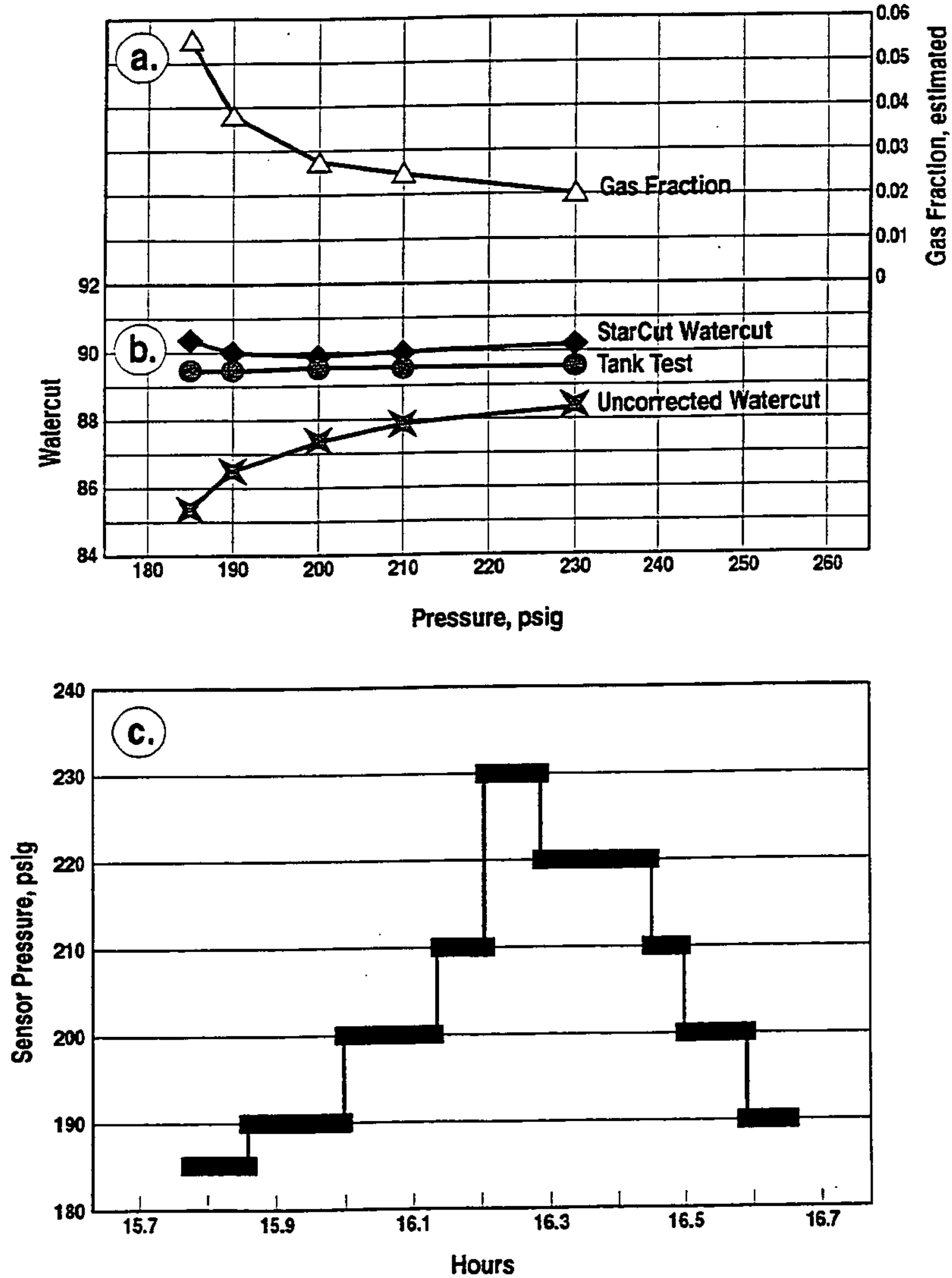

Figure 3 Demonstration of Starcut well test gas detection and compensation capability, well 3D-86