

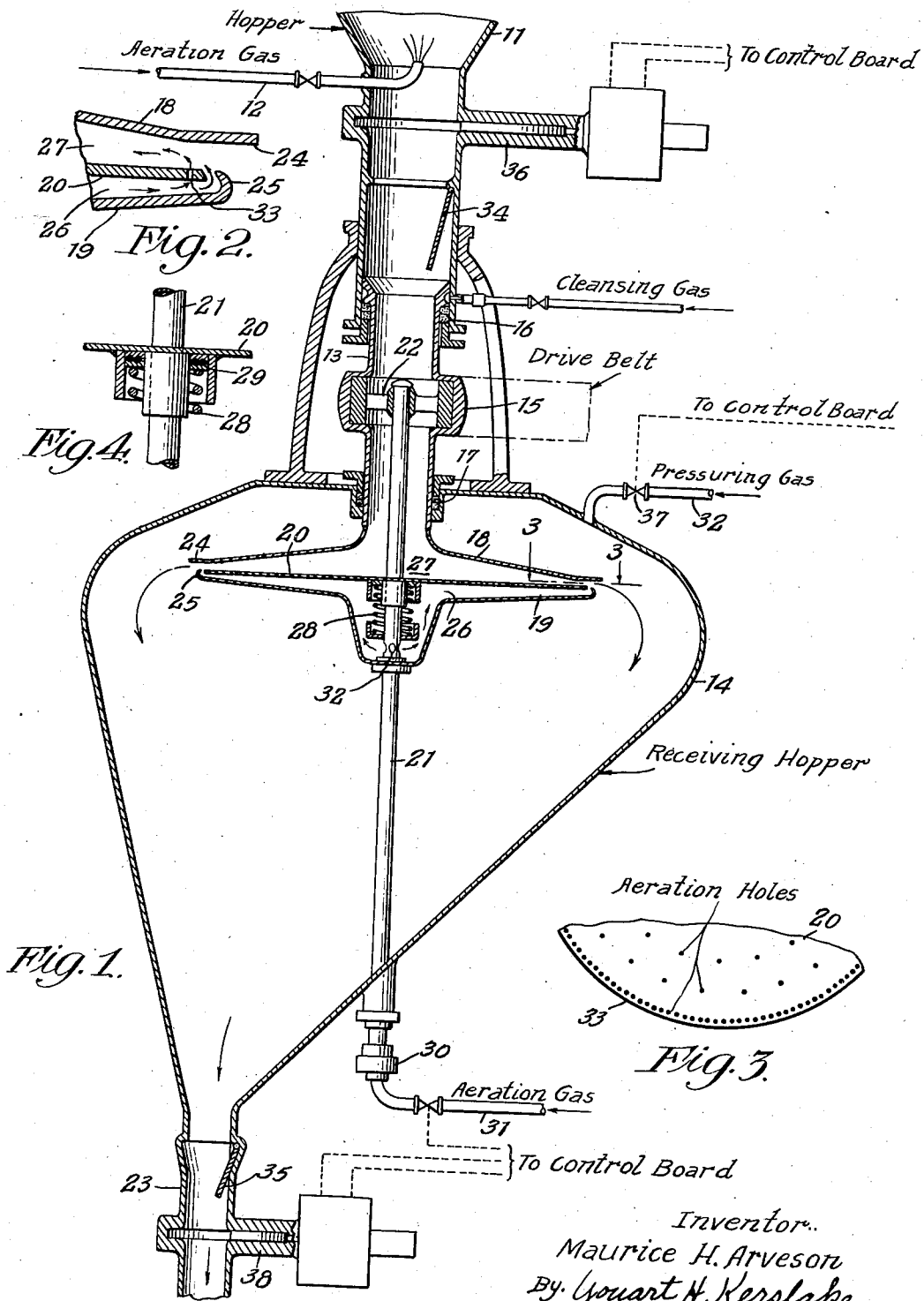
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CENTRIFUGAL PUMP

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CENTRIFUGAL PUMP

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The present invention relates to centrifugal pumps for finely divided solid material such as abrasive powders and the like. This invention is particularly useful for handling powdered catalysts in apparatus for catalytically treating petroleum products.

Many difficulties, particularly erosion and caking, arise in devices for impelling powdered solids. Whenever a powdered abrasive solid comes between moving metal surfaces erosion occurs and the impelling device wears out quickly. In other devices where the powder is permitted to come to rest, caking or bridging occurs and the device becomes inoperative. The present invention provides a method and means for impelling or pumping a finely divided solid material, particularly from a lower pressure zone to a higher pressure zone. By the term "finely divided solid material" I mean to include those materials which have a particle size of from about 50 mesh to about 500 mesh and which are normally subject to packing or caking and which cause erosion.

Powdered catalyst systems have been found to be far superior to fixed bed systems in many respects, but a serious problem in powdered catalyst systems is that of handling the abrasive powder and particularly introducing this powder from a zone of low pressure to a zone of high pressure. Ordinary pumps or blowers cannot be used for this purpose because when powdered catalyst comes into contact with metal surfaces which are subject to sliding friction, the metal surfaces quickly become eroded and worn away by the abrasive action of the catalyst. A pressure screw of gradually diminished pitch has been proposed as a solution to this problem but the friction losses in such a screw are enormous, and here again the erosion due to contact of the catalyst particles with moving metal surfaces makes it necessary to replace metal parts at very short intervals. Pumps of the pressure-screw type are also subject to the disadvantage that they are mechanically very inefficient and cause an agglomeration of the catalyst which seriously impairs its activity.

An object of the present invention is to provide a means for handling powdered catalyst which will avoid the above difficulties.

A further object is to provide a pump which is subject to less erosion than in previously known devices.

Still another object is to provide a pump for a finely divided solid material wherein bridging or caking of the material is prevented.

A still further object is to provide an improved

pump for transferring powdered catalyst material from a lower pressure zone to a higher pressure zone without excessive wear of the pump and without disintegrating or agglomerating the catalyst material.

Other objects of the invention will be apparent as the description thereof proceeds.

With the foregoing objects in mind, the present invention provides for a centrifugal impeller which receives the finely divided solid material from a low pressure zone and forces it by centrifugal action into a high pressure zone. In order to prevent the powdered material from caking and bridging in the impeller, I have provided means for keeping the material aerated while it is passing through the impeller.

One form of the invention will be described in detail with reference to the drawing forming a part of this specification.

Figure 1 is a vertical cross-sectional view of one example of my improved centrifugal pump;

Figure 2 is an enlarged cross-sectional view of a portion of the pump shown in Figure 1;

Figure 3 is a plan view of another portion of the pump drawn along lines 3—3 of Figure 1; and

Figure 4 is an enlarged cross-sectional view of still another portion of Figure 1.

In the detailed description which follows I shall refer particularly to powdered catalyst material, although other powdered solids are within the scope of the present invention.

Referring to the drawing, a chamber or hopper 11 containing the powdered catalyst is aerated by means of inert gas entering through line 12. This aeration prevents bridging and ensures steady, even and continuous flow of the powder in a "liquid-like" state down to the impeller. A rotatable neck member 13 connects the hopper 11 with the chamber or receiving hopper 14 which is under a higher pressure than hopper 11. The neck member 13 is provided with a pulley 15 which may be driven by a belt or by any other driving means, mechanically, electrically, pneumatically, or otherwise. Conventional stuffing boxes 16 and 17 are used to permit rotation of the neck member while at the same time preventing leakage of the aerated powder. A cleansing gas under high pressure may be introduced into the stuffing boxes to prevent any powdered catalyst from entering the stuffing boxes and eroding the surfaces thereof.

Connected to and preferably integral with the lower end of neck 13 is disc 18 which, as shown in the drawing, may be slightly conical in shape. Disc 19 and plate 20 are arranged as shown be-

neath disc 18. A rotatable hollow shaft 21 passes from the pulley 15 to which it is secured by spider 22 down through neck 13, plate 20, disc 19 and the wall of the receiving hopper 14. Disc 19 is securely fixed to hollow shaft 21 while plate 20 may be securely fixed or keyed for vertical sliding movement or loosely mounted thereon. It is clear that when the neck 13 is rotated, the hollow shaft 21 as well as the discs 18 and 19 will rotate also. The powdered catalyst will pass downwardly through the neck member 13 past the spider 22 into the centrifugal zone 27 between disc 18 and plate 20 where it will be thrown outwardly into receiving hopper 14, finally passing therefrom through pipe 23. Referring particularly to Figure 2, it will be seen that the disc 18 has at its outer edge a flat annular flange 24 extending slightly beyond the outer edges of the plate 20 and the disc 19. Disc 19 on the other hand has an upwardly and inwardly curved flange-like portion 25 extending approximately to the upper surface of plate 20. Plate 20 has a bevelled outer edge which cooperates with the flange-like portion 25 to form an annular channel communicating between zone 26 and zone 27. If the plate 20 is to be rotatably and yieldably supported on hollow shaft 21 it is mounted on a tension spring 28 and roller bearings 29, as shown on Figure 4. This construction permits the plate 20 to revolve freely around hollow shaft 21 and at the same time move upwardly or downwardly depending on the pressure exerted on the upper and lower surfaces of said plate.

At the lower end of hollow shaft 21 externally of receiving hopper 14 is a swivel joint 30 to which is connected line 31. An inert aeration gas is passed through line 31 and hollow shaft 21 and through openings 32 provided in hollow shaft 21 into aeration gas zone 26. The aeration gas passes from zone 26 into centrifugal zone 27 through the annular channel around the outer edge of plate 20 as described hereinbefore. The flow of aeration gas through centrifugal zone 27 is countercurrent to the flow of powdered catalyst in zone 27 and thereby prevents the caking or bridging and ensures an even, uniform and continuous flow of the catalyst into receiving hopper 14. In Figure 3 are shown aeration holes 33 which may be provided in plate 20 to assist in the flow of aeration gas from zone 26 into centrifugal zone 27. In addition, other aeration holes may be provided in plate 20 nearer the center thereof. A pressuring gas can be introduced into receiving hopper 14 through line 32.

Catalyst powder when in its fully compacted state or settled condition weighs from about 40 to about 55 pounds per cubic foot. This or a similar powder is fed to the pump while in an aerated dense phase condition and has a density of the order of from about 8 to about 30 pounds per cubic foot, which, in other words, is about 15 to about 50% of its density when fully compacted. In the centrifugal zone 27 the density of the powdered catalyst will be somewhat greater, say from about 25 to about 60% of the fully compacted density, but it will still be free flowing due to the introduction of aerating gas at various points as described, thus maintaining the powdered solid in a dense phase condition which might be termed "liquid-like." This dense phase has the free flowing density characteristics of a liquid but the elastic and compressible characteristics of a gas. Because of this characteristic of compressibility an aerating gas is introduced near the periphery of the disc 18 and plate 20 to maintain the volume

of gas in the dense phase at a high enough level to keep the powdered catalyst in a free-flowing condition. This dense phase, while being centrifuged, creates a much increased pressure near the periphery of the impeller and the dense phase moves out against the higher pressure in the receiving hopper 14.

The operation of the centrifugal pump is as follows:

10 The aerated powdered catalyst in hopper 11 passes down through rotating neck 13 into zone 27. Some motion is imparted to the catalyst by the spider 22 as well as by contact with rotating disc 18 and plate 20. As the powdered material 15 passes outwardly through centrifugal zone 27 its speed is increased and it finally passes into receiving hopper 14. The pressure at the center of centrifugal zone 27 is from a few ounces to about 10 pounds per square inch less than at the periphery thereof and in receiving hopper 14 while the pressure in aeration gas zone 26 is from a fraction of an ounce to several ounces greater than the gas pressure in receiving hopper 14. Since the aeration gas in zone 26 is directed into zone 27, the latter having a lower gas pressure, it will flow back through centrifugal zone 27 into hopper 11 thereby keeping the powdered catalyst in zone 27 in aerated form, preventing bridging or caking. The momentum of the particles of 20 powdered catalyst is great enough to prevent the particles from being blown back into zone 27 and they will pass through the opening between curved flange 25 and flange 24 into the receiving hopper 14 which is under greater pressure than 30 hopper 11.

In order to prevent the powdered catalyst from backing up from receiving hopper 14 to hopper 11 when the impeller, comprising discs 18 and 19 and plate 20, is stopped, conventional check valves 34 and 35 may be inserted in the bottom of hopper 11 and/or in pipe 23; such check valves are necessary whenever plate 20 is securely fixed to shaft 21. If, however, plate 20 is slidably mounted on the shaft 21 as shown in the drawing, the check 40 valves 34 and 35 are optional since the plate will move upwardly and contact disc 18 along flange 24 when the impeller is stopped due to the pressure exerted on the bottom of plate 20 by the aeration gas in zone 26 which overcomes the action of the spring 28 and the pressure on top of the plate. In normal operation the plate 20 is drawn down by the action of spring 28 which is sufficient to overcome the difference between the pressures on the top and bottom of plate 20. When the plate 20 is 50 in its upper position the aeration gas in zone 26 will pass through aeration holes 33 into zone 27 thereby keeping the powdered catalyst in zone 27 in aerated form. At the same time a portion of the aeration gas in zone 26 will leak past the curved flange 25 into pressure hopper 14 thereby preventing any back flow from occurring.

The operation of the centrifugal pump, according to the present invention, may be controlled by several different methods or by a combination thereof. For example, the rate of flow of powdered catalyst may be controlled by means of a valve 36 located at or near the bottom of hopper 11. Likewise, the flow of catalyst may be controlled by increasing or decreasing the flow of pressuring gas in line 32 by means of valve 37. Still another method of controlling the flow of catalyst is by controlling the speed of rotation of shaft 21. Likewise, a regulating valve 38 may be inserted in pipe 23. If this latter method of control is used, it is desirable to combine therewith

either the method of controlling the speed of rotation of shaft 21 or the regulating valve 36 in the bottom of hopper 11 in order to prevent the powdered catalyst material from backing up in receiving hopper 14. A preferred combination of methods of control of the flow of powdered catalyst comprises regulation of flow of pressuring gas in line 32 by means of valve 37 and the regulation of speed of rotation of shaft 21.

It is evident that when the plate 20 is securely mounted on the shaft 21 it may be unnecessary to have the aeration holes 33, or at least to provide only a few of them, since the aeration gas in zone 26 may pass at all times into zone 27 through the annular channel.

As stated hereinbefore, this invention is particularly suitable for handling powdered catalyst materials in connection with the catalytic treatment of petroleum products. One such catalyst material is known as Super Filtrol powder having a particle size between 1 to 100 microns. A material of this type when allowed to stand for even a short period of time tends to bridge and lose its "liquid-like" properties. Centrifugal pumps of conventional design are not capable of operating on such products.

While the invention has been described with particular reference to the drawing, it should be understood from the foregoing that various modifications are within the scope of the invention. For example, two pumps of the type shown in the drawing may be operated in multiple stages so that the receiving hopper 14 of the first pump will become the feed hopper 11 of the next pump, and so on. Catalysts are used in many hydrocarbon conversion processes, and pumps, according to the present invention, will find application in any of such processes wherein a powdered catalyst is used. Examples of such conversion processes are catalytic cracking, hydroforming of naphtha, isomerization of cracked naphthas, catalytic dehydrogenation of liquids and gases, pressure regeneration of contact materials, etc. It will also be noted that whenever it is desired to use the pump in a catalytic conversion process, the feed hopper or low pressure zone and receiving hopper or high pressure zone may be constituted by a portion of the apparatus already in use; for example, the receiving hopper may, in actual practice, be the chamber in which the catalytic conversion of hydrocarbons takes place, and likewise the feed hopper may be constituted by the chamber in which the regeneration of the catalyst takes place; or, as another example, the feed hopper may be constituted by a cyclone separator.

A pump for powdered solid materials according to the present invention may be used for pumping catalyst against line drop and pressure head from a reactor to a catalyst regenerator and from a regenerator to a reactor in a "fluid catalyst" hydrocarbon conversion unit. Similarly it may be used, several stages if necessary, for introducing fresh or make-up catalyst into the system at any desired point such as the reactor or the regenerator. Another important application of my apparatus is a "fluid conversion unit" for circulating dense phase catalyst from a dense phase regenerator to a dense phase heat exchanger for cooling the catalyst and back to the dense phase regenerator. Other applications include transfer of powdered foods such as milk, sugar, cocoa, etc. from one zone to another, transfer of powdered minerals such as Portland cement, whiting, contact clays, pottery clays and the like from one zone to another, etc.

The scope of the present invention is to be defined by the claims appended hereto.

I claim:

1. A centrifugal pump for transferring an aerated, finely divided solid material from a low pressure zone to a high pressure zone comprising rotatable means communicating with each of said zones for receiving the aerated finely divided solid material from the low pressure zone and for centrifuging it into the high pressure zone and means for passing aeration gas countercurrently through the finely divided solid material while it is undergoing said centrifuging, whereby the finely divided solid material is maintained in an aerated condition during centrifugation.

2. A centrifugal pump for finely divided solid material comprising a low pressure chamber, a high pressure chamber, rotatable means communicating with each of said chambers for receiving the finely divided solid material from the low pressure chamber and for centrifuging it into the high pressure chamber, and means for passing an aeration gas through the rotatable centrifuging means countercurrent to the flow of finely divided solid material whereby bridging and caking therein is prevented.

3. A centrifugal pump for finely divided solid material comprising a high pressure chamber, a centrifuge rotatably mounted within said chamber, said centrifuge comprising two discs and a circular perforated plate disposed therebetween and spaced therefrom, said discs and plate forming an upper zone through which the finely divided solid material passes and a lower zone, means for introducing an aeration gas into said lower zone, the pressure in the lower zone being greater than the pressure in the high pressure chamber and the pressure in said high pressure chamber being greater than the pressure in said upper zone, whereby the aeration gas will pass from the lower zone to the upper zone and there aerate the finely divided material countercurrently as it is centrifuged.

4. A centrifugal pump for finely divided solid material comprising a low pressure chamber, a high pressure chamber, a rotatable neck member connecting said chambers, a centrifuge connected to said rotatable neck member and disposed within said high pressure chamber, said centrifuge comprising two oppositely disposed substantially conical discs and a circular perforated plate disposed therebetween to form two zones, said finely divided solid material passing from the low pressure chamber through the rotatable neck member to one of said zones where it is centrifuged into the high pressure chamber, means for introducing an aeration gas into the other of said zones, said aeration gas being under a pressure higher than the pressure in the high pressure chamber and in the first-mentioned zone, whereby the aeration gas will pass into said first-mentioned zone countercurrently to the flow of finely divided solid material through said zone, thereby preventing caking and bridging of the finely divided solid material as it is centrifuged.

5. A centrifugal pump for finely divided solid material comprising a low pressure chamber, a high pressure chamber, rotatable means mounted within said high pressure chamber and communicating with each of said chambers for receiving the finely divided solid material from the low pressure chamber and for centrifuging it into the high pressure chamber, and means for passing an aeration gas through the rotatable

centrifuging means countercurrent to the flow of finely divided, solid material whereby bridging and caking therein is prevented.

6. A centrifugal pump for finely divided, solid material comprising a high pressure chamber, a centrifuge rotatably mounted within said chamber, said centrifuge comprising two discs and a circular perforated plate disposed therebetween and spaced therefrom, said discs and plate forming an upper zone and a lower zone, said finely divided solid material passing through one of said zones into said high pressure chamber, and means for passing an aeration gas through the other of said zones and then through the first-mentioned zone countercurrent to the flow of finely divided, solid material whereby bridging and caking therein is prevented.

7. A centrifugal pump for finely divided, solid material comprising a high pressure chamber, a centrifuge rotatably mounted within said chamber, said centrifuge comprising two discs and a circular perforated plate disposed therebetween and separated therefrom, said discs and plate forming an upper zone through which the finely divided, solid material passes and a lower zone, means for passing an aeration gas through said lower zone and then through said upper zone countercurrent to the flow of finely divided solid material whereby bridging and caking therein is prevented.

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