ABSTRACT: The disclosure describes apparatus for circulating slurry from a tank in which the solid particles of the slurry settle, the apparatus comprising a passage which opens at one end into the tank above the level of the particles so that liquid can enter the passage, the other end of the passage being connected to a pump and an outlet aperture being provided in the tank to lead particles into the passage intermediate the ends thereof. There is also described a method of slurry circulation as above.
SLURRY CIRCULATION APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to slurry circulation apparatus. Such apparatus finds use in wet-blasting apparatus, in which a mixture or slurry of solid particles and liquid, usually water with or without additives, is projected at a workpiece to clean it, descale it, degrease it or to perform some other surface treatment on it.

2. Description of the Prior Art

Wet-blasting apparatus normally comprises a cabinet in which the workpiece to be treated is supported over a sump on a grid and has the mixture of liquid and solid particles projected thereat by a gun which is supplied with compressed air to accelerate the mixture. After the mixture has impinged on the workpiece, the mixture drains into the sump from whence it is recirculated back to the gun. When the mixture reaches the sump, the solid particles tend to settle in the lower part thereof with a supernatant layer of liquid. Heretofore, the slurry has been removed from the sump for recirculation through a single oriﬁce adjacent the bottom of the sump. It will be appreciated that this oriﬁce will become blocked with the solid particles and if the pump being used to remove the slurry from the sump has only a small head, it sometimes happens that the pump cannot clear the blockage. The difﬁculty in removing the slurry from the sump and thus the required power of the pump will depend, to some extent, on the shape of the lower part of the sump. If the sump has a vertical wall and an inclined wall which is located so that the walls converge towards the bottom of the sump and if the oriﬁce oriﬁce is at the bottom of the vertical wall, then the blockage problem can normally be overcome by a pump of suitable power. If, however, the lower part of the sump is arranged with two inclined walls which converge there is a greater risk that the oriﬁce will become blocked so as to be incapable of being cleared except with a very powerful pump.

Although the above problem occurs particularly in wet-blasting machines it may also arise in other applications where it is required to remove slurry from a sump.

It is an object of the present invention to provide apparatus for circulating slurry and which enables a low-power pump to be used.

SUMMARY OF THE INVENTION

According to the invention we provide apparatus for circulating a slurry which consists of a mixture of a liquid and solid particles, the apparatus comprising a tank to receive the slurry and having a lower part shaped to lead the particles settling therein to an outlet aperture adjacent the bottom of the tank, a passage into which the outlet aperture opens intermediate the ends of the passage, one end of the passage communicating with the tank at a level above that normally occupied by the settled particles but below the surface of the supernatant liquid on the settled particles and a pump arranged to withdraw the slurry from the tank, the other end of the passage communicating with the pump.

With this arrangement, it has been found that a low-power pump is normally able to establish a ﬂow along the passage from the one end to the other end thereof in spite of the fact that particles will have dropped into the passage from the outlet aperture. We believe that this is due to the face that there is not the same opportunity for the slurry to rush into a hole formed therein by the pump suction as in the known arrangements and due to the face that, as soon as a hole has been formed in the deposit of slurry in the passage, there will be a ﬂow of liquid through the passage which will quickly clear any deposit under the outlet aperture.

In the known arrangements it has been necessary to use a very powerful motor to drive the pump and use a lined pump, i.e., a pump lined with rubber or the like. When using the invention, it is possible to have a pump which does nothing more than circulate the slurry and which may be unlined being made of cast iron and driven at a low speed by a comparatively small electric motor. The small pump is cheaper since it is unlined and since it is driven at a comparatively low speed its wear rate will be low and it will last for a considerable time.

The saving in cost may be judged from the fact that a powerful motor and a lined pump as used heretofore may cost between six and eight times a smaller motor and unlined pump which may be used in the apparatus of the invention.

Preferably, the one end of the passage is formed with a restriction to limit the quantity of liquid entering the passage and thus increase the speed. The speed of the liquid ﬂowing through the passage must be sufﬁcient to carry particles from the outlet aperture to the inlet of the pump. Generally the larger the outlet aperture the greater must be the restriction to ensure that the speed of liquid ﬂow is sufﬁcient.

Preferably, said one end of the passage is provided with a bafﬂe to prevent particles entering said one end as they settle in the tank. This bafﬂe may be in the form of a pair of inclined plates which converge upwardly over said one end of the passage.

Preferably, the outlet aperture is provided with a removable plug. If the apparatus is to be left inoperative for some time the plug will be inserted into the aperture before the operation is terminated and while the mixture in the tank is still turbulently rotating. On starting up, a liquid ﬂow will be established through the passage before the plug is inserted into the aperture. The plug may be operated automatically or manually.

The delivery from the pump may be fed to a gun which is also fed with compressed air, the slurry and air mixing in the gun and the air accelerating the slurry so that it may be caused to impinge upon a workpiece and then drain from the workpiece back into the tank. If the pump has a comparatively small head then there will be provided a restricted bypass between the outlet of the pump and the tank to prevent a head building up above the pump which could cause reverse circulation through the pump. Excess slurry will be returned directly to the tank and may be caused to impinge on a bafﬂe plate to prevent aeration of the slurry in the tank.

The invention also provides a method of circulating a slurry comprising a mixture of liquid and solid particles from a tank in the bottom of which the particles tend to settle with a supernatant layer of the liquid, comprising establishing a ﬂow of liquid from a position in the tank above the settled particles but below the surface of the liquid layer and feeding the particles into said flowing liquid at a position adjacent the bottom of the tank.

This method has the advantages described above in that the ﬂow of liquid carries away the particles which are delivered therein from the tank.

The slurry may be circulated in a number of operating periods between which are interposed rest periods, the method comprising the steps of preventing the particles passing into said ﬂowing liquid immediately before the start of a rest period but prior to cessation of said liquid ﬂow and, at the end of such rest period, commencing said liquid ﬂow prior to feeding the particles to the ﬂowing liquid.

BRIEF DESCRIPTION OF DRAWING

The invention will now be described in detail by way of example with reference to the accompanying diagrammatic drawing which shows a wet-blasting apparatus embodying the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, the apparatus comprises an upright cabinet 10 spanned by a grid 11 on which may be mounted a workpiece 12 to be treated. Below the grid 11 is a sump indicated generally at 13. The sump is partly defined by a vertical wall 14 and an inclined wall 15 which converge towards the bottom 16 of the sump, such bottom being provided with an outlet aperture 17.
The outlet aperture 17 leads into a passage 18 provided by the bore of a pipe 19. One end 20 of the pipe 19 passes through the inclined wall 15 and is formed with a restricted opening 21. A baffle indicated generally at 22 covers the end 20, the baffle being in the form of two inclined plates forming a "root" over the end 20, the baffle being open as indicated by the arrow 33 to allow liquid to flow into the end 20. The pipe 19 is connected at its other end 24 to the inlet of a pump 25. The outlet from the pump is connected to a pipe 26 which extends over the top of the cabinet 10 and has in an upper part thereof an air vent 27 and a leadoff 28 leading to a blast gun 29. The pipe 26 has a downcoming portion 30 which enters the sump 13 and a baffle 31 is positioned opposite the end of the bore 30.

The pump 25 is conveniently of the construction described in British Pat. No. 840,671. In such a pump the seal between the impeller shaft and the casing is formed by the liquid being pumped and this liquid is returned along a pipe 32 to the sump. A bypass 33 extends from the pipe 26 back into the sump 13 and is provided with a restriction 34 at its outlet. A plug 35 is provided for the outlet aperture 17 and is connected by a rod 36 to an operating pneumatic cylinder 37. The cylinder 37 may be operated to insert the plug 35 into the aperture 17 and withdraw the plug from the aperture. The plug 35 need not be a good fit in the aperture 17 so long as when inserted therein, it substantially prevents the passage of particles into the pipe 19.

The blast gun 29 is supplied with compressed air along a line 38 from a supply 39. The operation of the apparatus is as follows. The sump 13 has placed therein a convenient amount of a slurry comprising solid abrasive particles and a liquid which will normally be water with or without chemical additives such rust-inhibiting agents and wetting agents. The solid particles will settle to the bottom of the sump and are indicated at 40, the upper level of the solid particles being indicated at 41. There will be a supernatant layer 42 of liquid whose surface is indicated at 43. It is to be noted that the end 20 of the pipe 19 opens into the sump 13 at a position which is above the upper level 41 of the settled particles but below the surface 43 of the supernatant layer 42. When the pump 25 is started, assuming that the plug 35 is clear of the aperture 17, a liquid flow will be induced along the passage 18 in the pipe 19 and particles will fall through the outlet aperture 17 into the flowing liquid and will be carried by the liquid. The net of the pump will then be delivered by the pump 25 into the pipe 25.

Some of the mixture of liquid and abrasive will be taken off by the pipe 28 and fed to the gun 29. This liquid and abrasive will be accelerated by compressed air from the supply 39 and may be projected at the workpiece 12 on the grid 11, the mixture of liquid and abrasive particles draining from the workpiece through the grid 11 back into the sump 13. Excess liquid and abrasive which is not required by the gun 29 is returned along the downcomming portion 30 to the sump 13, the portion opening below the liquid level 43 and being opposite to the baffle 31 so that the returning mixture does not aerate the mixture in the sump. The air vent 27 is provided to allow the excess slurry to pass down the downcomming portion 30 into the sump 13.

As described above, it is preferred to use a comparatively low pressure pump 25 and under these circumstances the bypass 33 serves to return some of the slurry back into the sump thus preventing the possibility that an overwhelming head could develop in the pipe 26 due to a transient increase of slurry concentration in the pipe, such head causing reverse flow through the pump for the siting up thereof.

The slurry draining from the workpiece 12 into the sump 13 will separate, the particles going to settle to the bottom and the liquid forming the supernatant layer and the slurry will be removed from the sump by the pump 25 as described above and returned to the gun so that the pump 25 serves to circulate the slurry through the apparatus.

While the apparatus is running continuously, the contents of the sump 13 will be turbulent and although the particles will tend to settle as indicated at 40 they are unlikely to form an absolutely solid block at the bottom of the sump. If the machine is shut down, however, the particles will form a solid block at the bottom of the sump and will flow into the passage 18 and substantially block it. While under these circumstances the pump may well be able to establish a flow of fluid on restarting of the apparatus through the pipe 19, since the end 20 thereof is above the level of the particles, it is preferred to close the outlet aperture 17 immediately prior to shutdown of the apparatus.

Thus, while the mixture in the sump 13 is still turbulent, immediately prior to shutdown of the apparatus, the air cylinder 37 is operated to close the plug 35 into the outlet aperture 17. The operation of the cylinder 37 may be coordinated with the operation of the pump 25 so that when the pump is switched off the cylinder will operate to insert the plug into the aperture 17. The pump will not cease operation immediately its driving motor is switched off so that there will still be some flow of liquid through the pipe 19 after the plug 35 has been inserted thus ensuring that there will be no complete blockage of the pipe 19. When the apparatus is to be restarted, the pump 25 is switched on thus establishing a flow of liquid along the passage 18 in the pipe 19 and the cylinder 37 is not operated to remove the plug 35 from the aperture 17 until the liquid flow through the pipe is established. The operation of the cylinder 37 may be effected automatically through a time-delay mechanism put into operation upon switching on the pump 25.

It is preferred to use a pump 25 which has a low head which serves merely to circulate the slurry and does not in any way accelerate the slurry in the blast gun 29, such acceleration taking place by the compressed air from the supply 39. It is therefore essential that the speed of liquid flow through the passage 18 in the pipe 19 shall be sufficient to carry particles passing through the aperture 17 into the flow to the inlet of the pump 25. The speed of the flow in the passage 18 may be controlled by the size of the restriction 21. It will be appreciated that for a given volume of flow into the pump 25, the smaller the restricted opening 21 the greater will be the velocity of liquid flow through the passage 18. This velocity must be sufficient to lift the particles to the end 24. In general terms, the larger the outlet aperture 17 the smaller will be the opening 21 and the greater the required velocity in the passage 18.

If it is desired to drain the sump 13 this can be effected through a drain pipe 44 and drain plug 45, the drain pipe 44 comprising a continuation of the pipe 19.

We have found that it is sufficient to use a pump 25 which gives a maximum pressure of less than 3 p.s.i. Such a pump will circulate a slurry of 40 percent concentration (i.e. the slurry having 40 percent of solid particles by volume) and the pump may be run comparatively slowly at, for example, 960 r.p.m. The wear rate of a pump is proportional to the cube of the peripheral speed of the impeller and by using a slow-running pump the life of the pump will be longer than that of a high-pressure pump working faster. With such a low-pressure pump, the distance between the leadoff 28 and the surface 43 of the liquid as indicated by the arrow 46 should generate a liquid head which is greater than half of the pump head.

Various modifications may be made to the apparatus as specifically described. Thus although it is an object of the invention to provide apparatus which will enable the use of a low-speed, low-pressure pump it is within the scope of the invention to use a high-pressure pump. In the latter case the bypass 33 would be dispensed with and the limitation that the distance indicated by the arrow 46 should not be greater than half the head of the pump would not apply.

In a further modification instead of operating the plug 35 automatically through an air cylinder 37, the plug could be operated manually by the apparatus operator.
What I claim is:
1. Apparatus for circulating a slurry which consists of a mixture of liquid and solid particles, the apparatus comprising a tank to receive the slurry and having a lower part shaped to lead the particles settling therein to an outlet aperture adjacent the bottom of the tank, a passage into which the outlet aperture opens intermediate the ends of the passage, one end of the passage communicating with the tank at a level above that normally occupied by the settled particles but below the surface of the supernatant liquid on the settled particles, and a pump arranged to withdraw the slurry from the tank, the other end of the passage communicating with the pump.
2. Apparatus according to claim 1 wherein said one end of the passage is formed with a restriction to limit the quantity of liquid entering the passage.
3. Apparatus according to claim 1 wherein said one end of the passage is provided with a baffle to prevent particles entering said one end as they settle in the tank.
4. Apparatus according to claim 3 wherein the baffle is in the form of a pair of inclined plates which converge upwardly over said one end of the passage.
5. Apparatus according to claim 1 wherein the outlet aperture is provided with a removable plug.
6. Apparatus according to claim 5 including fluid operating means for moving the plug in timed relation with the operation of said pump.
7. A method of circulating a slurry comprising a mixture of liquid and solid particles from a tank in the bottom of which the particles tend to settle with a supernatant layer of liquid, comprising establishing a flow of liquid from a position in the tank above the settled particles but below the surface of the layer and feeding the particles into said flowing liquid at a position adjacent the bottom of the tank.
8. A method according to claim 7 wherein said slurry is circulated in a number of operating periods between which are interposed rest periods and comprising the steps of preventing the particles passing into said flowing liquid immediately before the start of the rest period but prior to the cessation of said liquid flow and, at the end of such rest period, commencing said liquid flow prior to feeding the particles into the flowing liquid.