mixing rings/pistons/devices and rocking, magnetically coupled impeller mixers, magnetic stirrers, static mixers, orifice mixers, circulation pumps, and ultrasonic stirrers (clamp-on externally mounted or transducer direct contact types).

[0011] In any case, existing devices lack sufficient sensor capabilities or combinations of sensor capabilities to enable sufficient phase behavior and sample validation studies of reservoir fluids.

~~BRIEF~~ SUMMARY ~~OF THE INVENTION~~

[0012] In general, the present application~~invention~~ provides an apparatus and method related to measuring thermodynamic properties of reservoir fluids. The technique utilizes a modular sensor assembly designed to evaluate a sample of a hydrocarbon containing fluid within a cell body. A variety of sensors may be selectively placed into communication with a sample chamber within the cell body to evaluate the sample at potentially high pressures and temperatures. By way of example, the sensors may comprise a single density-viscosity sensor located in-situ to efficiently measure both the density and viscosity of the sample as a function of pressure and temperature. Other sensors, such as an optic sensor and/or a pressure-temperature sensor, may also be positioned to measure parameters of the sample while the sample is retained in the sample chamber.

[0012a] In accordance with a first aspect of the present application, there is provided an apparatus for measuring the density and viscosity of reservoir fluids, comprising: a sensor assembly, the sensor assembly comprising: a cell body having a sample chamber for receiving a sample of single phase or coexisting two-phase fluid, the fluid sample forming a fluid column in the sample chamber, the sample chamber having therein a piston movable to adjust pressure in the sample chamber; a thermal management system to control temperature in the sample chamber; and a pressure and temperature sensor; and a density-viscosity sensor located in-situ in the cell body to

measure the density and viscosity of the sample in the sample chamber as a function of pressure and temperature, wherein the cell body is movable relative to the fluid column.

[0012b] In accordance with a second aspect of the present application, there is provided a method of measuring the density and viscosity of a reservoir fluid sample, comprising: assembling a sensor assembly, the sensor assembly comprising a cell body having therein a sample chamber; charging the sample chamber with the fluid sample and thereby forming a fluid column in the same chamber; adjusting the temperature and the pressure of the fluid sample within the sample chamber, wherein the temperature is adjusted with a thermal management system surrounding the cell body, and the pressure is adjusted by a piston in the sample chamber; and utilizing a single sensor located in-situ in the cell body to determine both density and viscosity of the sample while in the sample chamber, wherein the cell body is movable relative to the fluid column.

[0012c] In accordance with a third aspect of the present application, there is provided a method of measuring the density and viscosity of reservoir fluids, comprising: providing a sensor assembly at a wellsite; charging a sample chamber in a cell body of the sensor assembly with a fluid sample from a subterranean reservoir and thereby forming a fluid column in the sample chamber; pressurizing the fluid sample in the sample chamber by compressing the fluid sample with a piston in the sample chamber; increasing the temperature of the fluid sample with a thermal management system positioned as an integral part of the sensor assembly; agitating the fluid sample while in the sample chamber to recombine fluid from multiple phases into a single phase; and utilizing sensors located in-situ in the cell body to measure the density and viscosity of the fluid sample, wherein the cell body is movable relative to the fluid column.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Certain embodiments of the invention will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:

[0014] Figure 1 is a schematic illustration of an example of a modular sensor assembly, according to an embodiment of the present invention;