DRIVE SYSTEM FOR AN APPARATUS SEPARATING HOT PARTICLES

Abstract: A drive system for an apparatus separating hot particles being received by a moving surface (500) includes a drive shaft (104) for driving the moving surface (500) receiving the hot particles, a drive unit (101) for rotating the drive shaft (104), and a flexible coupling (102) arranged between the drive shaft (104) and the drive unit (101). The flexible coupling (102) includes first thin portions (201) defining a portion of a heat transfer path from the drive shaft (104) to the drive unit (101). The first thin portions (201) have large surface area to volume ratios for extending the heat transfer path. The first thin portions (201) dissipate heat when the flexible coupling (102) is driven by the drive unit (101). A method for dissipating heat from a drive system for an apparatus for separating hot particles includes providing a flexible coupling (102) and dissipating heat from the flexible coupling (102).
DRIVE SYSTEM FOR AN APPARATUS SEPARATING HOT PARTICLES

TECHNOLOGICAL FIELD

[0001] The present invention relates generally to a drive system, and particularly to a drive system for an apparatus for separating hot particles. The present application also relates generally to a method of dissipating heat from a drive system for an apparatus for separating hot particles.

BACKGROUND DISCUSSION

[0002] There is a significant need to magnetically separate materials at as high a temperature as feasible. Typically, in a hot magnetic separation process the materials are coming from a hot process. Once separated, the magnetic fraction and the non-magnetic fraction of the materials are returned to a hot process. There is therefore a need to maintain the material stream at an elevated temperature so that the materials are not cooled and subsequently reheated after processing.

[0003] A hot magnetic separator apparatus is disclosed in U.S. Patent No. 7,478,727, the entire content of which is incorporated by reference herein. In the hot magnetic separator apparatus of U.S. Patent No. 7,478,727, a variable frequency drive rotates the drum, and a control and instrumentation package controls the variable frequency drive. Conventional magnetic separator apparatuses that operate at elevated temperatures transfer heat from the hot magnetic separation process to the drive system, which may cause the drive
system to exceed its maximum design temperature. Conventional magnetic separator apparatuses with drive systems also do not correct any misalignment between a drive shaft and the drive unit. [0004] A need exists for a more efficient, cost-effective configuration for a drive system for an apparatus separating hot particles so that these and other concerns may be addressed.

**SUMMARY**

[0005] The disclosure here involves a drive system for an apparatus for separating hot particles. The drive system includes a drive shaft arranged to drive the moving surface receiving the hot particles, a drive unit arranged to rotate the drive shaft, and a flexible coupling arranged between the drive shaft and the drive unit. The flexible coupling is configured to align the drive shaft and the drive unit and comprises first thin portions that define a portion of a heat transfer path from the drive shaft to the drive unit. The first thin portions have large surface area to volume ratios for extending the portion of the heat transfer path between the drive shaft and the drive unit. The first thin portions dissipate heat when the flexible coupling is connected to the drive unit.

[0006] The disclosure here also involves a method for dissipating heat from a drive system for an apparatus for separating hot particles where the drive system includes a drive shaft arranged to drive a moving surface receiving hot particles and a drive unit arranged to rotate the drive shaft. The method comprises providing a flexible coupling arranged between the drive shaft and the drive unit.
The flexible coupling aligns the drive shaft and the drive unit. The flexible coupling comprises first thin portions defining a portion of a heat transfer path from the drive shaft to the drive unit. The first thin portions have large surface area to volume ratios for extending the heat transfer path between the drive shaft and the drive unit. The method also comprises dissipating heat from the first thin portions of the flexible coupling when the flexible coupling is connected to the drive unit.

**BRIEF DESCRIPTION OF THE DRAWING FIGURES**

[0007] Additional features and aspects of the drive system for separating hot particles being received by a moving surface and a method of dissipating heat from a drive system for an apparatus for separating hot particles disclosed here will become more apparent from the following detailed description considered with reference to the accompanying drawing figures in which like elements are designated by like reference numerals.

[0008] FIG. 1 is a view of a drive system with an apparatus for separating hot particles;

[0009] FIG. 2 is a view of the flexible coupling used in the drive system disclosed here.

**DETAILED DESCRIPTION**

[0010] The drive system disclosed in this application allows for the dissipation of heat so that the drive system operates well below the maximum design...
temperature for the drive system. The drive system disclosed here also corrects any shaft misalignment that may arise between the components of the drive system.

[001] The drive system disclosed here is particularly suitable for use with magnetic drum separators including Hot Magnetic Separator (HMS) Systems. The design temperature for HMS systems is typically about 800 degrees Celsius. A significant economic benefit is achieved by separating the materials at a high temperature. The materials are typically obtained from a hot process. Once separated, the magnetic fraction and the non-magnetic fraction are often returned to a hot process. It is therefore beneficial to maintain the material streams at an elevated temperature during the magnetic separation process so that the material streams do not have to be cooled and then reheated. The energy savings are significant and translate to lower operating costs. Capital costs are also reduced because there is less of a need for the purchase and installation of cooling and reheating equipment.

[0012] Known drive systems, however, have a maximum design temperature. In conventional magnetic drum separators, the HMS system would tend to heat the drive shaft that rotates the drum. If a conventional magnetic separator were used for hot material, the heat would be transferred to the drive system and cause the drive system to approach its maximum design temperature. Known drive systems have attempted to address this by extending the shafts, using different materials for the shaft, and using insulating spacers that are bolted in a fixed
location in the system. Other known drive systems have directly cooled shafts using cooled water or air. These methods introduce specialized materials or additional components to the drive system which increases the manufacturing costs. These methods also do not correct any shaft misalignment that may occur in the drive system.

[0013] To address this concern and to ensure shaft alignment, the drive system at issue here includes, in combination with other features, a flexible coupling as will be described below.

[0014] An embodiment of an apparatus for separating hot particles being received by a moving surface is shown in FIG. 1. The apparatus includes a moving surface 500 for receiving the hot particles. The moving surface 500 is rotated by the drive system. The drive system includes a drive unit 101, a flexible coupling 102, a drive side bearing assembly 103, and a drive shaft 104. The drive unit 104 can be a fixed speed drive unit, but in alternative embodiment, the drive unit 104 is a variable speed drive unit

[0015] In the embodiment, the drive unit 101 drives a driven shaft which then rotates the flexible coupling 102. The flexible coupling 102 transfers this rotation to the drive shaft 104. The movable surface 500 is rotated by the drive shaft 104. Thus, when the drive unit 101 of the drive system generates rotation, the rotation is transferred to the movable surface 500. In the embodiment shown in FIG. 1, the drive shaft 104 is supported by a drive side bearing assembly 103 which supports the drive shaft 104. In another embodiment, the drive system may
include a gearbox and other components including drive belts and pulleys. Other components may be included in the drive system and are not specifically enumerated here.

[0016] The flexible coupling 102 may be configured to engage with the drive shaft 104 and the driven shaft by friction, bolts, keyway, or other similar methods. The engagement of the flexible coupling 102 to the drive shaft 104 and the driven shaft is sufficient so that the flexible coupling 102 is rotated by the rotation of the driven shaft of the drive unit 101. The rotation of the flexible coupling 102 then rotates the movable surface 500.

[0017] An embodiment of the flexible coupling 102 is shown in detail in FIG. 2. This embodiment of the flexible coupling 102 includes first thin portions 201 and a connection between the first thin portions 201 that define at least a portion of a heat transfer path from the drive shaft 104 to the drive unit 101. The first thin portions 201 and the connection between the first thin portions 201 lengthen the heat transfer path between the drive shaft 104 and the driven shaft of the drive unit 101. The first thin portions 201 are formed to have a large surface to volume ratio to extend the heat transfer path and also to dissipate heat more effectively.

In one embodiment, the first thin portions 201 are particularly effective at dissipating heat by convection when the drive system is operating. In particular, the rotation of the flexible coupling 102 increases dissipation of heat from the drive shaft 104. The surface area to volume ratio is preferably, but not necessarily, between 0.005 and 0.02, such as about 0.01.
The flexible coupling 102 remains torsionally strong while accommodating for shaft misalignment. In some embodiments, the flexible coupling 102 may be a double disc style coupling comprising two hubs, two flexible members, and a center spacer sandwiching the two flexible members. In other embodiments, the flexible coupling 102 may be a single disc style coupling comprising two hubs and one flexible member. In both styles of couplings, the flexible members are fastened to the hubs so that the flexible members are fixed relative to the hubs. The flexible members bend relatively easily so that misalignment may be accommodated by the flexible coupling 102.

The flexible coupling 102 shown in FIG. 2 comprises two substantially parallel first thin portions 201 that are arranged orthogonal to the longitudinal axis of the drive shaft 104 and the driven shaft of the drive unit 101. In one embodiment, the first thin portions 201 comprise flexible members. The depicted flexible coupling 102 also includes two substantially parallel second thin portions 202 that are arranged parallel to the longitudinal axis of the drive shaft 104 and the driven shaft of the drive unit 101. In one embodiment, the second thin portions 202 are fasteners that secure the flexible members to the hub. In another embodiment, if the flexible coupling 102 is a double disc style coupling, the second thin portions 202 also secure the flexible members to the center spacer. This arrangement of the first thin portions 201 and the second thin portions 202 forms a portion of the heat transfer path from the drive shaft 104 to the drive unit 101. The depicted arrangement is merely one possible example.
arrangement of first thin portions 201 and second thin portions 202 in the flexible coupling 102. The arrows included in FIG. 2 illustrate one possible heat transfer path formed by the first thin portions 201 and the second thin portions 202 which extend the heat transfer path from the drive shaft 104 to the drive unit 101.

[0020] The first thin portions 201 and the second thin portions 202 may be made of metal or another suitable heat conductive material, or plastic or another suitable heat insulating material. The first thin portions 201 and the second thin portions 202 may also include features to facilitate dissipation of heat. The features may increase the surface area to volume ratio of the first thin portions 201 and the second thin portions 202 to further extend the heat transfer path and to also improve heat dissipation characteristics. In some embodiments, the features may be surface features such as slots, slits, holes, or dimples. In some embodiments, a combination of these features may be used to improve heat dissipation characteristics.

[0021] In addition to lengthening or extending the heat transfer path and dissipating heat from the drive shaft 104 so that the heat load of the drive system does not exceed the maximum design temperature, the flexible coupling 102 also corrects misalignment between the drive shaft 104 and the driven shaft so that the movable surface 500 and the drive unit 101 operate smoothly.

[0022] A technique for dissipating heat in a drive system for use with a magnetic drum separator is also disclosed here. The technique includes providing a flexible coupling between the drive shaft and the drive unit so that thin portions with large
surface area to volume ratios extend the heat transfer path between the drive shaft and the drive unit. The heat is dissipated from the thin portions of the flexible coupling when the flexible coupling is connected to the drive unit. As discussed above, the incorporation of the disclosed flexible coupling helps prevent the drive system from exceeding its maximum design temperature while still allowing the apparatus for separating hot particles to operate at a high temperature.

[0023] The detailed description above describes features and aspects of embodiments of a drive system for an apparatus separating hot particles and are disclosed by way of example. The invention is not limited, however, to the precise embodiments and variations described. Changes, modifications, and equivalents can be employed by one skilled in the art without departing from the spirit and scope of the invention as defined in the appended claims. It is expressly intended that all such changes, modifications, and equivalents which fall within the scope of the claims are embraced by the claims.
WHAT IS CLAIMED IS:

1. A drive system for an apparatus for separating hot particles being received by a moving surface (500), characterized by the drive system comprising:
   - a drive shaft (104) arranged to drive the moving surface (500) receiving the hot particles;
   - a drive unit (101) arranged to rotate the drive shaft (104); and
   - a flexible coupling (102) arranged between the drive shaft (104) and the drive unit (101), said flexible coupling (102) configured to align the drive shaft (104) and the drive unit (101), said flexible coupling (102) comprising first thin portions (201) defining a portion of a heat transfer path from the drive shaft (104) to the drive unit (101), the first thin portions (201) having large surface area to volume ratios for extending the portion of the heat transfer path between the drive shaft (104) and the drive unit (101), the first thin portions (201) dissipating heat when said flexible coupling (102) is connected to the drive unit (101).

2. The drive system as defined in claim 1 characterized by further comprising a drive side bearing assembly (103) arranged to support the drive shaft (104), said flexible coupling (102) being arranged between the drive side bearing assembly (103) and the drive unit (101).
3. The drive system as defined in claim 1 or 2, characterized by at least one of the first thin portions (201) of said flexible coupling (102) is arranged substantially orthogonally to a longitudinal axis of the drive shaft (104).

4. The drive system as defined in claim 1 or 2, characterized by at least two of the first thin portions (201) of said flexible coupling (102) are arranged substantially orthogonally to a longitudinal axis of the drive shaft (104), the first thin portions (201) being arranged on opposite ends of said flexible coupling (102).

5. The drive system as defined in any of the claims 1 to 4, characterized by the first thin portions (201) are made of a heat conductive material.

6. The drive system as defined in any one of the claims 1 to 4, characterized by the first thin portions (201) are made of a heat insulating material.

7. The drive system as defined in any one of the claims 1 to 6, characterized by the drive unit (101) is a fixed speed drive unit.
8. The drive system as defined in any one of the claims 1 to 6, characterized by the drive unit (101) is a variable speed drive unit.

9. The drive system as defined in any one of the claims 1 to 8, characterized by the surface area to volume ratio being between 0.005 and 0.02, such as about 0.01.

10. A method of dissipating heat from a drive system for an apparatus for separating hot particles, said drive system comprising a drive shaft (104) arranged to drive a moving surface (500) receiving hot particles, and a drive unit (101) arranged to rotate the drive shaft (104), characterized by the method comprising:

    providing a flexible coupling (102) arranged between the drive shaft (104) and the drive unit (101), said flexible coupling (102) configured to align the drive shaft (104) and the drive unit (101), said flexible coupling (102) comprising first thin portions (201) defining a portion of a heat transfer path from the drive shaft (104) to the drive unit (101), the first thin portions (201) having large surface area to volume ratios for extending the heat transfer path between the drive shaft (104) and the drive unit (101); and

    dissipating heat from the first thin portions (201) of said flexible coupling (102) when said flexible coupling (102) is connected to the drive unit (101).
11. The method defined in claim 10, characterized by the drive system further comprises a drive side bearing assembly (103) arranged to support the drive shaft (104), said flexible coupling (102) being arranged between the drive side bearing assembly (103) and the drive unit (101).

12. The method defined in claim 10 or 11, characterized by at least one of the first thin portions (201) of said flexible coupling (102) is arranged substantially orthogonally to a longitudinal axis of the drive shaft (104).

13. The method defined in claim 10 or 11, characterized by at least two of the portions of said flexible coupling (102) are arranged substantially orthogonally to a longitudinal axis of the drive shaft (104), the first thin portions (201) being arranged on opposite sides of said flexible coupling (102).

14. The method as defined in any one of the claims 10 to 13, characterized by the first thin portions (201) are made of a heat conductive material.

15. The method as defined in any one of the claims 10 to 13, characterized by the first thin portions (201) are made of a heat insulating material.
16. The method as defined in any one of the claims 10 to 15, characterized by the drive unit (101) is a fixed speed drive unit.

17. The method as defined in any one of the claims 10 to 15, characterized by the drive unit (101) is a variable speed drive unit.

18. The method as defined in any one of the claims 10 to 17, characterized by the surface area to volume ratio being between 0.005 and 0.02, such as about 0.01.
This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      - ☑ the international application in the language in which it was filed
      - ☐ a translation of the international application into _______________, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 9.1 (Rule 43.6(b)(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. 1.

2. ☐ Certain claims were found unsearchable (See Box No. II)

3. ☐ Unity of invention is lacking (see Box No III)

4. With regard to the **title**,
   - ☑ the text is approved as submitted by the applicant
   - ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,
   - ☑ the text is approved as submitted by the applicant
   - ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings**,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 2
   - ☐ as suggested by the applicant
   - ☑ as selected by this Authority, because the applicant failed to suggest a figure
   b. ☐ none of the figures is to be published with the abstract

**NOTE:** The applicant's or agent's file reference is FOR FURTHER ACTION as w$e as applicable, item 5 below.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16D3/78 B03C1/14

ADD.

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)
F16D B03C B01D

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)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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
L' document which may throw doubts on priority claims or which is cited to establish the publication date of another citation or other special reason as specified
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"A" document member of the same patent family

Date of the actual completion of the international search
17 December 2015

Date of mailing of the international search report
04/01/2016

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Authorized officer
Van Overbekee, Sim
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