

ELECTRIC SUBMERSIBLE PUMP STAGE

BACKGROUND

Field

[0001] The present disclosure generally relates to electric submersible pumps (ESPs), and more particularly to ESPs having impellers and diffusers made of different materials.

Description of the Related Art

[0002] Various types of artificial lift equipment and methods are available, for example, electric submersible pumps (ESPs). An ESP includes multiple centrifugal pump stages mounted in series, each stage including a rotating impeller and a stationary diffuser mounted on a shaft, which is coupled to a motor. In use, the motor rotates the shaft, which in turn rotates the impellers within the diffusers. Well fluid flows into the lowest stage and passes through the first impeller, which centrifuges the fluid radially outward such that the fluid gains energy in the form of velocity. Upon exiting the impeller, the fluid flows into the associated diffuser, where fluid velocity is converted to pressure. As the fluid moves through the pump stages, the fluid incrementally gains pressure until the fluid has sufficient energy to travel to the well surface.

SUMMARY

[0003] In some configurations, an electric submersible pump (ESP) comprises a plurality of stages, at least one of the plurality of stages including an impeller comprising a first material; and a diffuser or bearing housing comprising a second material, wherein the second material is different than the first material.

[0004] The impeller can be entirely made of the first material. The impeller can include the first material and be coated and/or treated. The diffuser or bearing housing can be entirely made of the second material. The diffuser or bearing housing can include the second material and be coated and/or treated. The second material can be a coated and/or heat treated version of the first material. The first material can be a coated and/or heat treated version of the second material. The ESP can further include one or more spacers, each spacer positioned axially between axially consecutive or adjacent impellers, wherein the one or more spacers comprise a third material that is different than the first and second materials.

[0005] In some configurations, an electric submersible pump (ESP) includes an upper section comprising one or more upper stages, each upper stage comprising an impeller and a diffuser or bearing housing, and the one or more upper stages comprising a first material; and

a lower section positioned downhole of the upper section in use and comprising one or more lower stages, each lower stage comprising an impeller and a diffuser or bearing housing, and the one or more lower stages comprising a second material that is different than the first material.

[0006] The ESP can further include a middle section positioned between the upper section and the lower section and comprising one or more middle stages, each middle stage comprising an impeller and a diffuser or bearing housing, and the one or more middle stages comprising a third material that is different than the first and second materials.

[0007] The impellers of the upper stages can include the first material, and the diffusers or bearing housings of the upper stages can include a third material that is different than the first and second materials. The impellers of the lower stages can include the second material, and the diffusers or bearing housings of the lower stages can include a third material that is different than the first and second materials.

[0008] The ESP can include one or more spacers, each spacer positioned axially between axially consecutive or adjacent impellers, wherein the one or more spacers comprise a third material that is different than the first and second materials.

[0009] The upper stages can be entirely made of the first material. The upper stages can be made of the first material with a coating and/or treatment. The lower stages can be entirely made of the second material. The lower stages can be made of the second material with a coating and/or treatment. The second material can be a coated and/or heat treated version of the first material. The first material can be a coated and/or heat treated version of the second material.

BRIEF DESCRIPTION OF THE FIGURES

[0010] Certain embodiments, features, aspects, and advantages of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein.

[0011] Figure 1 shows a longitudinal cross-section of a portion of a legacy ESP design.

[0012] Figure 2 shows a longitudinal cross-section of a portion of an ESP having impellers and diffusers made of different materials from each other.

[0013] Figure 3 shows a longitudinal cross-section of a portion of an ESP having different materials used for different sections of the ESP.

[0014] Figure 4 shows a longitudinal cross-section of a portion of an ESP including different materials.

DETAILED DESCRIPTION

[0015] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the disclosure. These are, of course, merely examples and are not intended to be limiting. However, it will be understood by those of ordinary skill in the art that the system and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments are possible. This description is not to be taken in a limiting sense, but rather made merely for the purpose of describing general principles of the implementations. The scope of the described implementations should be ascertained with reference to the issued claims.

[0016] As used herein, the terms “connect”, “connection”, “connected”, “in connection with”, and “connecting” are used to mean “in direct connection with” or “in connection with via one or more elements”; and the term “set” is used to mean “one element” or “more than one element”. Further, the terms “couple”, “coupling”, “coupled”, “coupled together”, and “coupled with” are used to mean “directly coupled together” or “coupled together via one or more elements”. As used herein, the terms “up” and “down”; “upper” and “lower”; “top” and “bottom”; and other like terms indicating relative positions to a given point or element are utilized to more clearly describe some elements. Commonly, these terms relate to a reference point at the surface from which drilling operations are initiated as being the top point and the total depth being the lowest point, wherein the well (e.g., wellbore, borehole) is vertical, horizontal or slanted relative to the surface.

[0017] Various types of artificial lift equipment and methods are available, for example, electric submersible pumps (ESP). An ESP typically includes a motor, a protector, a pump, a pump intake, and one or more cables, which can include an electric power cable. The motor can be powered and controlled by a surface power supply and controller, respectively, via the cables. In some configurations, the ESP also includes gas handling features and/or one or more sensors (e.g., for temperature, pressure, current leakage, vibration, etc.). The well may include one or more well sensors.

[0018] The pump includes multiple centrifugal pump stages mounted in series within a housing 230, for example as partially shown in Figure 1. Each stage includes a rotating

impeller 210 and a stationary diffuser 220. In some configurations, a portion of one or more diffusers 220 acts as a bearing housing 260 that houses a bearing assembly 262. A shaft 202 extends through the pump (e.g., through central hubs or bores or the impellers 210 and diffusers 220) and is operatively coupled to the motor. The shaft 202 can be coupled to the protector (e.g., a shaft of the protector), which in turn can be coupled to the motor (e.g., a shaft of the motor). The impellers 210 are rotationally coupled, e.g., keyed, to the shaft 202. The diffusers 220 are coupled, e.g., rotationally fixed, to the housing 230. In use, the motor causes rotation of the shaft 202 (for example, by rotating the protector shaft, which rotates the pump shaft 202), which in turn rotates the impellers 210 relative to and within the stationary diffusers 220.

[0019] In use, well fluid flows into the first (lowest) stage of the ESP and passes through an impeller 210, which centrifuges the fluid radially outward such that the fluid gains energy in the form of velocity. Upon exiting the impeller 210, the fluid makes a sharp turn to enter a diffuser 220, where the fluid's velocity is converted to pressure. The fluid then enters the next impeller 210 and diffuser 220 stage to repeat the process. As the fluid passes through the pump stages, the fluid incrementally gains pressure until the fluid has sufficient energy to travel to the well surface.

[0020] In existing ESPs, all of the impellers 210 and diffusers 220 are made of the same material, for example Ni-resist as shown in Figure 1. The present disclosure provides ESPs and/or portions thereof made of or including two or more different materials.

[0021] For example, in some ESPs and ESP components according to the present disclosure, one, multiple, or all of the impeller(s) 210 can be made of (e.g., entirely or partially made of) or include a first material, while one, multiple, or all of the diffuser(s) 220 are made of (e.g., entirely or partially made of) or include a second material that is different than the first material. Figure 2 illustrates an example ESP section in which the diffusers 220 are made of a first material, Alloy 1, and the impellers 210 are made of a second material, Alloy 2.

[0022] In some ESPs and ESP components according to the present disclosure, multiple materials can be used within the impeller and/or diffuser stacks. For example, Figure 4 illustrates a configuration in which the impellers 210 are made of or include Alloy 1, and spacers 212 positioned axially between certain adjacent impellers 210 are made of another material, for example Alloy 3. Such a configuration can be made for functional reasons, for example, improved erosion resistance, galling resistance, or other considerations.

[0023] In some ESPs and ESP components according to the present disclosure, one or more bottom or lower stages are made of or include a first material, while one or more top or upper stages are made of or include a second material that is different than the first material.

Middle stages positioned between the top or upper stage(s) and the bottom or lower stage(s) can be made of the first material, the second material, or a third material that is different than the first and second materials. Figure 3 illustrates an example ESP section in which a first stage is made of a first material, Alloy 1, and a second stage located below the first stage is made of a second material, Alloy 2. In some ESPs and ESP components according to the present disclosure, the impellers of the lower stage(s) can be made of a different material than the diffusers of the lower stage(s), and each of these materials can be different than one or more materials included in the upper stage(s). Similarly, the impellers of the upper stage(s) can be made of a different material than the diffusers of the upper stage(s), and these materials can be different than one or more materials included in the lower stage(s), and/or impellers of the middle stage(s) can be made of a different material than diffusers of the middle stage(s), which can be different than one or more materials included in the upper and/or lower stage(s).

[0024] The materials for various sections or components of such ESPs can be selected based on various design, functionality, and/or application considerations, such as sand erosion or erosion resistance, material yield strength, galling, reliability, and/or cost. For example, if a first material, Alloy 1, is harder and has better erosion resistance compared to a second material, Alloy 2, and if erosion resistance is more important or critical for the diffusers than the impellers for a particular sandy application, the harder Alloy 1 can be used for the diffusers, and the relatively softer Alloy 2 can be used for the impellers. As another example, a higher strength alloy can be used for lower or bottom stage(s) of the pump, which typically experience higher pressure and/or thrust loads in use. A relatively lower strength alloy, which may be lower cost, can be used for the middle and/or top stage(s) of the pump, where cumulative thrust loads are relatively low. This can advantageously help prevent or reduce the likelihood of collapse of the lower stage(s) in a more cost competitive manner.

[0025] The materials or alloys used in ESPs or components thereof according to the present disclosure can be, for example, Ni-Resist Type 1, Type-4, Duplex SS, White Iron, and/or any other suitable downhole stage alloy. ESPs or components thereof according to the present disclosure can include various coating(s), heat treatment(s), and/or other treatments. For example, a component (e.g., an impeller, a diffuser, a spacer, a portion of an impeller or a diffuser, an upper stage or section, a lower stage or section, or a middle stage or section) can include or be made of Alloy 1 and heat treated and/or coated with another material. In some configurations, Alloy 2 is a coated and/or heat treated version of Alloy 1.

[0026] Language of degree used herein, such as the terms “approximately,” “about,” “generally,” and “substantially” as used herein represent a value, amount, or characteristic

close to the stated value, amount, or characteristic that still performs a desired function or achieves a desired result. For example, the terms “approximately,” “about,” “generally,” and “substantially” may refer to an amount that is within less than 10% of, within less than 5% of, within less than 1% of, within less than 0.1% of, and/or within less than 0.01% of the stated amount. As another example, in certain embodiments, the terms “generally parallel” and “substantially parallel” or “generally perpendicular” and “substantially perpendicular” refer to a value, amount, or characteristic that departs from exactly parallel or perpendicular, respectively, by less than or equal to 15 degrees, 10 degrees, 5 degrees, 3 degrees, 1 degree, or 0.1 degree.

[0027] Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims. It is also contemplated that various combinations or sub-combinations of the specific features and aspects of the embodiments described may be made and still fall within the scope of the disclosure. It should be understood that various features and aspects of the disclosed embodiments can be combined with, or substituted for, one another in order to form varying modes of the embodiments of the disclosure. Thus, it is intended that the scope of the disclosure herein should not be limited by the particular embodiments described above.

CLAIMS

What is claimed is:

1. An electric submersible pump (ESP) comprising a plurality of stages, at least one of the plurality of stages comprising:
 - an impeller comprising a first material; and
 - a diffuser or bearing housing comprising a second material, wherein the second material is different than the first material.
2. The ESP of Claim 1, wherein the impeller is entirely made of the first material.
3. The ESP of Claim 1, wherein the impeller comprises the first material and is coated or treated.
4. The ESP of Claim 1, wherein the diffuser or bearing housing is entirely made of the second material.
5. The ESP of Claim 1, wherein the diffuser or bearing housing comprises the second material and is coated or treated.
6. The ESP of Claim 1, wherein the second material is a coated and/or heat treated version of the first material, or the first material is a coated and/or heat treated version of the second material.
7. The ESP of Claim 1, further comprising one or more spacers, each spacer positioned axially between axially consecutive or adjacent impellers, wherein the one or more spacers comprise a third material that is different than the first and second materials.
8. An electric submersible pump (ESP) comprising:
 - an upper section comprising one or more upper stages, each upper stage comprising an impeller and a diffuser or bearing housing, and the one or more upper stages comprising a first material; and
 - a lower section positioned downhole of the upper section in use and comprising one or more lower stages, each lower stage comprising an impeller and a diffuser or bearing housing, and the one or more lower stages comprising a second material that is different than the first material.
9. The ESP of Claim 8, further comprising a middle section positioned between the upper section and the lower section and comprising one or more middle stages, each middle stage comprising an impeller and a diffuser or bearing housing, and the one or more middle stages comprising a third material that is different than the first and second materials.

10. The ESP of Claim 8, wherein the impellers of the upper stages comprise the first material and the diffusers or bearing housings of the upper stages comprise a third material that is different than the first and second materials.

11. The ESP of Claim 8, wherein the impellers of the lower stages comprise the second material and the diffusers or bearing housings of the lower stages comprise a third material that is different than the first and second materials.

12. The ESP of Claim 8, further comprising one or more spacers, each spacer positioned axially between axially consecutive or adjacent impellers, wherein the one or more spacers comprise a third material that is different than the first and second materials.

13. The ESP of Claim 8, wherein the upper stages are entirely made of the first material.

14. The ESP of Claim 8, wherein the upper stages comprise the first material and are coated or treated.

15. The ESP of Claim 8, wherein the lower stages are entirely made of the second material.

16. The ESP of Claim 8, wherein the lower stages comprise the second material and are coated or treated.

17. The ESP of Claim 8, wherein the second material is a coated and/or heat treated version of the first material, or the first material is a coated and/or heat treated version of the second material.