CYCLONE SEPARATOR FOR HIGH GAS VOLUME FRACTION FLUIDS

BACKGROUND OF THE INVENTION

The present invention relates to a cyclone separator for separating a multiphase fluid into its different fractions. In particular, the invention relates to a cyclone separator which is effective for separating a multiphase fluid comprising heavy, medium and light fractions into a heavy fraction and a mixture of light and medium fractions. In this manner, comparatively high heavy fraction/light fraction separation efficiencies may be achieved even when the fluid contains relatively large volumes of the light fraction.

Bulk de-oilers and hydrocyclones, which may be referred to generically as cyclone separators, are used in the hydrocarbon production industry to separate multiphase fluid streams into their different fractions so that these fractions may be treated separately. For example, cyclone separators are commonly used to separate the production fluid from a hydrocarbon well into separate streams of oil and water so that the oil can be conveyed to a processing facility and the water can be, e.g., re-injected into the well.

Prior art cyclone separators operate by rotating the production fluid to created centrifugal forces which cause the higher density water to move toward the outer portion of the fluid stream and the lighter density oil to move toward the middle of the fluid stream. The water is then discharged through a heavy fraction outlet and the oil is discharged through a separate light fraction outlet.

WO 2007/021181 A1 discloses a cyclone separator for separating heavy fraction from a multiphase fluid comprising a heavy fraction, a medium fraction and a light fraction. The cyclone separator includes an elongated cyclone tube having a fluid inlet, a heavy fraction outlet and a flow bore that extends between the fluid inlet and the heavy fraction outlet. Furthermore, the separator includes a mandrel which is positioned concentrically within the cyclone tube and having a light fraction outlet.

EP 1445025 A1 describes a separating cyclone and associated method for separation of a mixture of fluids having different densities. The fluids are separated into a light fraction mixture and a heavy fraction mixture.

The separating cyclone comprises a flow body in a flow space. One or more bypass channels are provided in the distal part of the body, and parts of the flow can be guided to said channels.

RU 2042435 C1 and DE 2105926 A1 show two other examples of separators within the field of the present invention.

Although these prior art cyclone separators work relatively well when the production fluid contains relatively small amounts of gas, problems arise when the volume of gas in the production fluid is relatively large. This is due to the fact that the gas, being less dense than oil, is displaced toward the middle of the rotating production stream and consequently interferes with the discharge of the oil through the light fraction outlet. As a result, larger amounts of oils than desired are discharged through the heavy fraction outlet with the water.

SUMMARY OF THE INVENTION

According to a first aspect, there is provided a cyclone separator for separating a heavy fraction from a multiphase fluid comprising a mixture of the heavy fraction, a medium fraction and a light fraction, the cyclone separator including: an elongated cyclone tube which comprises a fluid inlet, a heavy fraction outlet and a flow bore that extends between the fluid inlet and the heavy fraction outlet; a mandrel which is positioned concentrically within the cyclone tube and comprises a light fraction outlet that extends generally axially therethrough and an outer diameter surface that together with the cyclone tube defines an annular flow path for the multiphase fluid which extends between the fluid inlet and the flow bore; the outer diameter surface comprising a generally cylindrical section which extends from proximate the fluid inlet to a convergence section which extends toward an outlet port that connects the light fraction outlet with the flow bore; *characterized in that* the mandrel further comprising a plurality of outlet holes which extend through the convergence section between the flow path and the light fraction outlet; wherein in operation of the cyclone separator, the multiphase fluid flows through the fluid inlet and the flow path and is separated into the light fraction, the medium fraction and the heavy fraction, and the light fraction flows through the outlet holes and is discharged through the light fraction outlet, the medium fractions flows through the outlet port and is discharged through the light fraction outlet, and the heavy fraction flows through the flow bore and is discharged through the heavy fraction outlet.

According to a second aspect, there is provided a method for separating a heavy fraction from a multiphase fluid comprising a mixture of the heavy fraction, a medium fraction and a light fraction, the method comprising: providing a cyclone separator which includes an elongated cyclone tube having a fluid inlet, a heavy fraction outlet and a flow bore that extends generally axially from the fluid inlet to the heavy fraction outlet; positioning a mandrel concentrically within the flow bore, the mandrel comprising an outlet port extending axially through the distal end thereof, a cylindrical section located adjacent the proximal end thereof, and a convergence section extending between the cylindrical section and the outlet port; introducing the multiphase fluid into the flow bore through the fluid inlet; the method further includes the steps of rotating the multiphase fluid to cause it to separate into the heavy fraction, the medium fraction and the light fraction; discharging the heavy fraction through the heavy fraction outlet; discharging the medium fraction through the outlet port; and discharging the light fraction through a number of outlet holes which extend through the convergence section of the mandrel.

According to a third aspect, there is provided a method for retrofitting an existing cyclone separator comprising a cyclone tube and a mandrel which is positioned concentrically within the cyclone tube, the cyclone tube including a fluid inlet which is connected to an axial flow bore and the mandrel including a light fraction outlet and a substantially solid outer surface which extends from proximate the fluid inlet toward an outlet port that connects the flow bore to the light fraction outlet, the method comprising: removing the mandrel from the cyclone tube; and *characterized in that* the method further includes the step of replacing the mandrel with a modified mandrel which comprises a light fraction outlet, a substantially solid outer surface which extends from proximate the fluid inlet toward an outlet port that connects the flow bore to the light fraction outlet, and a number of outlet holes which connect the flow bore to the light fraction outlet between the outlet port and the fluid inlet.

In accordance with embodiments of the present invention, these and other limitations in the prior art are addressed by providing a cyclone separator for separating a heavy fraction from a multiphase fluid comprising a mixture of the heavy fraction, a medium fraction and a light fraction. The cyclone separator includes an elongated cyclone tube which comprises a fluid inlet, a heavy fraction outlet and

a flow bore that extends between the fluid inlet and the heavy fraction outlet. The cyclone separator also includes a mandrel which is positioned concentrically within the cyclone tube and comprises a light fraction outlet that extends generally axially therethrough and an outer diameter surface that together with the cyclone tube defines an annular flow path for the multiphase fluid which extends between the fluid inlet and the flow bore. The outer diameter surface comprises a generally cylindrical section which extends from proximate the fluid inlet to a convergence section which extends toward an outlet port that connects the light fraction outlet with the flow bore, and the mandrel further comprises a plurality of outlet holes which extend through the convergence section between the flow path and the light fraction outlet. In operation of the cyclone separator, the multiphase fluid flows through the fluid inlet and the flow path and is separated into the light fraction, the medium fraction and the heavy fraction, and the light fraction flows through the outlet holes and is discharged through the light fraction outlet, the medium fractions flows through the outlet port and is discharged through the light fraction outlet, and the heavy fraction flows through the flow bore and is discharged through the heavy fraction outlet.

Embodiments of t~~T~~he present invention also provide~~s~~ a method for separating a heavy fraction from a multiphase fluid comprising a mixture of the heavy fraction, a medium fraction and a light fraction. The method comprises introducing the multiphase fluid into a cyclone separator comprising an axially extending flow bore; rotating the multiphase fluid to cause it to separate into the heavy fraction, the medium fraction and the light fraction; discharging the heavy fraction through a heavy fraction outlet which is connected to the flow bore; discharging the medium fraction through an outlet port which is connected to the flow bore; and discharging the light fraction through a number of outlet holes which are connected to the flow bore upstream of the outlet port. In this regard, the light and medium fractions may be discharged through a light fraction outlet which is connected to the outlet port and the outlet holes.

Embodiments of t~~T~~he present invention further provide~~s~~ a method for retrofitting an existing cyclone separator comprising a cyclone tube and a mandrel which is positioned concentrically within the cyclone tube. The cyclone tube includes a fluid inlet which is connected to an axial flow bore, and the mandrel includes a light fraction outlet and a substantially solid outer surface which extends from proximate the

fluid inlet toward an outlet port that connects the flow bore to the light fraction outlet. The method of retrofitting this existing cyclone separator comprises removing the mandrel from the cyclone tube; and replacing the mandrel with a modified mandrel which comprises a light fraction outlet, a substantially solid outer surface which extends from proximate the fluid inlet toward an outlet port that connects the flow bore to the light fraction outlet, and a number of outlet holes which connect the flow bore to the light fraction outlet between the outlet port and the fluid inlet.

Thus, the cyclone separator as per embodiments of the present invention provides a simple but effective means for separating the heavy fraction from the medium fraction even in the presence of large volumes of the light fraction. Embodiments of tThe invention operates to first remove a substantial portion of the light fraction before the medium fraction is removed from the heavy fraction. Consequently, the light fraction will not interfere with the discharge of the medium fraction through the light fraction outlet. As a result, the cyclone separator can achieve relatively high heavy fraction/medium fraction separation efficiencies with fluid mixtures comprising relatively large volumes of the light fraction.

These and other embodimentsobjects and advantages of the present invention will be made apparent from the following detailed description, with reference to the accompanying drawings. In the drawings, the same reference numbers may be used to denote similar components in the various embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross sectional representation of the cyclone separator of the present invention shown installed in an exemplary pipe assembly;

Figure 2 is a longitudinal cross sectional view of the cyclone separator of Figure 1;

Figure 3 is an enlarged cross sectional view of the left hand portion of the cyclone separator shown in Figure 2;

Figure 4 is a representation showing how the gas, oil and water fractions are separated in the cyclone separator of the present invention;

Figure 5 is a longitudinal cross sectional view of a prior art cyclone separator; and

Figure 6 is a representation showing how the gas, oil and water fractions are separated in the prior art cyclone separator.

What is Claimed is:

1. A cyclone separator (10) for separating a heavy fraction from a multiphase fluid comprising a mixture of the heavy fraction, a medium fraction and a light fraction, the cyclone separator (10) including:

an elongated cyclone tube (36) which comprises a fluid inlet (62), a heavy fraction outlet (64) and a flow bore (42) that extends between the fluid inlet (62) and the heavy fraction outlet (64);

a mandrel (66) which is positioned concentrically within the cyclone tube (36) and comprises a light fraction outlet (72) that extends generally axially therethrough and an outer diameter surface that together with the cyclone tube (36) defines an annular flow path (90) for the multiphase fluid which extends between the fluid inlet (62) and the flow bore (42);

the outer diameter surface comprising a generally cylindrical section which extends from proximate the fluid inlet (62) to a convergence section which extends toward an outlet port (74) that connects the light fraction outlet (72) with the flow bore (42);

characterized in that the mandrel (66) further comprising a plurality of outlet holes (66) which extend through the convergence section between the flow path and the light fraction outlet (72);

wherein in operation of the cyclone separator (10), the multiphase fluid flows through the fluid inlet (62) and the flow path and is separated into the light fraction, the medium fraction and the heavy fraction, and the light fraction flows through the outlet holes (94) and is discharged through the light fraction outlet (72), the medium fractions flows through the outlet port and is discharged through the light fraction outlet (72), and the heavy fraction flows through the flow bore (42) and is discharged through the heavy fraction outlet (64).

2. A method for separating a heavy fraction from a multiphase fluid comprising a mixture of the heavy fraction, a medium fraction and a light fraction, the method comprising:

providing a cyclone separator (10) which includes an elongated cyclone tube (36) having a fluid inlet (62), a heavy fraction outlet (64) and a

flow bore (42) that extends generally axially from the fluid inlet (62) to the heavy fraction outlet (64); positioning a mandrel (66) concentrically within the flow bore (42), the mandrel comprising an outlet port (74) extending axially through the distal end thereof, a cylindrical section (84) located adjacent the proximal end thereof, and a convergence section (88) extending between the cylindrical section (84) and the outlet port (74);

introducing the multiphase fluid into the flow bore (42) through the fluid inlet (62);

the method further includes the steps of

rotating the multiphase fluid to cause it to separate into the heavy fraction, the medium fraction and the light fraction;

discharging the heavy fraction through the heavy fraction outlet (64);

discharging the medium fraction through the outlet port (74); and

discharging the light fraction through a number of outlet holes (94) which extend through the convergence section (88) of the mandrel (66).

3. The method of claim 2, wherein the light and medium fractions are discharged through a light fraction outlet (72) which is connected to the outlet port (74) and the outlet holes (94).

4. A method for retrofitting an existing cyclone separator (10) comprising a cyclone tube (36) and a mandrel (66) which is positioned concentrically within the cyclone tube (36), the cyclone tube (36) including a fluid inlet (62) which is connected to an axial flow bore (42) and the mandrel (66) including a light fraction outlet (72) and a substantially solid outer surface which extends from proximate the fluid inlet (62) toward an outlet port (74) that connects the flow bore (42) to the light fraction outlet (72), the method comprising:

removing the mandrel (66) from the cyclone tube (36); and

characterized in that the method further includes the step of replacing the mandrel (66) with a modified mandrel which comprises a light fraction outlet (72), a substantially solid outer surface which extends from proximate the fluid inlet (62) toward an outlet port (74) that connects the flow bore (42) to the light fraction outlet (72), and a number of outlet holes (94)

which connect the flow bore (42) to the light fraction outlet (72) between the outlet port (74) and the fluid inlet (62).