ROTARY DOWNHOLE GAS SEPARATOR

BACKGROUND

[001] This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

[002] Gas separators are well-known to be used to precondition gassy well fluid entering an electrical submersible pump. Conventional separators have numerous shortcoming which may be affect their performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[003] The present disclosure is best understood from the following detailed description when read with the accompanying Figures. It is emphasized that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

[004] FIG. 1 shows an ESP string with a conventional gas separator, according to one or more examples of the disclosure.

[005] FIG. 2 shows a conventional gas separator, according to one or more examples of the disclosure.

[006] FIG. 3 shows a conventional gas separator with a paddle wheel, according to one or more examples of the disclosure.

[007] FIG. 4 shows a conventional gas separator with a paddle wheel, according to one or more examples of the disclosure.

[008] FIG. 5 shows a conventional gas separator with a shrouded paddle wheel, according to one or more examples of the disclosure.

[009] FIG. 6 shows a comparison between conventional rotary gas separators and conventional vortex gas separators, according to one or more examples of the disclosure.

[0010] FIG. 7 shows an improved gas separator, according to one or more examples of the disclosure.

[0011] FIG. 8 shows a conventional gas separator with a compressor impeller, according to one or more examples of the disclosure.

[0012] FIG. 9 shows a conventional gas separator with a propeller having “washout” twist at the end of a separation chamber, according to one or more examples of the disclosure.

DETAILED DESCRIPTION

[0013] Illustrative examples of the subject matter claimed below will now be disclosed. In the interest of clarity, not all features of an actual implementation are described in this specification. It will be appreciated that in the development of any such actual implementation, numerous implementation-specific decisions may be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort, even if complex and time-consuming, would be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0014] Embodiments of the present disclosure may direct towards a gas separator.

[0015] FIG. 1 shows an ESP string with a conventional gas separator 150, which are well-known for preconditioning gassy well fluid entering an electrical submersible pump 126. Conventional gas separators such as one shown in FIG. 2 often have a rotating prime mover called an inducer 235, which is capable of pumping high gas volume fraction fluid. The inducer 235 boosts the pressure of the gassy fluid entering the intake of the separator, and then a downstream rotating impeller 240 further boosts the fluid pressure and imparts substantially increased swirl velocity to the fluid entering the separation chamber 210. The fluid swirl in the separation chamber 210 tends to separate the higher density liquid toward the bore of the separator housing and lower density gas towards the shaft. The separation chamber 210 must be of sufficient length to allow time for the heavier and lighter components to migrate as described. The crossover head 220 at the end of the separation chamber 210 ports the separated gas to the casing-separator annulus and the liquid to the ESP intake. Gas separators of this type are sometimes called vortex gas separators, and they tend to have two problems: 1) the fluid swirl tends to decay along the longer separation chamber after leaving the impeller such that the transition band from low density gas to high density liquid is wide, resulting in liquid contamination of the gas path and gas contamination of the liquid path in the cross over, and 2) the axial momentum of the low density gas tends to be low at the entrance to the crossover, and as a result, significant gas is drawn or sucked into the higher momentum liquid stream, thereby contaminating the liquid stream to the pump.

[0016] FIG. 3, FIG. 4, and FIG. 5 shows another example of a conventional gas separator having a paddle wheel. These conventional gas separators often feature a rotating inducer which boosts the pressure of the gassy fluid, and then a downstream rotating paddle wheel located close to the entrance to the crossover which imparts very high swirl to the gassy fluid. Separation occurs in the paddle wheel chambers, and therefore the paddle wheel must be relatively long in the axial direction to permit time for fluid migration and efficient separation to occur. Separators of this type are sometimes called rotary separators, and they have three problems: 1) the inducer generates relatively low boost pressure, and therefore the maximum flowrate is limited since the paddle generates essentially no boost pressure, 2) fluid in the long paddle chambers tends to recirculate due to its relative motion with the stationary bore of the separator resulting

in separated gas near the shaft being swept back into the water region, and 3) the long length of the paddle tends to cause high frictional pressure drop which further reduces the maximum operating flowrate of rotary separators compared to vortex separators, as shown in the comparison in FIG. 6.

[0017] FIG. 7 shows an embodiment of an improved gas separator which may alleviate the above issues. In one or more embodiments, a gas separator may comprise an inducer to boost intake gassy fluid, an impeller to further boost the gassy fluid and impart significant swirl to the fluid, a separation chamber for inducing centrifugal separation to the swirling fluid, a rotating paddle for inducing increased fluid swirl in the separated fluid and increase low-density gas momentum.

[0018] In one or more embodiments, the gas separator may further comprise a crossover. The separated fluid of the gas separator exits the rotating paddle via a gas (inner) path and a liquid (outer) path of the crossover.

[0019] In one or more embodiments, the gas separator may further comprise a ceramic housing bore sleeve for minimizing erosive wear from high fluid swirl to the paddle.

[0020] In one or more embodiments, hubs of the rotating components may be clamped in compression by shaft tension. By doing so, separate hubs of the inducer, impeller and paddle may act as a monolithic unit with high bending stiffness, hence minimizing rotordynamic vibrations.

[0021] In comparison to conventional gas separators shown in FIG. 2 – FIG. 5, embodiments of the improved gas separator may have several advantages. Firstly, embodiments of the improved gas separator may produce high boost pressure from the rotating inducer and impeller. The short, unshrouded paddle of embodiments of the improved gas separator has essentially no impact on the pressure of the fluid entering the crossover, resulting in a high maximum operating flowrate. Secondly, the short paddle of embodiments of the improved gas separator at the send of the separation chamber substantially increases fluid swirl and nearly eliminates the transition zone between gas and liquid layers, thereby minimizing cross-contamination of the gas and liquid flow streams entering the crossover to give high separation efficiency. Thirdly, the short paddle of embodiments of the improved gas separator at the end of the separation chamber increases the static pressure of the water layer exiting the paddle, which reduces the tendency of the gas stream to be sucked into the higher momentum water stream, resulting in increased separation efficiency.

[0022] FIG. 8 and FIG. 9 shows two additional conventional gas separators. The conventional gas separator shown in FIG. 8 has a small diameter fan-type compressor 86 for accelerating the gas core at the end of the separation chamber 50 and at the entrance to the crossover 56. The conventional gas separator shown in FIG. 9 has an impeller 300 with “washout” twist (which preferentially increases the axial momentum of the fluid near the hub) at the end of the separation chamber 210.

[0023] In contrast to embodiments of the improved gas separator, the conventional gas separators shown in FIG. 8 and FIG. 9 only allow gas stream to pass through compressor 86 and impeller 300, and neither

the compressor nor the impeller imparts substantial swirl to the fluid. Advantageously, the paddle of embodiments of the improved gas separator substantially increases fluid swirl of 1) all fluid, 2) most of the vane length parallel to the axis (not an “impeller”), and the 3) vane has essentially no hub-to-shroud “twist” (as it is a radial projection from hub to shroud) when compared to the conventional gas separators shown in FIG. 8 and FIG. 9.

[0024] The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the disclosure. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the systems and methods described herein. The foregoing descriptions of specific examples are presented for purposes of illustration and description. They are not intended to be exhaustive of or to limit this disclosure to the precise forms described. Obviously, many modifications and variations are possible in view of the above teachings. The examples are shown and described in order to best explain the principles of this disclosure and practical applications, to thereby enable others skilled in the art to best utilize this disclosure and various examples with various modifications as are suited to the particular use contemplated. It is intended that the scope of this disclosure be defined by the claims and their equivalents below.

CLAIMS

What is claimed is:

1. A gas separator comprising:

an inducer for receiving and boosting fluid flow from a separator intake;

an impeller for further boosting the fluid flow and imparting significant swirl to the fluid;

a separation chamber for inducing centrifugal separation to the fluid; and

a paddle for inducing increased fluid swirl in the separated fluid and increase low-density gas momentum.

2. The gas separator of claim 1, further comprising a crossover for receiving the separated fluid.

3. The gas separator of claim 1, further comprising a ceramic housing bore sleeve for minimizing erosive wear from high fluid swirl to the paddle.

4. The gas separator of claim 1, wherein the inducer, the impeller, and the paddle are tensioned to act as a single unit.