An electric submersible pump for use in a well, comprising: an electric motor section including a rotor and a stator; and a pump section comprising a series of impellers and diffusers; wherein a common, single-piece shaft extends through the motor and pump sections, the rotor and impellers being mounted on the common shaft.
Electric Submersible Pump

Technical field

This invention relates to electric submersible pumps (ESPs) of the type commonly used in the oil industry to provide artificial lift in wells where the pressure is insufficient to produce to the surface.

Background art

Figure 1 shows a known type of ESP. Such devices are well-known in the oil industry and are located downhole in oil wells and operated to pump oil to the surface. The ESP shown in Figure 1 comprises a pre-motor section 10 with electronics, one or more motor sections 12 (two are shown here), each of which contains a stator and a rotor mounted on a drive shaft; a protector section 14 including a pump intake 16, and a series of pump sections 18 (four are shown here, although the number of sections can be selected according to the amount of lift and volume the pump must deliver. In each of the sections, various components are mounted on a rotary shaft and the shafts in adjacent sections are connected in order that drive can be passed from the motor section(s) 12 to the pump section(s) 18. Such a construction can comprise six or more shafts made from steel, Inconel and Monel alloys.

There are a number of problems with such an arrangement that can affect the reliability of the ESP, including the difficulty in balancing the various rotating shafts for operation at speeds of up to 3000rpm, the inherent weaknesses created by the linkages between the shafts, and the extra length that each connection adds to the overall ESP length. An ESP of the type shown in Figure 1 can easily approach 50m in length and so require complex assembly on site.

The cost of manufacturing such devices can be high since the material used to make the shaft is expensive and complex machining of keyways, grooves and splines is necessary.

It is an object of this invention to try to provide an ESP construction that minimises some or all of the problems discussed above.

Disclosure of the invention

This invention provides an electric submersible pump for use in a well,
comprising:
- an electric motor section including a rotor and a stator; and
- a pump section comprising a series of impellers and diffusers; wherein a common, single-piece shaft extends through the motor and pump sections, the rotor and impellers being mounted on the common shaft.

Preferably, the pump further comprises a protector section disposed between the motor and pump sections, the common shaft extending through the protector section.

The common shaft can be solid or hollow and can comprise a flat and/or keyway to allow components to be fixed thereto.

The motor is a DC motor with multiple rotor poles. A commutation system for the motor can be provided on the opposite side of the motor section to the pump section, the common shaft extending into the commutation system.

The shaft preferably includes compression attachments at its ends which serve to hold all components mounted on the shaft in compression.

Other aspects of the invention will be apparent from the following description.

**Brief description of the drawings**

Figure 1 shows a prior art ESP;
Figure 2 shows an ESP according to an embodiment of the invention;
Figure 3 shows the sections of the ESP of Figure 2 separated; and
Figure 4 shows various shaft profiles for use in an ESP according to the invention.

**Mode(s) for carrying out the invention**

Figure 2 shows an embodiment of an ESP according to the invention. This ESP comprises a single motor section 20, a protector section with a crossover and a pump inlet 22 and a single pump section 24. The overall length of the ESP is less than 12m.

Figure 3 shows a sectional view of the ESP of Figure 2, comprising (from left to right) the motor section 20, a crossover section 21 which is connected at the top of the motor section 20; a protector section connected to the crossover section,
and the pump section 24 connected on top of the protector section 22. A single-piece common shaft 26 runs through all of these sections.

The shaft 26 can be solid or hollow and can include flats and/or keyways to allow components of the pump to be fixed thereto. Figure 4 shows a series of shaft profiles (solid with key A, solid with flat B, hollow with key C, and hollow with flat D) that might be appropriate in different cases. Double flat or double keyways (at 180°) can be brought into straightness tolerances most easily after distortion during manufacturing.

The shaft can be made of various materials, such as low alloy carbon steel or Martensitic-type stainless steel or Inconel or Monel alloys. The diameter of the shaft can be selected according to the shaft profile and shaft material to give the desired properties. The shaft outer diameter may typically be between 22mm up to 40-50mm (higher diameters typically being selected for lower strength materials). A typical hollow shaft might have an outer diameter of 36 mm and an inner diameter of 30mm. By using a slightly higher diameter than is usual, lower cost, lower strength materials can be used effectively.

The shaft preferably has no radial grooves or diameter reduction in areas of high stresses which can cause weak points. Also, all components are held on the shaft in compression as is described below.

The motor section 20 comprises a commutation section 30 at its lower end for controlling the motor. The very end of the shaft 26 is provided with a snap ring 32 against which supports the various rotating components of the ESP. The motor section includes a housing 34 with a stator 36 fixed to its inner surface. A rotor 38 is mounted on the shaft 26 inside the stator 36. The motor is preferably a high torque DC motor with multiple magnet rotor poles.

The shaft leads from the motor section 20, through the crossover section 21 and into the protector section 22 which serves to separate the motor and pump sections. The protector section comprises three pressure compensating bags 40, each with an associated high speed face seal 42. The protector section will also include a pump inlet and other seals and filters to prevent fluids from entering the motor housing.

The shaft 26 leads from the protector section into the pump section 24. The pump comprises a housing 44 having a series of diffusers 46 fixed thereto.
Corresponding impellers 48 are mounted on the shaft 26 so as to be positioned adjacent the diffusers and define centrifugal pump elements. A compression nut 50 is provided at the top of the shaft in the pump section. By tightening the compression nut 50, the impellers and other components mounted on the shaft 26 are forced against each other and held in compression against the snap ring 32.

By providing a single shaft, expensive manufacturing steps and potential areas of weakness formed by joints are avoided. Also, the ESP can be relatively compact so as to be manufactureable and installable as a single unit. The improved balance allowed by the single shaft allows operation at relatively high speeds, up to 6000rpm in many cases.

It will be apparent that changes may be made while staying within the scope of the invention.
5
Claims
1. An electric submersible pump for use in a well, comprising:
   - an electric motor section including a rotor and a stator; and
   - a pump section comprising a series of impellers and diffusers;
   wherein a common, single-piece shaft extends through the motor and pump
   sections, the rotor and impellers being mounted on the common shaft.
2. A pump as claimed in claim 1, further comprising a protector section disposed
   between the motor and pump sections, the common shaft extending through
   the protector section.
3. A pump as claimed in claim 1 or 2, wherein the common shaft is solid or
   hollow.
4. A pump as claimed in claim 1, 2 or 3, wherein the shaft comprises at least one
   flat and/or keyway to allow components to be fixed thereto.
5. A pump as claimed in any preceding claim, wherein the motor is a DC motor
   with multiple rotor poles.
6. A pump as claimed in any preceding claim, further comprising a commutation
   system on the opposite side of the motor section to the pump section, the
   common shaft extending into the commutation system.
7. A pump as claimed in any preceding claim, wherein the shaft includes
   compression attachments at its ends which serve to hold all components
   mounted on the shaft in compression.
Figure 4
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

- **F04D 13/10** (2006.01)
- **F04D 29/043** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

- **F04D 13/00, 13/02, 13/06-13/10, 29/00-29/057, 29/60-29/64, 1/00, 1/06**

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

- Esp@cenet, RUPAT, RUABRU, RUPAT-OLD, RUABU1

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 2005/0109515 A1 (SCHLUMBERGER TECHNOLOGY CORPORATION) 26.05.2005, p. 2, paragraph [0031], first line, claim 28</td>
<td>2</td>
</tr>
<tr>
<td>Y</td>
<td>US 2006/0245959 A1 (JEFFREY A. LAROSE et al.) 02.1.2006, abstract, fig. 1</td>
<td>5</td>
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<tr>
<td>Y</td>
<td>RU 2276287 C1 (ANOKHIN VLADIMIR DMITRIEVICH et al.) 10.05.2006, p. 5, lines 17-18, fig. 1-3</td>
<td>4</td>
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<tr>
<td>Y</td>
<td>SU 1298424 A1 (F.V. SLAVUTIN et al.) 23.03.1987, kol. 1, lines 11-15, kol. 2, lines 5-8, fig. 1</td>
<td>7</td>
</tr>
</tbody>
</table>

See patent family annex

- **E** Special category of cited document
- **A** Document defining the general state of the art which is not considered to be of particular relevance
- **E** Earlier application or patent but published on or after the international filing date
- **X** Document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- **O** Document referring to an oral disclosure, use, exhibition or other means
- **P** Document published prior to the international filing date but later than the priority date claimed

**Date of the actual completion of the international search**

12 May 2009 (12.05.2009)

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