

**REDUCTION IN OVERALL SIZE, WEIGHT AND EXTENSION OF
DYNAMIC RANGE OF FLUID METERING SYSTEMS**

Field of the Invention

This invention pertains to multiple phase metering system for use in the oil and gas industry and, more particularly, to multiple phase metering system using microwave measurements to measure the oil, water and gas components of a three phase flow stream.

Background of the Invention

Separators are designed to cause separation of liquids and gas or oil, water and gas. For good separation, separator size must be large enough to give fluid time to slow down and separate. This large size presents great problems for measurements in cost of materials, weight, and space. This invention deliberately uses undersize separators in combination with measurement tools which do not require perfect separation for accurate readings. Many systems have been developed for measuring the oil, water and gas volume flow rates or fractions of three phase flow in industrial applications in the oil and gas industry. One successful such system has been that known as the STARCUT[®] (registered trademark of Texaco Inc.) water cut monitor system. This system when used with an (generally <5%) incline separator, or with a vertical separator in series, can substantially eliminate gas from the STARCUT system's measurement of oil/water ratio and has proven to be very accurate in field use. The STARCUT[®] system used as just described is shown in U.S. Patent 5,127,272 and U.S. Patent 5,234,012 and U.S. Patent 5,625,293 which are incorporated herein by reference for all purposes. The STARCUT[®] system accuracy can be better than 0.1% in high water cut (100%) and low water cut (0%) cases and the presence of up to 15% and 20% gas in the flow line does not significantly affect this accuracy. However, reduction in size of the system and the extension of the accurate measurement dynamic range

of the system would be most desirable for higher gas cut values, say above 20%.

The previously referenced U.S. Patents substantially separate most of the gas from the fluid flow line prior to its entry into the STARCUT® system. However, the use of the incline separator or vertical separator in series to condition fluid flows to remove most gas causes the size of the system to be much larger than is economic. Also, since the STARCUT® system can handle up to 15-20% gas flow, it is not necessary to eliminate substantially all of the gas flow while measuring the oil/water ratio very accurately, therefore the combination of gas sensitive STARCUT® with a fluid conditioner allows the reduction in size of the overall system.

Brief Description of the Invention

In a first aspect, this invention provides a system for measuring the oil/water/gas ratios in a multiphase fluid flow stream having greater than 20% gas flow phase comprising:

- a monitor system capable of accurately measuring the oil, water and gas content of a three phase fluid flow regime having up to 20% gas flow therein;

- a fluid preconditioner for "mostly" preconditioning said three phase fluid flow regime to contain 20% or less gas flow after passage therethrough; and

- means for passing said three phase fluid flow regime having greater than 20% gas flow therein through said fluid flow preconditioner and then sequentially through said monitor to produce output oil/gas/water ratios.

In a second aspect, this invention provides a method for measuring the oil/water/gas ratios in a multiphase fluid flow stream having greater than 20% gas flow phase, comprising the steps of:

- flowing said multiphase fluid flow stream having greater than 20% gas flow phase sequentially into a "mostly" flow preconditioning system which bypasses from the main fluid flow stream a portion of the gas phase flow

to produce an output flow stream having 20% or less of gas phase flow;

flowing said output stream through a monitor system capable of accurately measuring the oil, water and gas content of a three phase flow regime having up to a 20% gas flow phase; and

measuring with said monitor system the oil/water/gas ration of said output stream.

In the present invention the fluid input to the STARCUT[®] monitor system is conditioned prior to its input by subjecting it to a partial phase separation. For this purpose a separator deliberately undersized based on conventional criteria which produces an output fluid stream of "mostly" liquid is placed in series with the STARCUT[®] monitor and the mostly gas stream can be made more liquid free by allowing more gas to be in the liquid stream. Feedback control from the STARCUT[®] monitor system can be used to control the portioning of gas and liquid in the pre-conditioning separator, if desired, as a function of the oil, water and gas fraction measurements made by the STARCUT[®] monitor. The STARCUT[®] monitor system is used with a special piping and orifice system which causes isokinetic (same fluid velocity) sampling from the flow stream into the side stream mounted STARCUT[®] monitor. This has been found to enhance the accuracy of measurement of the system over a wide range of flow rates. This STARCUT[®] can allow gas carry under into the liquid stream up to its limits of detection which is currently set at 70% gas.

While one embodiment of the system of the present invention is illustrated herein using a "mostly" liquid/mostly gas (a 2D) phase separator ahead of the STARCUT[®] monitor to condition the fluid prior to its entry, it will be understood that, if desired, a mostly 3D (i.e. mostly oil, mostly water, and mostly gas) separator could be used for this purpose. Such 3D "mostly" separators for flow line use are available from many sources such as NATCO Inc. of Houston, Texas or Daniel Industries (INFAB

Division) of Houston, Texas but must be deliberately sized using conventional separator criteria for less than 1/10 the flow ranges for ultimate use.

The invention will be best understood by reference to the following detailed description thereof when taken in conjunction with the accompanying drawings.

Brief Description of the Drawings

Figure 1 is a schematic drawing of a 2D deliberately undersized conventional conditioner separator (mostly liquid mostly gas) system used ahead of a STARCUT® monitor system to measure oil/water/gas ratio in a flowline.

Figure 2 is a schematic drawing of the STARCUT® monitor system of Figure 1 showing its piping arrangement used to obtain isokinetic sampling in the fluid flow line being measured.

Description of the Preferred Embodiment

It has been experimentally determined through use of the STARCUT® monitor system in many flow regime environments that the three phase measurement accuracy is enhanced if the captured fluid velocity through the monitor system, which is on a side flow line in parallel with the main flow stream, is the same as that through the main flow line. This principle is known as isokinetic sampling. Referring initially to Figure 2 a schematic diagram of the STARCUT® monitor side stream sampling from the main flow line which achieves this is shown. Flow in the main line 11 is in the direction of flow arrows 12. Flow into side stream sampling line 13 is in the direction of flow arrows 15. It will be understood that all references to fluid flow herein refer to 3 phase mixed fluid flow of oil/water/gas.

Side stream flow line 13 directs the fluid flow through a microwave test cell 16 which comprises a part of the STARCUT® monitor system shown generally as 20. The test cell may be of the type described in more detail in U.S. Patent No. 5, 625, 293 which is assigned to the assignee of the present invention. The STARCUT® monitor comprises a microwave (10 GHz) energy source, microwave energy

receivers, the test cell and means for redirecting flow through the test cell. The operation of the system is disclosed in more detail in the aforementioned U.S. patents, but may be thought of as measuring the phase shift across the test cell, and the attenuation across the test cell of the microwave energy. A computer portion 17 of the STARCUT[®] monitor system takes these measurements and interprets them in terms of the oil/water and gas ratio of the fluid being measured. The computer portion 17 is also capable of generating output control signals on a bus 18 to other system components for their control as will be described subsequently.

A first orifice 19 in the flow line 11 causes a pressure drop via input line 13 and output line 14 across the STARCUT[®] monitor which causes the input line 13 and output line 14, each having a smaller diameter than the main flow line 11, to have the same fluid velocity as that in the flow line 11. Fluid is pulled through line 13 via J_{in} and J_{out} if desired. A flow straightener 11A is used to restore flow consistency after making the several bends and sidetracks for the measurement by the STARCUT[®] monitor and, finally, a second orifice 19A restores the original fluid velocity prior to output.

Bearing in mind the foregoing, reference is now made to Figure 1 which shows a preferred embodiment of the measuring system accordingly to the present invention. A piping system having a main flow line 24 is provided with a 2D mostly liquid/mostly gas separator shown generally at 30. The separator 30 separates fluid in the input line 24 via input flange 21 into a primarily liquid component flowing downwardly in flow line 24 and a primarily gas component flowing upwardly in line 22. A level gauge 23 can be used to measure gas and liquid levels in the separator 30.

The "mostly" liquid flow it will be understood is less than 20% gas in line 24 after passing through the separator 30. It is thus input via line 24A into the STARCUT[®] monitor

system 20 as shown. The STARCUT[®] monitor system operates as previously described to determine oil/water and gas flow rates and ratios in the flow line 24. The measured fluid returns via line 25A to flow line 24 wherein the flow is in the direction of flow arrows 31. Gas flow from separator 30 goes via a control valve 26 and line 25, through a wet gas meter 27, check valve 29 into line 23 where it is returned to main flow line 24 downstream of the STARCUT[®] monitor system at 23A as shown in Figure 1. The rejoined flow of gas and liquid at 23A goes in the direction of flow arrows 31 and exits the system at flange 29.

The computer 17 part of STARCUT[®] monitor system 20 will be understood to be a dedicated digital processor of considerable power based on such as an INTEL 40486 processor chip, several megabytes of Random Access Memory, its own software operating system, etc. As such it is capable of analyzing the oil/water/gas measurements of the system and generating control signals on bus 18 to go to globe valve 26 to control the flow of gas from the separator 30. Closing valve 26 will drop the liquid level in separator 30 and force more gas into the STARCUT[®] monitor 20. Opening valve 26 will allow the liquid level to rise in the separator 30 and put less gas into the STARCUT[®] monitor. By keeping the allowable gas flow into the STARCUT[®] monitor within the 20% tolerance for accurate measurement, the fluid flow through the system can be optimized and low liquid content has in the gas leg can be also optimized.

As previously described a 3D "mostly" separator of the types herein described could be used in place of the 2D separator 30 of Figure 1, if desired. The forgoing descriptions may make other equivalent changes and modifications apparent to those of skill in the art. The aim of the appended claims is to cover all such changes and modifications that fall within the true spirit and scope of the invention.

CLAIMS:

1. A system for measuring the oil/water/gas ratios in a multiphase fluid flow stream having greater than 20% gas flow phase comprising:
 - a monitor system (20) capable of accurately measuring the oil, water and gas content of a three phase fluid flow regime having up to 20% gas flow therein;
 - a fluid preconditioner (30) for "mostly" preconditioning said three phase fluid flow regime to contain 20% or less gas flow after passage therethrough;
 - and
 - means for passing said three phase fluid flow regime having greater than 20% gas flow therein through said fluid flow preconditioner and then sequentially through said monitor to produce output oil/gas/water ratios.
2. The system of claim 1 wherein said output oil/gas/water ratios are used to derive a control signal which is applied to said fluid flow preconditioner.
3. The system of claim 2 wherein said control signal maintains said output as ratio at 20% or less by controlling the amount of gas bypassed by said preconditioner.
4. The system of claim 1 wherein said preconditioner comprises a conventional separator which is deliberately sized at 1/10 or less of the recommended dimensions for the applied flow rate.
5. The system of claim 1 wherein said monitor system comprises a side flow stream device having isokinetic input with said multiphase fluid flow stream having greater than 20% gas flow phase.



6. A method for measuring the oil/water/gas ratios in a multiphase fluid flow stream having greater than 20% gas flow phase, comprising the steps of:

flowing said multiphase fluid flow stream having greater than 20% gas flow phase sequentially into a "mostly" flow preconditioning system (30) which bypasses from the main fluid flow stream a portion of the gas phase flow to produce an output flow stream having 20% or less of gas phase flow;

flowing said output stream through a monitor system (20) capable of accurately measuring the oil, water and gas content of a three phase flow regime having up to a 20% gas flow phase; and

measuring with said monitor system the oil/water/gas ratio of said output stream.

7. The method of claim 6 and further including developing in said monitor system a control signal for said fluid preconditioner and applying said control to said preconditioner.

8. The method of claim 7 wherein said control signal to said preconditioner maintains the gas phase of said output stream at a 20% or less ratio.

9. The method of claim 8 wherein said control signal controls the amount of gas bypassed by said preconditioner.

10. The method of claim 6 wherein said preconditioner is a conventional mostly liquid/mostly gas separator deliberately sized at 1/10 of the dimensions predicted for the applied flow rates.