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(54) **Powder flow control valve.**

(57) A powder flow control valve (1) has a powder flow path surrounded by a frusto-conical perforated boundary surface (3). Means are provided for creating a drop in pressure across the boundary surface (3) with the higher pressure on the powder flow path side of the boundary surface.

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Powder Flow Control Valve

This invention relates to a powder flow control valve and to a method of controlling powder flow.

The term "powder" as used herein refers to materials made up of discrete particles. As will be clear from the description below the term includes a relatively fine powder such as flour and also a granular material such as granulated salt (5 mm maximum particle dimension) or agglomerated coffee powder (3 mm maximum particle dimension).

When a container is to be filled with a powder, it may be desirable to measure the weight of powder accurately. For example in the food industry it may be necessary to fill a container with a measured weight of powder such as coffee or milk powder. It is desirable that the measurement of the weight of powder should be as accurate as possible since a minimum quantity of powder must be provided in the container but once that minimum weight is reached any extra powder in the container is wasted.

Various problems have to be overcome in producing an accurate measurement of the powder but one problem is providing a valve that can operate reliably over a prolonged period and that is not too difficult to maintain and in particular clean. The valve may also have to be sterilisable.

According to the invention there is provided a powder flow control valve in which a powder flow path is surrounded by a perforated boundary surface and means are provided for creating a drop in pressure across the boundary surface with the higher pressure on the powder flow path side of the boundary surface.

When the pressure drop is created powder flowing through the valve is drawn towards the boundary surface and held there so that flow of powder through the valve is terminated. A major advantage of this design is that there need be no moving parts in the powder flow path resulting in a very simple design which is also easy to clean.

The means for creating a drop in pressure across the boundary surface preferably operates by reducing the pressure on the opposite side of the boundary surface to the powder flow path without reducing (or without reducing so much) the pressure along the powder flow path. Alternatively, but less desirably, it could operate by increasing the pressure along the powder flow path without increasing (or without increasing so much) the pressure on the opposite side of the boundary surface.

The cross-sectional area of the flow path surrounded by the perforated boundary surface preferably decreases in the downstream direction.

Preferably the boundary surface has rotational symmetry and preferably includes a substantially frusto-conical portion with the smaller diameter portion downstream of the large diameter portion. In use the portion of the powder flow path surrounded by the perforated boundary surface is advantageously substantially vertical.

The precise dimensions and shape of the boundary surface may be chosen by experiment and different dimensions and shapes may be used for different powders. In this way the valve may be used to control the flow of a wide variety of powders including, for example, flour, powdered milk, agglomerated coffee powder and granulated salt.

The perforated boundary surface may be made of a porous material, for example sintered metal powder, glass or a plastics material, or may be made by a component with apertures formed therein at a multiplicity of predetermined locations. In the latter case the locations are preferably evenly distributed around the boundary surface.

In addition to providing means for creating a pressure drop across the boundary surface with the higher pressure on the powder flow path side of the boundary surface means may be provided for creating a pressure rise across the boundary surface with the lower pressure on the powder flow path side of the boundary surface. When the pressure rise is created powder flowing through the valve is inhibited from adhering to the boundary surface or forming a stable arch. This technique of preventing powder sticking to a surface is already known per se but its use in a valve according to the invention is original.

According to another aspect of the invention there is provided a method of controlling the flow of a powder in which a portion of the path along which powder flows is surrounded by a perforated boundary surface and powder flow is stopped by creating a drop in pressure across the boundary surface with the higher pressure on the powder flow path side of the boundary surface.

By way of example a powder flow control valve embodying the invention will be described with reference to the accompanying drawing which is a side sectional view of the valve.

The control valve 1 is sited at the bottom of a shaft 2 of circular cross-section and includes a frusto-conical part 3 made of porous plastics material which in this particular example is that sold by Porvair Ltd. under the trademark VYON. Immediately below the frusto-conical part 3 is a cylindrical part 4 leading to an outlet 5 of the valve. A plenum chamber 6 is defined between the outside of the frusto-conical part 3 and the walls of the shaft 2. The plenum chamber 6 is connected to a pumping system when can be arranged to suck air out of, or force air into, the chamber 6. The pumping system comprises a duct 11 which is connected, on the one hand, via a duct 7 and a valve 8 to a reservoir 9 of low pressure air maintained at low pressure by a pump 10 and, on the other hand, via a duct 12 and a valve 13 to a compressed air cylinder 14.

In use, powder is supplied to the top of the shaft 2 and falls down the shaft. When the valve 8 is open and the valve 13 closed, air is sucked out of the plenum chamber 6 and into the reservoir 9. Consequently, air is caused to flow from the shaft through the frusto-conical part 3 into the chamber 6 and this causes powder to adhere to the surface of the part 3 and no powder reaches the outlet 5; this situation corresponds to the "closed" state of the valve. If, on the other hand, the valve 8 is closed and the valve 13 opened then air is blown into the plenum chamber 6 from the cylinder 14, the air flow through the part 3 is reversed and powder is prevented from sticking to the part 3 and falls through the outlet 5; this situation corresponds to the "open" state of the valve.

The valve 1 can therefore be used very effectively to control powder flow.

One particular example of a valve and powder that have been used successfully together will now be described. In this example the shaft 2 had an internal diameter d of 60 mm, the frusto-conical part 3 had a height h of 42 mm and a minimum internal diameter d_2 of 15 mm. The inclination α of the frusto-conical boundary surface to the horizontal was 60°. The powder used was agglomerated coffee which when subjected to a sieve analysis gave the results shown in the table below:

TABLE

Sieve Size (μm)	Cumulative Weight Undersized (%)
2800	97
2400	91.2
2000	79.3
1680	73.8
1400	66.8
1200	61
1000	53.1
850	46.1
500	22.8

The porous material defining the boundary surface had a mean pore size of 70 microns and a thickness of 4.75 mm. The thickness is not however believed to be particularly significant. The porous material allowed a flow of air of 3.5 $cm^3/m^2/min$ at a pressure of 3 kN/m^2.

In the "closed" state of the valve, the pressure in the plenum chamber 6 was 15" Hg (about 51 kN/m^2) below atmospheric pressure and there was an air flow rate of 48 litres per minute (at atmospheric pressure). In the "open" state of the valve, the pressure in the plenum chamber was 6 psi (about 41 kN/m^2) above atmospheric pressure and there was an air flow rate of 47 litres per minute (at atmospheric pressure).

The same valve was also tested with powdered milk and proved entirely satisfactory. Nonetheless it should be understood that the dimensions of the valve may need to be altered for different powders and in particular the dimensions d_2 may need to be varied. It is also possible to omit the cylindrical part 4 at the outlet of the valve without affecting the operation of the valve.

Tests have also been performed on powdered coffee, freeze dried coffee, household salt, granulated salt, coffee creamer, talc and flour and the valve of the invention has proved able to handle all these materials.

While in the described embodiments of the valve, the boundary surface is frusto-conical, other shapes of boundary surface could be employed. For example a surface of inverted pyramid shape could be used, or even a cylindrical shape.

Although the valve has been described almost exclusively in relation to controlling the flow of food powders it will be understood that applications of the valve may also be found outside the food industry.

Claims

1. A powder flow control valve in which a powder flow path is surrounded by a perforated boundary surface and means are provided for creating a drop in pressure across the boundary surface with the higher pressure on the powder flow path side of the boundary surface.

2. A valve as claimed in claim 1 in which the means for creating a drop in pressure across the boundary surface operates by reducing the pressure on the opposite side of the boundary surface to the powder flow path without reducing, or without reducing so much, the pressure along the powder flow path.

3. A valve as claimed in claim 1 or 2 in which the cross-sectional area of the flow path surrounded by the perforated boundary surface decreases in the downstream direction.

4. A valve as claimed in any preceding claim in which the boundary surface has rotational symmetry.

5. A valve as claimed in claim 4 in which the boundary surface includes a substantially frusto-conical portion with the smaller diameter portion downstream of the larger diameter portion.

6. A valve as claimed in any preceding claim in which the portion of the powder flow path surrounded by the perforated boundary surface is substantially vertical.

7. A valve as claimed in any preceding claim in which the perforated boundary surface is made of a porous material.

8. A valve as claimed in any of claims 1 to 6 in which the perforated boundary surface is provided by a component with apertures formed therein at a multiplicity of predetermined locations.

9. A valve as claimed in claim 8 in which the locations are evenly distributed around the boundary surface.

10. A valve as claimed in any preceding claim further including means for creating a pressure rise across the boundary surface with the lower pressure on the powder flow path side of the boundary surface.

11. A method of controlling the flow of a powder in which a portion of the path along which powder flows is surrounded by a perforated boundary surface and powder flow is stopped by creating a drop in pressure across the boundary surface with the higher pressure on the powder flow path side of the boundary surface.

12. A method as claimed in claim 11 in which the drop in pressure is created by reducing the pressure on the opposite side of the boundary surface to the powder flow path without reducing, or without reducing so much, the pressure along the powder flow path.

13. A method as claimed in claim 11 or 12 in which the cross-sectional area of the flow path surrounded by the perforated boundary surface decreases in the downstream direction.

14. A method as claimed in any of claims 11 to 13 in which the boundary surface has rotational symmetry.

15. A method as claimed in claim 14 in which the boundary surface includes a substantially frusto-conical portion with the smaller diameter portion downstream of the larger diameter portion.

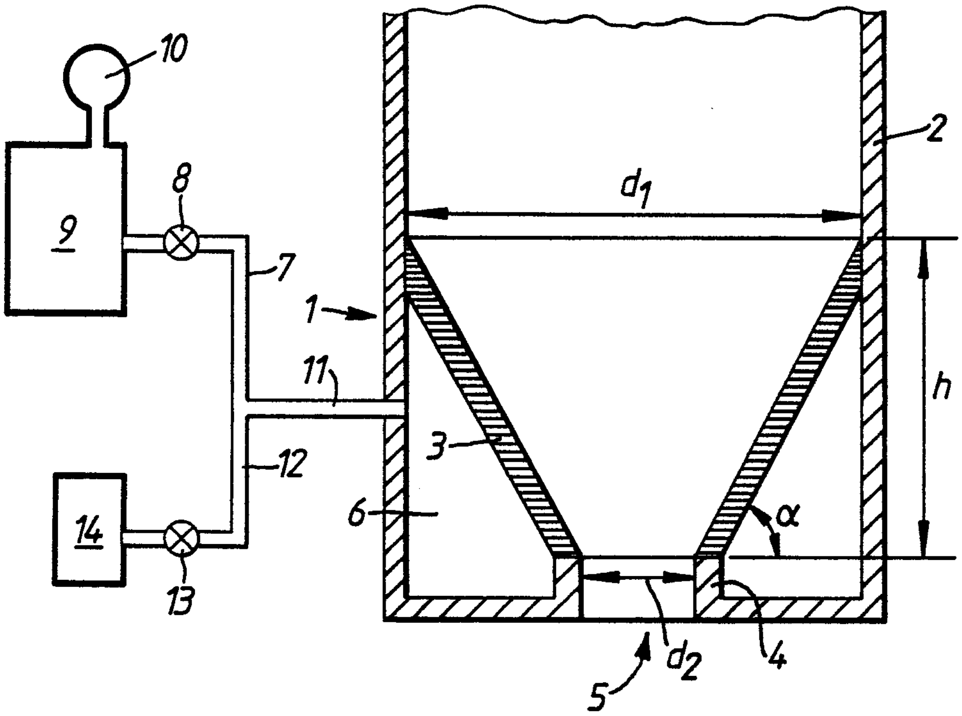
16. A method as claimed in claim 14 or 15 in which the portion of the powder flow path surrounded by the perforated boundary surface is substantially vertical.

17. A method as claimed in any of claims 11 to 16 in which the perforated boundary surface is made of a porous material.

18. A method as claimed in any of claims 11 to 17 in which the perforated boundary surface is provided by a component with apertures formed therein at a multiplicity of predetermined locations.

19. A method as claimed in claim 18 in which the locations are evenly distributed around the boundary surface.

20. A method as claimed in any of claims 11 to 19 further including the step of creating a pressure rise across the boundary surface with the lower pressure on the powder flow path side of the boundary surface.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EUROPEAN SEARCH REPORT

Application number

EP 85 30 8409

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	US-A-3 305 276 (K. WEBER) * Whole document * ---	1-20	B 65 D 88/72 B 65 G 53/22
Y	GB-A- 422 699 (W. WARRENTRIGGS) * Figure 1; page 1, line 17 - page 2, line 106 * ---	1-20	
A	EP-A-0 125 585 (P. ROSENSTRÖM) * Figure 1; abstract * ---	1,11	
A	US-A-4 067 623 (H. KLEIN) * Figures 1,2; column 2, line 51 - column 4, line 35 * ---	3-6,8,9,13-16,18,19	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
E	GB-A-2 158 813 (Ph.J. LLOYD) * Whole document * -----	1-20	B 65 D B 65 G B 65 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24-07-1986	WERNER D.M.

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