

POWDER DISPENSERS AND METHODS OF DISPENSING POWDER

Technical Field of the Invention

The present invention relates to powder dispensers and powder filling machines, particularly to methods and devices for metering the flow of powders from such dispensers or machines and to methods of filing flexible containers with free-flowing powders using such devices. The invention further relates to spinning discs comprising openings or perforations for metering powder from powder dispensers and powder filling machines.

Background to the Invention

Powder dispensing machines, powder dispensers and powder filling machines are well known. Powder dispensers and powder dispensing machines are analogous whereas powder filling machines typically include a further component to form or handle the container that is to be filled. All three devices are used to dispense measured amounts of powder; typically to fill a container or package. The container or package can be of almost any design, including rigid containers, bottles, cartons or flexible film packages such as stick packs.

Stick packs are a common packaging format for many powders. They are also well-known in the art as generally 'stick' or tube-shaped containers formed of any suitable sheet material such as paper, plastic, metal, laminates, etc. In powder applications, stick packs are typically formed from sheet material at the point of filling to simplify handling and processing. An example of a prior art powder filling machine designed to be used to form and fill a stick pack is a model TM70-ZC machine, manufactured by Toyo Machine Manufacturing Co. The model TM70-ZC generally comprises a powder hopper and associated auger to move the powder down a tube from the hopper. At the bottom of the tube is a perforated disc (also known as a "spinning disc" or "rotating disc" or "disc shaped distributor") closing the tube. The disc is attached to the end of the auger and is intended to allow powder to pass through its perforations when rotating and to arrest the flow of powder completely when not being rotated by the auger. Spinning discs of the prior art function adequately with many powders and have remained substantially the same for many years.

Powders can be defined by their ability to flow when poured from a container. An analytical measure of such a property is defined by the Hausner's ratio. Hausner's ratio is calculated as the ratio of bulk density to the packed density of a powder. Hausner's ratio is calculated as follows:

- 1- A known mass of test powder is poured through a funnel into a measuring cylinder and the volume the powder occupies is read off.
- 2- From calculation of the mass of the test powder divided by volume, the bulk density is recorded.
- 5 3- The cylinder is then tapped 150 times to pack the test powder and a new volume occupied by the test powder is read off.
- 4- From calculation of the mass of the test powder divided by this new volume, the packed density is recorded.
- 10 5- The Hausner's ratio is then calculated as the ratio of the tapped density divided by the bulk density.

Table 1 shows a classification of powder flow character based on the Hausner's ratio.

Flow character	Hausner's ratio
Excellent/very free-flowing	1.00-1.11
Good/free-flowing	1.12-1.18
Fair	1.19-1.25
Passable	1.26-1.34
Poor/cohesive	1.35-1.45
Very poor/very cohesive	1.46-1.59
Very, very poor/approx. no flow	>1.60

Table 1: Hausner's ratio and flow character of powders

15 Fine control of the flow of powders in stick pack filling machines is particularly desirable as any powder flow present when the stick pack is being sealed downstream of the dispensing tube, results in a weakened or failed seal as excess powder inhibits the adhesion of the layers of flexible material to one another.

20 Spinning discs of the prior art are known to fail to arrest the flow of some free-flowing and very free-flowing powders, that is powders with a Hausner's ratio of <1.18, or up to 1.25.

It would be advantageous to provide a powder filling machine and/or spinning disc that improves the cessation of flow of free-flowing powders in order to allow a packaging seal to be
25 created in a stick pack sufficient to stop the package reopening during the supply chain.

It would be advantageous to provide a powder filling machine and/or a spinning disc that would work in conjunction more free-flowing powders; further it would be advantageous to provide a powder filling machine and/or a spinning disc that arrests the flow of very free-flowing and/or free flowing powders, i.e. powders with a Hausner's ratio of 1.00-1.11 and/or 1.12-1.18 and/or 1.19-1.25.

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It would be advantageous to provide a powder filling machine and/or a spinning disc that arrests the flow of very free-flowing and/or free flowing powders, i.e. powders with a Hausner's ratio of 1.00-1.11 and/or 1.12-1.18 and/or 1.19-1.25, when stationary, yet permits the free-flow of powder when spinning, particularly over significant durations such as required in a 24-hour production run.

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Embodiments of powder dispensers of the prior art with alternate powder metering methods are: powder metering by choke valve, powder metering by shutter gate, powder metering by spinner plate. Each presents unique disadvantages when used in conjunction with a stick-pack packaging format.

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A powder dispenser metered by a choke valve generally comprises a powder hopper and associated auger to move the powder down a tube from the hopper. Beyond the end of the auger but within the tube is a choke valve pivoting about an axis lateral to the length of the tube. With the choke valve open and auger turning, powder can be metered from the tube. With the choke valve closed and auger stopped, the powder flow is arrested. The problems presented by this are complexity in driving and programming the choke valve and auger separately or very complicated gearing within the tube; a static barrier to powder flow even with the choke valve in the open position and additional mechanism and/or width to the tube that inhibits the ease of flow of packaging film material along the outside of the tube, thus preventing or inhibiting the downstream formation of a stick pack package.

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A powder dispenser metered by a shutter gate works in a largely similar way to that comprising a choke valve, differing only in that the choke valve is replaced by a shutter gate (or gates) that slides laterally to the direction of the length of the tube and can be in a closed or open position. The problems presented by this are similar to those of a choke valve i.e. added complexity in driving and programming the shutter gate and auger separately and added width and mechanism beyond the width of the tube inhibiting or preventing the flow of flexible packaging material down the outside of the tube in order to create a stick pack package downstream of the dispensing tube.

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A powder dispenser metered by a spinner plate is similar to that of a powder dispenser comprising a spinning disc. It differs in that the spinner plate does not comprise perforations and is positioned in a bell-shaped housing pendant to the bottom of the powder dispensing tube. The spinner plate is driven by the auger and operates by allowing powder flow when spinning yet arrests flow when stationary. Powder builds up on the spinner plate when stationary to form a column of powder up the powder dispensing tube. When spinning the powder is moved, by the rotation of the plate, outward and into the bell-shaped housing where it is directed downwards and dispensed. The problems presented by this are additional length of the powder dispensing tube incorporating the bell-shaped housing and a large increase in overall diameter of the powder dispensing tube at the bell-shaped housing such that a flexible packaging material guided down the outside of the tube to form a stick pack downstream would have an excessively large diameter.

It would therefore also be advantageous to provide a powder filling machine to be used in conjunction with a stick pack package that reliably allowed and arrested the flow of free-flowing and very-free flowing powders without inhibition to the downstream packaging in a stick pack format and/or widening of the diameter of the stick pack.

It would furthermore be advantageous to provide a spinning disc with physical dimensions to arrest the flow of free-flowing and very free-flowing powders that could be retrofitted to existing stick pack powder filling machines.

It is therefore an aim of embodiments of the invention to mitigate or reduce a disadvantage presented by the prior art.

Summary of the Invention

According to a first aspect of the invention there is provided a powder dispenser comprising a tube of circular cross-section; an auger extending axially through the tube; and a disc-shaped distributor extending laterally to the axis of the tube and partially closing the tube, wherein the disc-shaped distributor comprises a central ring and arms extending radially therefrom, characterised in that, the central ring has a radius of between 55% - 90% of the internal radius of the tube; at least one of the arms extends to no more than 1mm from the internal wall of the tube; and wherein there is a distance defined by a circular arc, concentric with the tube, between each arm at a distance of 1mm from the tube wall of between 30%-65% of the internal radius of the tube.

In some embodiments, the powder dispenser is a beverage powder dispenser.

In some embodiments, the circular arc distance between each arm of the disc-shaped distributor at a distance of 1mm from the tube wall is between 35% and 65%; 30% and 60%; or 40% and 60% of the internal radius of the tube. The inventors have found that within the 30%-65% range, the disc-shaped distributor works well for some time without blockage or powder build up, and that within the range 35% - 65% the disc-shaped distributor works indefinitely without significant powder build up.

In some embodiments, the circular arc distance, concentric with the tube, between each arm of the disc-shaped distributor at a distance of 1mm from the tube wall is between 2mm and 7.5mm or between 3mm and 7mm.

Disc-shaped distributors with such distances between arms have the particular advantages of an excellent balance of good flow of powder when in rotation and good cessation of powder flow when not in rotation; and ease of manufacture.

In some embodiments, the radius of the central ring of the disc-shaped distributor is between 55% and 85%; or 60% and 85% of the internal radius of the tube. In some embodiments, the internal radius of the tube is between 10mm and 14mm and the radius of the central ring of the disc-shaped distributor is between 7mm and 9mm; preferably the internal radius of the tube is between 11mm and 13mm and the radius of the central ring of the disc shaped distributor is between 7.5mm and 8.5mm.

In other embodiments, the internal radius of the tube is between 7mm and 9mm and the radius of the central ring of the disc-shaped distributor is between 5mm and 7mm; preferably the internal radius of the tube is between 7.5mm and 8.5mm and the radius of the central ring of the disc shaped distributor is between 5.5mm and 7mm.

Disc-shaped distributors with a central ring and tube with such dimensions have the particular advantages of an excellent balance of good flow of powder when in rotation and good cessation of powder flow when stationary by facilitating powder build up on the disc-shaped distributor when not in rotation; and economic use of materials.

In some embodiments, the disc-shaped distributor comprises between 4 and 12 arms and preferably between 6 and 10 arms.

In embodiments where the internal radius of the tube is between 10mm - 14mm or 11mm - 13mm, the width, along the plane of cross-section of the tube, of each arm of the disc-shaped distributor is preferably between 1.5 mm - 2.5mm. In embodiments where the internal radius of the tube is between 7mm – 9mm or 7.5mm – 8.5mm the width, along the plane of cross-section of the tube, of each arms of the disc-shaped distributor is preferably between 1mm – 2mm.

Disc-shaped distributors with this number of arms have the particular advantages of an even powder flow when in rotation; good upstream powder bridging between arms when not in rotation; and ease of manufacture. In particular, arms with the stated width dimensions have the additional particular advantage of improved surface area and rigidity in use.

In some embodiments, the central ring of the disc shaped distributor extends up to 4mm from the plane of the disc-shaped distributor, preferably the central ring of the disc-shaped distributor extends up to 3mm, 2mm or 1mm from the plane of the disc shaped distributor. In some embodiments, the central ring extends from the plane of the disc-shaped distributor by these amounts on one or on both sides. In such embodiment the central ring has a greater depth than the arms, in the longitudinal direction of the tube.

Such embodiments have the particular advantages of ease of manufacture and identification and straightforward addition of a central ring to adapt an existing disc-shaped distributor not of the invention to one of the invention. Embodiments where the central ring extends from both sides of the disc-shaped distributor have the particular advantage of the disc-shaped distributor being reversible and eliminating the risk of insertion in the unintended orientation.

In some embodiments, the central ring of the disc-shaped distributor further comprises at least one aperture, each with a maximum width, in a direction along the radius of the tube, of no more than 30%; 26%; 24% or preferably no more than 22% of the radius of the tube.

In some embodiments, the central ring of the disc-shaped distributor further comprises at least one aperture, each with a maximum width, in a direction along the radius of the tube, of no more than 2.5mm.

Preferably the apertures are in the form of slots or radial slots; more preferably the slots are concentric to the perimeter of the ring; most preferably the slots are also equally spaced.

A central ring with such apertures has the particular advantages of less build-up of powder in the tube of the powder dispenser over time and reduction in pressure within the tube when the disc-shape distributor and/or auger are in rotation.

5 In some embodiments, the area of all apertures in the central ring is no more than 15%, preferably no more than 12%, most preferably no more than 10% of the cross-sectional area of the tube.

 A central ring with apertures with such limited overall size has the particular advantage of preventing excessive build-up of powder in the tube of the powder distributor over time whilst
10 maintaining the powder stopping properties of the disc-shaped distributor when not in rotation.

 In some embodiments, the disc-shaped distributor is within 50mm, 40mm, 30mm, 20mm or preferably within 10mm of the end of the tube.

15 Such positions of the disc-shaped distributor have the particular advantage of preventing blockage of the tube after the disc-shaped distributor and greater flexibility in downstream operations.

 In some embodiments, the outer diameter of the tube is between 25mm and 60mm;
20 preferably between 30mm and 50mm.

 Such outer diameters have the additional advantage of easy and reliable use with stick packs of dimensions acceptable to consumers, good packaging efficiency and good packaging fill times.

25 In some embodiments, the auger and disc-shaped distributor are operably connected, preferably the disc-shaped distributor and auger are operably connected and separable. In preferred embodiments the disc-shaped distributor is connected at the end of the auger, but in other embodiments may be connected part-way along the auger, within the tube.

30 In some embodiments, the disc-shaped distributor is driven by the rotation of the auger.

 Such embodiments have the particular advantage of simplicity in operation and manufacture; and only requiring a single drive motor.

In some embodiments, the powder dispenser further comprises a powder with Hausner's ratio of between 1.00 – 1.25.

5 Powder dispensers with such powders have the particular advantages of excellent powder flow properties; reduced blockages and/or build up of powder in the tube of the powder dispenser.

In some embodiments, the powder is a beverage powder.

10 According to a second aspect of the invention there is provided a method of dispensing powder comprising:

- a- providing a powder dispenser of the first aspect of the invention;
- b- adding a powder;
- c- rotating the auger and/or disc-shaped distributor to convey the powder through and out of the tube;
- 15 d- collecting the powder in a container.

In some embodiments the powder is a consumable powder, preferably a beverage powder, especially a powder comprising milk, coffee, tea, creamer, sugar and/or n artificial sweetener.

20 In some embodiments, the powder has a Hausner's ratio of between 1.00 and 1.25, 1.00 and 1.22, 1.00 and 1.20 or, preferably, between 1.05 and 1.18.

25 Methods using the powder dispenser of the first aspect of the invention and comprising such powders have the particular advantages of excellent powder flow properties; reduced blockages and/or build-up of powder in the tube of the powder dispenser.

In some embodiments the container has a diameter of between 25mm and 55mm, preferably between 30mm and 50mm, most preferably between 35mm and 45mm.

30 In some embodiments, between 10g and 50g, preferably between 15g and 40g and most preferably between 15g and 30g of powder is added to the container.

Such fill weights have the particular advantage of excellent dosing for end consumer use.

35 In some embodiments, powder is collected by a plurality of containers in sequence.

In some embodiments the or each container comprises a flexible film.

In some embodiments the or each container is formed at the point of powder collection.

5 According to a third aspect of the invention, there is provided a powder filling machine comprising the powder dispenser of a first aspect of the invention and a packaging apparatus.

In some embodiments the packaging apparatus is a flexible film packaging apparatus, preferably a stick pack packaging apparatus.

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Detailed Description of the Invention

In order that the invention may be more clearly understood embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings, of which:

- 15 Figure 1 is a schematic cross-section of a powder filling machine (1) of the prior art.
- Figure 2 is a top down view of a spinning disc (14) of the prior art used in conjunction with the powder filling machine (1) of Figure 1.
- Figures 3a-j are perspective views of numerous different failing designs of spinning discs (14) used in conjunction with the powder filling machine (1) of Figure 1 and not falling
- 20 within the scope of the spinning discs used in the claimed invention.
- Figures 4a-c Figure 4a is a perspective view of a first embodiment of a spinning disc used in conjunction with the powder filling machine (1) of Figure 1, and which together form a powder dispenser of the invention. Figure 4b is a plan view and Figure 4c is a side-view of the same spinning disc.
- 25 Figures 5a-c Figure 5a is a perspective view of a second embodiment of a spinning disc used in conjunction with the powder filling machine (1) of Figure 1, and which together form a powder dispenser of the invention. Figure 5b is a plan view and Figure 5c is a side-view of the same spinning disc of the invention.
- Figures 6a-c Figure 6a is a perspective view of a third embodiment of a spinning disc used in
- 30 conjunction with the powder filling machine (1) of Figure 1, and which together form a powder dispenser of the invention. Figure 6b is a plan view and Figure 6c is a side-view of the same spinning disc of the invention.
- Figure 7 is a perspective view of an alternative embodiment of the spinning disc of Figure 6 used in conjunction with the powder filling machine (1) of Figure 1, and which
- 35 together form a powder dispenser of the invention.

Figure 8 is a perspective view of another alternative embodiment of the spinning disc of Figure 6 used in conjunction with the powder filling machine (1) of Figure 1, and which together form a powder dispenser of the invention.

5 Figure 1, shows a powder filling machine (1) of the prior art comprising a hopper (10); a vertical auger (12) extending through and out of the hopper and into a tube (13) connected to the downstream end of the hopper; a means of rotating the auger, in the form of a motor (not shown); a powder dispersion means, in the form of a spinning disc (14); a packaging material, in the form of flow wrap (16); and a packaging sealing means (18). The auger (12) extends from a motor (not
10 shown) into the hopper (10) and down into the tube (13). The spinning disc (14) is attached to the end of the auger (12) within the tube (13) partially closing the tube (13) close to its end. The spinning disc (14) has an overall diameter sufficiently less than the internal diameter of the tube (13) in order to allow it to rotate freely within the tube (13) whilst preventing powder flow between the outer edge of the disc and the tube wall. The flow wrap (16) rests along the outside surface of the
15 tube (13) and the packaging sealing means (18) is beyond the end of the tube (13).

In use, the hopper (10) is loaded with powder to be dispensed from the tube (13). The spinning disc (14) and auger (12) are rotated together by the motor (not shown). The auger (12) drives the powder through the tube (13) and the spinning disc (14) disperses and dispenses the
20 powder from the end of the tube (13) into the flow wrap (16). When not being rotated, the auger (12) no longer drives powder through the tube (13) and the spinning disc (14), no longer rotating, has shape and size configured to arrest the flow of powder from the tube (13) and prevent any “dribbling” of powder from the tube (13) in this stationary state. The duration of the period of rotation of the auger (12) and spinning disc (14) determine how much powder is dispensed into the
25 flow wrap (16). Upon cessation of the rotation of the auger (12) and spinning disc (14), the sealing means (18) seals the flow wrap providing a top seal on the filled package and a bottom seal for the next package. Prevention of “dribbling” is important to produce a good seal between faces of the flow wrap (16) and correct packaging fill volume.

30 With reference to Figure 2, where like numbers represent like components compared to Figure 1, the spinning disc of the prior art (14) has an overall diameter of 24mm and comprises a central ring (22) with radius 5.5mm; 8 arms (24) and a central attachment means, in the form of a hole (26) with radius 4.05mm. The 8 arms (24) extend from and are evenly spaced about the circumference of the ring (22); each arm (24) has a width of 2mm. The largest diameter of the

spinning disc (14) is 24mm and it is designed to be used at the end of the tube (13) of the powder filling machine (1) of Figure 1.

The spinning disc of Figure 2 when used in conjunction with the powder filling machine (1) of 1, with an industry standard tube (13) having an external diameter of 45 mm and an internal diameter of 25mm (radius 12.5 mm), is not of the invention, as the central ring (22) has a radius of 44% of the radius of the tube (13) and the circular arc distance, concentric with the tube, between each arm of the disc-shaped distributor at a distance of 1mm from the tube wall is 7.42mm, 59.4% of the internal radius of the tube (13).

It will be understood that when describing the spinning discs various dimensions are relied upon. With reference to the spinning disc (14) of Figure 2, when describing the radius of the ring of a spinning disc (22) the radius is measured from the theoretical centre of the disc to the outer edge of the ring. When describing the radius of a disc (14), measurement is taken from the theoretical centre of the disc to the outer tip of the point on the disc that is furthest from the centre, in most embodiments of the invention, this point is the tip of one of the arms (24). A diameter is therefore calculated as a radius multiplied by 2.

With reference to Figures 3a-3h: Figure 3a is of a spinning disc comprising a central attachment hole with radius 4.05mm; a central ring with radius 5.5mm and 12 arms; Figure 3b is of a spinning disc comprising a central attachment hole with radius 4.05mm; a central ring with radius 5.5mm and 14 arms; Figure 3c is of a spinning disc comprising a central attachment hole with radius 4.05mm; a central ring with radius 5.5mm and 5 1.5mm wide radial slots; Figure 3d is of a spinning disc comprising a central attachment hole with radius 4.05mm; a central ring with radius 5.5mm and 2.5mm wide radial slots; Figure 3e is of a spinning disc comprising a central attachment hole with radius 4.05mm and 12 1.5mm wide radial slots; Figure 3f is of a spinning disc comprising a central attachment hole with radius 4.05mm and 11 radial slots; Figure 3g is of a spinning disc comprising a central attachment hole with radius 4.05mm and 8 5mm diameter holes; Figure 3h is of and a spinning disc comprising a central attachment hole with radius 4.05mm; an array of 2.5mm diameter holes and an undulating perimeter. Each of the spinning discs of Figures 3a-3h have a largest diameter of 24mm and are designed to be used at the end of the tube (13) of the powder filling machine (1) of Figure 1.

None of the spinning discs of Figures 3a-3h when used in conjunction with the powder filling machine (1) of Figure 1, with tube (13) internal diameter of 25mm, are of the invention. With

reference to Figure 3a, the central ring has a radius of 44% of the radius of the tube (13) and the circular arc distance, concentric with the tube, between each arm of the disc-shaped distributor at a distance of 1mm from the tube wall is 4.28mm, 34.3% of the radius of the tube (13). With reference to Figure 3b, the central ring has a radius of 44% of the radius of the tube (13) and the circular arc distance, concentric with the tube, between each arm of the disc-shaped distributor at a distance of 1mm from the tube wall is 3.39mm, 27.1% of the radius of the tube (13). With reference to Figures 3c; 3d; 3e; 3f and 3g, the central ring has a radius of 44% of the internal radius of the tube (13) and there are no arms or arm gaps. With reference to Figure 3h there is no central ring, nor arms or arm gap.

Figures 4a-4c show a first embodiment of a spinning disc used in conjunction with the powder filling machine (1) of Figure 1 to form a powder dispenser of the invention, with tube (13) internal diameter 25mm (radius 12.5 mm), the spinning disc has height 2mm (i.e. height in the longitudinal direction of the tube (13)); a central attachment hole with radius 4.05mm; a central ring with radius of 8mm, 64% of the radius of the tube (13); ten arms extending from the central ring to a distance of 12mm from the centre of the disc, with circular arc distance of 5.5mm, 44.3% of the internal radius of the tube (13) at 1mm from the tube wall.

Figures 5a-5c show a second embodiment of a spinning disc used in conjunction with the powder filling machine (1) of Figure 1 to form a powder dispenser of the invention, with tube (13) internal diameter of 25mm, is similar to that of Figures 4a-4c and differs only in that the central ring extends in height (longitudinal direction of the tube) 1mm from the plane of the arms (i.e. is thicker in the longitudinal direction of the tube (13)). Without wishing to be bound by theory, the inventors believe that if the central ring extends significantly more than 1mm, such as for example 4mm or more, from the plane of the arms a narrow channel and flow restriction is created between the side of the central ring and the tube wall increasing the likelihood and/or incidence of powder blockage of the tube over time.

The spinning disc of Figure 5a-5c may be used in the powder filling machine (1) in either of the two possible orientations (central ring extending towards the hopper (10) or away from it). An embodiment of the invention, not shown, exists where the central ring extends by 1mm from both sides of the disc. This embodiment has the particular advantage of being able to be used either way up to reduce the risk of installation error.

Figures 6a-6c show a third embodiment of a spinning disc used in conjunction with the powder filling machine (1) of Figure 1 to form a powder dispenser of the invention, with tube (13) internal diameter of 25mm, the spinning disc has height 2mm; a central attachment hole with radius 4.05mm; a central ring with radius 8mm, 64% of the radius of the tube (13); the central ring comprises five 2.5mm wide (20% of the internal radius of the tube) radial slots and ten 2mm wide arms, extending from the central ring to a distance of 12mm from the centre of the disc, with circular arc distance of 5.5mm, 44.3% of the internal radius of the tube (13) at 1mm from the tube wall. The five radial slots occupy a total area of 44.2mm², 9% of the cross-sectional area of the tube (13).

Figure 7 shows a fourth embodiment of a spinning disc used in conjunction with the powder filling machine (1) of Figure 1 to form a powder dispenser of the invention, with tube (13) internal diameter of 25mm, the spinning disc is similar to that of Figures 6a-6c and differs only in that it comprises 12 arms with circular arc distance, concentric with the tube, between each arm of the disc-shaped distributor at a distance of 1mm from the tube wall of 4.3mm, 34.3% of the internal radius of the tube.

Figure 8 shows a fifth embodiment of a spinning disc used in conjunction with the powder filling machine (1) of Figure 1 to form a powder dispenser of the invention, with tube (13) internal diameter of 25mm, the spinning disc of the invention is similar to that of Figure 6a-6c and differs only in that the central ring comprises five 1.5mm wide (12% of the internal radius of the tube) radial slots. The five radial slots occupy a total area of 20.67mm², 4.2% of the cross-sectional area of the tube (13).

Example 1 – First test powder

A model TM70-ZC, manufactured by Toyo Machine Manufacturing Co. Ltd Powder filling machine (1) with the layout of Figure 1, with a tube (13) with outside diameter of 45mm and an internal diameter of 25mm was provided and the hopper (10) filled with a First test powder.

The First test powder was a spray dried powder comprising: 37% sugar, 19% skimmed milk powder, 37% creamer, 0.5% xanthan gum, 1% flavour and 5.5% soluble coffee, having Hausner's ratio 1.08, a 'very free-flowing powder' by the classification of Table 1, and x50 particle size distribution 197 microns.

A composite flow wrap packaging material was fitted around the tube (13) of the powder filling machine of Figure 1 in order to produce a stick pack package of 45mm diameter and 180mm length.

5 The Powder filling machine was set to run at a rate of 37 stick packs per minute with a powder fill weight of 21.5g.

The auger was set to rotate at a rate of 35-42 rotation per minute.

10 Each of the different designs of spinning discs (14) of Figures 2-3 (not falling within the scope of the claimed invention) and Figures 5 - 8 (falling within the claimed scope of the invention) were attached to the end of the auger (12) by the central attachment hole (26); the powder filling machine was run for 6 hours for each different disc, whilst 1. The extent of blockage of the tube (13) by the First test powder, during operation, and 2. The extent of test powder leakage through the
15 spinning disc (14), when rotation was stopped, were both measured. The results are recorded in Table 2.

Spinning disc ID	1. Extent of tube blockage	2. Extent of powder leakage past disc when not rotating
Figure 2	Not blocked after 6 hours	Powder flow not arrested
Figure 2: variant with 10 arms	Not blocked after 6 hours	Powder flow not arrested
Figure 3a	Blocked before completion of trial	No powder leakage
Figure 3b	Blocked before completion of trial	No powder leakage
Figure 3c	Blocked rapidly	No powder leakage
Figure 3d	Blocked rapidly	No powder leakage
Figure 3e	Blocked rapidly	No powder leakage
Figure 3f	Blocked rapidly	No powder leakage
Figure 3g	Blocked rapidly	Powder flow not arrested
Figure 3h	Blocked before completion of trial	Powder flow not arrested
Figure 4a-c (of the	Not blocked after 6 hours	No powder leakage

invention)		
Figure 5a-c (of the invention)	Not blocked after 6 hours	No powder leakage
Figure 6a-c (of the invention)	Not blocked after 6 hours	No powder leakage
Figure 7 (of the invention)	Not blocked after 6 hours, some signs of powder build up on the disc	No powder leakage
Figure 8 (of the invention)	Not blocked after 6 hours, some signs of powder build up on the disc	No powder leakage

Table 2: Results of trials with numerous different spinning disc designs and a First test powder.

The spinning disc of Figure 2 and a variant of the spinning disc of Figure 2 with 10 arms evenly spaced around the circumference of the disc did not prevent powder flow from the tube (13) when rotation was stopped. Without wishing to be bound by theory, the inventors believe that these discs lacked sufficient body towards the centre of the tube to provide a surface for the powder to stack upon when not in rotation, such that even when a variant with 10 arms was substituted, powder flow was not prevented. The spinning disc of the Figure 2 variant with 10 arms had identical dimensions to that of Figure 2, varying only in that it comprised 10 arms and the gap between the arms at, a distance of 1mm from the tube wall, was 5.5mm (44.3% of the radius of the tube).

The spinning discs of Figures 3a, 3b stopped powder flow when not in rotation yet resulted in build-up of powder back through the tube during the period of the trial. These spinning discs are simple 12 and 14 arm variants of the spinning disc of Figure 2. Without wishing to be bound by theory, the inventors believe that the introduction of additional arms had the effect of preventing the flow of powder when not in rotation yet introduced sufficient additional body to the spinning discs such that powder did not flow freely from the tube when in rotation throughout the duration of the trial.

The spinning discs of Figures 3c, 3d, 3e, 3f and 3g all stopped powder flow when not in rotation yet resulted in build-up of powder back through the tube during the period of the trial. Without wishing to be bound by theory, the inventors believe that the distribution of mass about the body of these discs did not take sufficient advantage of the forces imposed by rotation to allow the

free-flowing of the test powder when under rotation and highlight the difficulty felt in overcoming the challenges of the prior art.

The spinning disc of Figure 3h neither prevented flow when not in rotation nor prevented build-up of powder and blockage of the tube during the trial.

The spinning discs of Figures 4a-c, 5a-c, 6a-c, 7 and 8 all showed good performance in stopping powder flow when not in rotation and did not result in a blocked tube during the period of the trial. Without wishing to be bound by theory, the inventors believe that the additional body provided by a central ring with the dimensions as claimed in combination with the gap between the arms at 1mm from the internal wall of the tube (13) in these embodiments provide a surface sufficient for powder build up within the tube when the disc is not in rotation yet when in rotation allow sufficient void space between the arms for powder to flow freely past the disc. The spinning discs of Figures 7 and 8 showed some signs of powder build up on the arms of the spinning disc after the trial period, without wishing to be bound by theory, the inventors believe this slight build up to attributed to the number of arms and gap between the arms being close to the limit of the scope of the invention.

Example 2 – Second test powder

A second set of trials were conducted in an identical way to those of Example 1, the only change made was that a Second test powder was used rather than the First test powder of Example 1. The Second test powder was a spray dried powder with the same composition as the First test powder but because of different spray drying process parameters and extent of drying had a higher Hausner's ratio of 1.18 and was a 'free-flowing powder' by the classifications in Table 1.

The results of the second set of trials with the Second test powder are given in Table 3.

Spinning disc ID	1. Extent of tube blockage	2. Extent of powder leakage past disc when not rotating
Figure 2	Not blocked after 6 hours	Powder flow not arrested
Figure 2: variant with 10 arms	Not blocked after 6 hours	Powder flow not arrested
Figure 3a	Blocked rapidly	No powder leakage
Figure 3b	Blocked rapidly	No powder leakage

Figure 3e	Blocked rapidly	No powder leakage
Figure 3d	Blocked rapidly	No powder leakage
Figure 3e	Blocked rapidly	No powder leakage
Figure 3f	Blocked rapidly	No powder leakage
Figure 3g	Blocked rapidly	Powder flow not arrested
Figure 3h	Blocked rapidly	Powder flow not arrested
Figure 4a-c	Showing signs of build-up but not blocked after 6 hours	No powder leakage
Figure 5a-c	Showing signs of build-up but not blocked after 6 hours	No powder leakage
Figure 6a-c	Not blocked after 6 hours	No powder leakage
Figure 7	Not blocked after 6 hours, some signs of powder build up on the disc	No powder leakage
Figure 8	Not blocked after 6 hours, some signs of powder build up on the disc	No powder leakage

Table 3: Results of trials with numerous different spinning disc designs and a Second test powder.

Results were generally comparable to those of Example 1, with a general trend towards more tube blockages and less powder leakage with the less free-flowing powder of Example 2. The disc designs of Figures 2 and the variant of Figure 2 with 10 arms failed in the same way as Example 1. The disc designs of Figures 3a-3h failed by blocking of the tube more rapidly and the design of Figure 3d did not fail by leakage of powder when not in rotation. As in Example 1, the spinning disc designs of Figures 4a-c, 5a-c, 6a-c, 7 and 8 stopped powder flow and did not block over the period of the trial with this less free-flowing Second test powder.

The spinning discs of Figures 6a-c, 7 and 8 showed enhanced resistance to build up of powder in the tube during operation. Without wishing to be bound by theory, the inventors believe that this was due to the passage of air through the piercings within the central ring of the spinning disc reducing any pressure build up beyond the spinning disc. Said piercings are believed to be sufficiently small so as not to compromise the powder stopping properties given by the enlarged central ring.

Without wishing to be bound by theory, the inventors believe that the distance between arms, the dimensions of the central ring, dimensions of any optional solid outer perimeter and the size and placement of any additional, optional, apertures through the disc are key to a successful spinning disc of this invention.

5

Example 3 – 35 mm outside diameter, 16 mm inside diameter tube

Scaled-down variants of the spinning discs of Figures 2-7 used in Examples 1 and 2 were used in a powder filling machine of Figure 1 with tube (13) scaled-down to an outside diameter of 35mm and an inside diameter of 16mm.

10

The scaled-down variants of the spinning discs had the following dimensions:

Each scaled-down disc had a central attachment hole with radius 2.5mm, arm width of 1.5mm (measured across the cross-section of the tube) and a disc diameter of 15mm.

15

Other dimensions of the scaled-down spinning disc are as shown in Tables 4, 5 and 6.

	Fig. 2 for 35mm tube	Alt. Fig 2 (10 arm) for 35mm tube	Fig 3a for 35mm tube	Fig 3b for 35mm tube	Fig 3c for 35mm tube
central ring radius (mm)	4	4	4	4	4
central ring radius (% of tube radius)	50.0%	50.0%	50.0%	50.0%	50.0%
number of arms	8	10	12	14	N/A
circular arc distance between arms 1mm from tube (mm)	4.39	3.21	2.43	1.87	N/A
circular arc distance between arms 1mm from tube (% of tube radius)	54.9%	40.2%	30.3%	23.3%	N/A

Table 4: Dimensions of scaled-down spinning discs of Figures 2 - 3c.

	Fig 3d for 35mm tube	Fig 3e for 35mm tube	Fig 3f for 35mm tube	Fig 3g for 35mm tube	Fig 3h for 35mm tube	Fig. 4a-c for 35mm tube	Fig. 5a-c for 35mm tube
central ring radius (mm)	4	4	4	4	4	5.5	5.5
central ring radius (% of tube radius)	50.0%	50.0%	50.0%	50.0%	50.0%	68.8%	68.8%
number of arms	N/A	N/A	N/A	N/A	N/A	10	10
circular arc distance between arms 1mm from tube (mm)	N/A	N/A	N/A	N/A	N/A	3.21	3.21
circular arc distance between arms 1mm from tube (% of tube radius)	N/A	N/A	N/A	N/A	N/A	40.2%	40.2%

Table 5: Dimensions of scaled-down spinning discs of Figures 3d – 5.

	Fig 6a-c for 35mm	Fig 7 for 35mm			Fig 6a-c for 35mm	Fig 7 for 35mm
central ring radius (mm)	5.5	5.5		Number of slots	5	5
central ring radius (% of tube radius)	68.8%	68.8%		Slot width (mm) [via radius of tube]	1.5	1.5
number of arms	10	12		Slot area (mm ²)	16.6	16.6
circular arc distance between arms 1mm from tube (mm)	3.21	2.43		Slot area (% of cross- sectional area of tube bore)	8.3%	8.3%
circular arc distance between arms 1mm from tube (% of tube radius)	40.2%	30.3%				

Table 6: Dimensions of scaled-down spinning discs of Figures 6 and 7.

The 35mm variants of Figures 2 and 3a-j when used in conjunction with the scaled-down powder filling machine (1) of Figure 1, with tube (13) outside diameter of 35mm, are not of the invention.

5 The 35mm variants of Figures 4-7 when used in conjunction with the scaled-down powder filling machine (1) of Figure 1, with tube outside diameter of 35mm, are of the invention.

10 The scaled-down powder filling machine (1) of Figure 1, was fitted with each of the scaled-down spinning discs in Tables 4, 5 and 6 and loaded with the test powders of Examples 1 and 2 in turn such that each combination of spinning disc and test powder was tested. The same parameters of rotation speed, filling rate, test duration, etc of Example 1 were used.

A scaled-down equivalent of the spinning disc of Figure 8 was not tested.

15 Results were found to be substantially the same as those obtained with the 45mm versions used in Examples 1 and 2 with powder filling machines fitted with spinning discs of Figures 4-7 performing well in the tests of arresting powder flow when stationary yet preventing blockage of the tube (13) over time, were those fitted with spinning discs of Figures 2 and 3a-j failing one or both tests as in Examples 1 and 2.

20 Further variants of the scaled-down spinning discs of Figures 4-7 were tested with extended central rings up to radii of up to 6.8mm, 85% of the internal radius of the tube in example 3 (all other dimensions remained the same). These variants showed the same excellent powder flow and stopping properties as those shown in Tables 4-6 without causing blockage over time.

25 The above embodiments are described by way of example only. Many variations are possible without departing from the scope of the invention as defined in the appended claims.

CLAIMS

1. A powder dispenser comprising a tube of circular cross-section; an auger extending axially through the tube; and a disc-shaped distributor extending laterally to the axis of the tube and partially closing the tube, wherein the disc-shaped distributor comprises a central ring and arms extending radially therefrom, characterised in that, the central ring has a radius, to an outer edge of the central ring, of between 55% - 90% of the internal radius of the tube; at least one of the arms extends to no more than 1mm from the internal wall of the tube; and wherein there is a distance defined by a circular arc concentric with the tube between each arm at a distance of 1mm from the tube wall of between 30%-65% of the internal radius of the tube.
2. The powder dispenser of claim 1 wherein the powder dispenser is a beverage powder dispenser.
3. The powder dispenser of any preceding claim wherein the circular arc distance, concentric with the tube, between each arm of the disc-shaped distributor at a distance of 1mm from the tube wall is between 35% and 65% of the internal radius of the tube.
4. The powder dispenser of any preceding claim wherein the circular arc distance between each arm of the disc-shaped distributor at a distance of 1mm from the tube wall is between 2mm and 7.5mm.
5. The powder dispenser of any preceding claim wherein the radius of the central ring of the disc-shaped distributor is between 55% and 85% of the internal radius of the tube.
6. The powder dispenser of any preceding claim wherein the internal radius of the tube is between 10mm and 14mm and the radius of the central ring of the disc-shaped distributor is between 7mm and 9mm.
7. The powder dispenser of any one of claims 1 to 5 wherein the internal radius of the tube is between 7mm and 9mm and the radius of the central ring of the disc-shaped distributor is between 5mm and 7mm.
8. The powder dispenser of any preceding claim wherein the disc-shaped distributor comprises between 4 and 12 arms.

9. The powder dispenser of claim 8 the disc-shaped distributor comprises between 6 and 10 arms.
- 5 10. The powder dispenser of any preceding claim wherein the central ring of the disc-shaped distributor further comprises at least one aperture, each with a maximum width, in a direction along the radius of the tube, of no more than 30% of the radius of the tube.
- 10 11. The powder dispenser of any preceding claim wherein the central ring of the disc-shaped distributor further comprises at least one aperture, each with a maximum width, in a direction along the radius of the tube, of no more than 2.5mm.
- 15 12. The powder distributor of claim 10 or 11 wherein the central ring of the disc shaped ring comprises apertures and wherein, the area of all apertures in is no more than 15% of the cross-sectional area of the tube.
13. The powder dispenser of any preceding claim wherein the disc-shaped distributor is within 10mm, 20mm, 30mm, 40mm, 50mm of the end of the tube.
- 20 14. The powder dispenser of any preceding claim wherein the auger and disc-shaped distributor are operably connected.
15. The powder dispenser of any preceding claim, wherein the powder dispenser further comprises a powder with Hausner's ratio of between 1.00 – 1.25.
- 25 16. A method of dispensing powder comprising steps of:
A- providing a powder dispenser as claimed in any one of the preceding claims;
B- adding a powder;
C- rotating the auger and/or disc-shaped distributor;
D- collecting the powder in a container.
- 30 17. The method of claim 16 wherein, the powder is a beverage powder.