

ABRASIVE FLUID JET SYSTEM

Field of the invention

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The present invention relates to an abrasive fluid jet cutting system and in particular discloses an operation for supplying a pressurised slurry from a pressurised abrasive slurry vessel to an abrasive-jet nozzle(s) to enable cutting or other abrasive-fluid jet machining operations to be carried out.

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Background and Prior Art

Abrasive fluid jet systems in the art are used in many applications where precision-cutting is required, such as in the singulation of substrates. One type
15 of abrasive jet system utilizes abrasive that is stored and discharged under pressure from a pressure vessel to mix with the driving fluid to form an abrasive slurry. The slurry is normally then accelerated through a nozzle to form an abrasive fluid jet tool, for cutting substrates or the like.

20 Increasingly higher liquid pressures are being used to take advantage of the increases in cutting power this provides. However at these high pressures the liquid compressibility becomes an important factor. When it is required to stop discharging abrasive slurry and depressurise the abrasive containment pressure vessel to pause the operational process or to facilitate abrasive recharge, at the
25 high pressures generated, there remains within the pressure vessel a volume of compressed fluid. With conventional state of the art systems, as the compressed volume is released on de-pressurisation its only route of escape is through the discharge conduit which, naturally, is positioned within the slurry confinement. Hence a volume of slurry is often discharged along with the compressed water
30 volume giving rise to problems with nozzle blockages.

Systems described in the state of the art use a variety of methods to overcome the above problem. For example, PCT publication no. WO 95/29792 for an "Abrasive Mixture Supply System" uses a diaphragm device to remove compressed liquid volume. Jet pumps to cause flow reversal have also been
5 used. In practice these methods have drawbacks, including high wear rates and reliability concerns brought about by the high pressures and the working medium itself which contains abrasives.

Summary of the Invention

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The invention seeks to mitigate the above disadvantages of nozzle blockage in the prior art. One principle of the invention thus relies on the natural tendency for water to take the path of least resistance to enable compressed fluid volume to be released into a discharge conduit without the abrasive.

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Accordingly the invention provides an abrasive fluid jet system comprising: a high-pressure fluid supply means supplying fluid to a vessel including a layer of abrasive slurry and a top layer comprising substantially of fluid over the layer of abrasive slurry; a first conduit leading from the fluid supply means to the top layer
20 of fluid in the vessel, which causes displacement of abrasive slurry from a discharge conduit as high-pressure fluid is fed into the vessel; a second conduit connected at different points to the first conduit and the discharge conduit including a fluid valve between the point of connection to the first conduit and the discharge conduit, which controls the fluid flow within the second conduit;
25 wherein the fluid valve is closed once the system is pressurised to displace abrasive slurry through the discharge conduit and the fluid valve is open upon de-pressurization of the system to allow fluid flow from the first conduit to the second conduit and to stop discharge of the abrasive slurry.

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It will be convenient to hereinafter describe the invention in greater detail by reference to the accompanying drawings which illustrate one embodiment of the

invention. The particularity of the drawings and the related description is not to be understood as superseding the generality of the broad identification of the invention as defined by the claims.

5 Brief description of the Drawings

Figure 1 is a diagram illustrating a first embodiment of the invention.

Figure 2 is a diagram illustrating a second embodiment of the invention.

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Detailed Description of the Preferred Embodiments of the Invention

Figure 1 is a diagram illustrating a first embodiment of the invention. The system includes a vessel 11 containing a fluid 4, such as water, mixed with abrasive in an abrasive slurry 2. There is a source of pressurised fluid 10 to feed fluid to the vessel 11 and a hopper 17 feeding abrasive slurry 2 to the vessel 11 through conduit 19. Feeding of fluid from the source 10 is through conduits 14 and 15. A fluid valve 13 controls the flow of fluid across conduit 21. When the pump system is activated, abrasive slurry 2 is drawn through conduit 16 to nozzle 12. A diaphragm pump 18 is used to draw fluid 4 from conduit 20, which creates a pressure in vessel 11 which in turn draws in abrasive slurry 4 from hopper 17 to vessel 11.

The conduit 21 between the top of the vessel 11 and the discharge conduit 16, connecting to the conduit 12 at a point outside the vessel 11 is closable. It is also connected to the top of the vessel 11 where there is no abrasive 2 present. Hence on depressurisation, when fluid valve 13 connecting this conduit 21 to the discharge conduit is opened, the compressed volume will have a preference to discharge through conduit 21, instead of through the discharge conduit 16 inlet inside the vessel 11, whose internal diameter, length and the resistance of the slurry bed 2 leads to a higher flow resistances.

On pressurisation, fluid valve 13 will be open. The fluid flow will travel into the vessel 11 through conduit 14. Nevertheless, once pressurised and with fluid valve 13 open, the top fluid flow will prefer to enter conduit 21 through fluid valve 13 outside the vessel instead of entering the vessel through conduit 14, effectively there will be no mass flow into the slurry pressure vessel 11 to cause a displacement of abrasive into the inlet of conduit 16.

Once pressurised, abrasive flow is initiated by closing valve 13. With valve 13 closed, the additional flow enters the vessel 11 through conduit 14, thus displacing abrasive into the inlet of conduit 16 where it mixes with the main flow from conduit 15 and is carried to the nozzle through conduit 16 and conduit 12. Abrasive flow is halted by opening valve 13.

On de-pressurisation, fluid valve 13 is left open to provide an alternative and preferred route through conduit 21 for the compressed water inside the vessel. As fluid valve 13 connects to the vessel at its apex, where the abrasive slurry is not present, the fluid valve 13 normally operates on clean water and with a minimal pressure differential hence its service life-time will be generally higher than would otherwise be the case. In addition the inner diameter of conduit 21 is sufficiently large to ensure that the velocity of the escaping fluid is well below the settling velocity of the abrasive slurry 2 used. In this way abrasive particles will further be prejudiced not to enter or travel along the conduit 14 or pass through the fluid valve 13.

Figure 2 illustrates a second embodiment of the invention where an additional conduit 22 and a second fluid valve 23 is interposed between conduit 15 and vessel 11 to provide fluid flow facilitating abrasive discharge from vessel 11 through conduit 16. Unlike the first embodiment shown in Figure 1, conduit 14 is not connected to conduit 15, and serves purely as a route of escape for the compressed volume in vessel 11 through conduit 21. This embodiment offers the

advantage that the second fluid valve 23 always operates on clean fluid, and the fluid valve 13 operates less frequently, ie. only at pressurisation and depressurisation stages. As a result, wear on valve 13 is decreased.

- 5 In the particular embodiment in Figure 2, with fluid valve 13 and second fluid valve 22 closed, the diaphragm pump 18 is used to withdraw fluid through conduit 20 from the vessel creating a vacuum to draw in abrasive slurry 2 from the hopper 17 through conduit 19.
- 10 It would be appreciated that the system avoids fluid compressibility leading to unwanted discharging of abrasives to the nozzle at system pressurising and depressurising stages. By providing an alternative route of less resistance 21 for the compressed fluid volume from within the vessel 11 from a point where abrasive is not present the depressurising water carries with it no abrasive to the
- 15 nozzle and so the invention helps prevent nozzle blockages.

The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall

20 within the spirit and scope of the above description.



CLAIMS

1. An abrasive fluid jet system comprising:

- 5 - a high-pressure fluid supply means supplying fluid to a vessel including a layer of abrasive slurry and a top layer comprising substantially of fluid over the layer of abrasive slurry;
- 10 - a first conduit leading from the fluid supply means to the top layer of fluid in the vessel, which causes displacement of abrasive slurry from a discharge conduit as high-pressure fluid is fed into the vessel;
- 15 - a second conduit operatively connected at different points to the fluid flow of the first conduit and the abrasive slurry from the discharge conduit, and including a fluid valve between the operative connection to the first conduit and the discharge conduit, which controls the fluid flow through the second conduit between the first conduit and the discharge conduit;

20 wherein the fluid valve is closed once the system is pressurised to displace abrasive slurry through the discharge conduit and the fluid valve is open upon de-pressurization of the system to allow fluid flow from the first conduit to the second conduit and to stop discharge of the abrasive slurry.

25 2. An abrasive fluid jet system according to claim 1, wherein upon starting the system, the fluid valve is open to allow water flow through the second conduit to pressurise the system and the fluid valve is closed for operation of the fluid jet system once the system is sufficiently pressurised.

3. An abrasive fluid jet according to claim 1 or 2, wherein the high-pressure fluid supply means also feeds fluid to the discharge conduit through a third



conduit to produce a mixture of fluid together with the abrasive slurry for ejection through an ejection means.

4. An abrasive fluid jet system according to any one of the preceding claims,
- 5 which includes a second fluid valve in the first conduit to control the flow of fluid from the high-pressure fluid supply means to the vessel.
5. An abrasive fluid jet system according to any one of the preceding claims,
- 10 which includes a hopper providing a supply of abrasive slurry to the vessel, and a pump for drawing fluid from the top layer of fluid in the vessel, wherein the resulting pressure caused by pumping fluid from the vessel draws abrasive slurry from the hopper into the vessel.