SYSTEMS AND PROCESS FOR ALIGNING PERMANENT MAGNET MOTORS IN AN ELECTRICAL SUBMERSIBLE PUMP

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is claims priority to US Provisional Application No. 62/903,979 filed September 23, 2019, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present inventions are directed to electric submersible pump assemblies for wells and in particular to high-speed components related to electric submersible pumps.

BACKGROUND AND SUMMARY OF THE INVENTION

[0003] Permanent magnet motors may be employed in electric submersible pumps as described in, for example, 16/232,811 filed February 22, 2019 and published as US 2019/0264703 on August 29, 2019 which publication is incorporated herein by reference in its entirety. Prior art systems could not employ two or more permanent magnet synchronous motors because it was not known how or if they could be aligned properly. Thus, if two or more permanent magnet synchronous motors are to be employed in an electric submersible pump in, for example, in series, then what is needed is an effective way to ensure that the motors are aligned. Advantageously, the present invention pertains to cost-effectively aligning such motors.

SUMMARY

[0003a] In a first aspect, the present disclosure provides a process for connecting two or more permanent magnet motors each having a rotor and a stator in series for an electrical submersible pump comprising: making a phase identifying mark on each stator of the two motors to be connected; making a pole identifying mark on each rotor of the two motors to be

connected; using the phase identifying marks to align the phases of the stators; and using the pole identifying marks to align the poles of the rotors.

[0004] In one example, the present disclosure pertains to a process for connecting two or more permanent magnet motors in series. The method comprises aligning the phases of the stators and aligning the poles on the rotors. A phase identifying mark is made on each stator while a pole identifying mark is made on each rotor.

[0005] In a second aspect, the present disclosure pertains to an electrical motor for an electrical submersible pump comprising a first permanent magnet motor comprising a first rotor with a first pole identifying mark and a first stator with a first phase identifying mark, a second permanent magnet motor comprising a second rotor with a second pole identifying mark and a second stator with a second phase identifying mark, wherein the phases of the first and second stators are aligned and wherein the poles of the first and second rotor are substantially aligned.

[0005a] In a third aspect, the present disclosure provides electric submersible pump comprising: a power module comprising a first permanent magnet electric motor comprising a first rotor with a first pole identifying mark and a first stator with a first phase identifying mark and a second permanent magnet electric motor comprising a second rotor with a second pole identifying mark and a second stator with a second phase identifying mark, wherein the phases of the first and second stators are substantially aligned and wherein the poles of the first and second rotor are substantially aligned; a head module; and a base module.

[0006] Electric Submersible Pumps (ESP) are widely used in the production of fluid from oil and gas wells. Traditional ESPs have a centrifugal pump coupled to an electric motor. The motor is typically protected from wellbore fluid ingress by a seal (also referred to as protector or equalizer). The seal section is located between the motor and the pump which serves to reduce any pressure difference between the wellbore fluid exterior of the motor and the lubricant on the interior of the motor.

[0007] The rotary pump in many ESPs includes a rotating shaft, impeller, and stationary diffuser. The impellers are coupled to the shaft and create lift as they rotate, driving wellbore fluid up the well. A standard induction type motor may include a single continuously wound stator, a single shaft, one or multiple induction type rotors mounted on

the shaft, and rotor bearings to the centralize the shaft.

[0008] Various disclosed embodiments of the invention may have one or multiple advantages over standard ESP units. Some disclosed embodiments utilize a wider range of operating speeds, utilize an active cooling system to reduce motor temperature rise, reduce the amount of time required to assemble or install a unit, and/or improve the power efficiency of the ESP system.

[0009] Disclosed embodiments may also reduce the inventory required through the use of standardized components, reduce capital requirements, reduce personnel requirements, and/or decrease rig exposure to an open well bore during installation, thereby increasing

CLAIMS

1. A process for connecting two or more permanent magnet motors each having a rotor and a stator in series for an electrical submersible pump comprising:

making a phase identifying mark on each stator of the two motors to be connected;

making a pole identifying mark on each rotor of the two motors to be connected;

using the phase identifying marks to align the phases of the stators; and

using the pole identifying marks to align the poles of the rotors.

2. The process of claim 1, wherein the process further comprises starting a winding on each stator at the phase identifying mark.

3. The process of claim 1, wherein the phase identifying mark comprises a mark machined onto the stator.

4. The process of claim 1, wherein the phase identifying mark comprises a mark painted onto the stator.

5. The process of claim 1, wherein the phase identifying mark comprises a mark adhered onto the stator.

6. The process of claim 1, wherein the process further comprises installing each stator in a motor housing and indicating the location of each phase identifying mark on the exterior of the motor housing.

7. The process of claim 1, wherein the pole identifying mark comprises a mark machined onto the rotor.

8. The process of claim 1, wherein the pole identifying mark comprises a mark painted onto the rotor.

9. The process of claim 1, wherein the pole identifying mark comprises a mark adhered onto the rotor.

10. The process of claim 1, wherein the pole identifying mark comprises a notch on an end of the rotor shaft wherein the notch is configured to mate with a coupling alignment notch.

11. An electric motor for an electric submersible pump comprising:

a first permanent magnet electric motor comprising a first rotor with a first pole identifying mark and a first stator with a first phase identifying mark;

a second permanent magnet electric motor comprising a second rotor with a second pole identifying mark and a second stator with a second phase identifying mark;

wherein the phases of the first and second stators are substantially aligned and wherein the poles of the first and second rotor are substantially aligned.

12. The electric motor of claim 11,

wherein the first permanent magnet motor comprises threads on an inner diameter which turn in a first direction and wherein second permanent magnet motor comprises threads on an inner diameter which turn in a second direction,

the electric motor further comprising a single-piece housing coupling comprising a first end and a second end, the first end of the single-piece housing coupling comprising threads on an outer diameter which turn in a first direction, the second end of the single-piece housing coupling comprising threads on an outer diameter which turn in a second direction,

wherein the first permanent magnet motor is joined to the second permanent magnet electric motor using the threads on the single-piece housing coupling, the threads on the first permanent magnet motor, and the threads on the second permanent magnet motor.

13. The electric motor of claim 11, further comprising a motor housing wherein the exterior of the motor housing indicates the location of the first and second phase identifying mark.

14. The electric motor of claim 11, wherein the first and second permanent magnet

electric motor are configured to be driven with a variable speed drive of less than 800 volts.

15. The electric motor of claim 11, wherein the motor comprises from 2-20 poles.

15. The electric motor of claim 11, wherein the pole identifying mark comprises a mark machined onto the rotor.

16. The electric motor of claim 11, wherein the pole identifying mark comprises a mark painted onto the rotor.

17. The electric motor of claim 11, wherein the pole identifying mark comprises a mark adhered onto the rotor.

18. The electric motor of claim 11, wherein the pole identifying mark comprises a notch on an end of the rotor shaft wherein the notch is configured to mate with a coupling alignment notch.

19. The electric motor of claim 11, wherein the rotor comprises a solid steel bar rotor.

20. An electric submersible pump comprising:

a power module comprising a first permanent magnet electric motor comprising a first rotor with a first pole identifying mark and a first stator with a first phase identifying mark and a second permanent magnet electric motor comprising a second rotor with a second pole identifying mark and a second stator with a second phase identifying mark, wherein the phases of the first and second stators are substantially aligned and wherein the poles of the first and second rotor are substantially aligned;

a head module; and

a base module.