(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 100 821 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.09.2009 Bulletin 2009/38

(51) Int Cl.:
B65D 33/01 *(2006.01)*

(21) Application number: **08152531.3**

(22) Date of filing: **10.03.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

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(54) **Two-ply paper sack**

(57) The invention relates to the field of sacks, and especially to deaeration thereof. A sack (1), wherein at least part of a sack wall of the sack comprises an inner ply (2), an outer ply (3) and an air permeable moisture barrier film (4) arranged between the inner ply (2) and the outer ply (3) is provided. A parameter of the outer ply (3) relates to the parameter of the inner ply (2) so as to form an interply space between the inner and outer ply if an overpressure is present inside the sack. The sack (1) is adapted to form at least one film-ply deaeration space between the moisture barrier film (4) and the outer ply (3) within the at least part of the sack wall if the overpressure is present. Also provided are a sack wall material, a method for deaeration of a sack (1) and a method for manufacturing a sack.

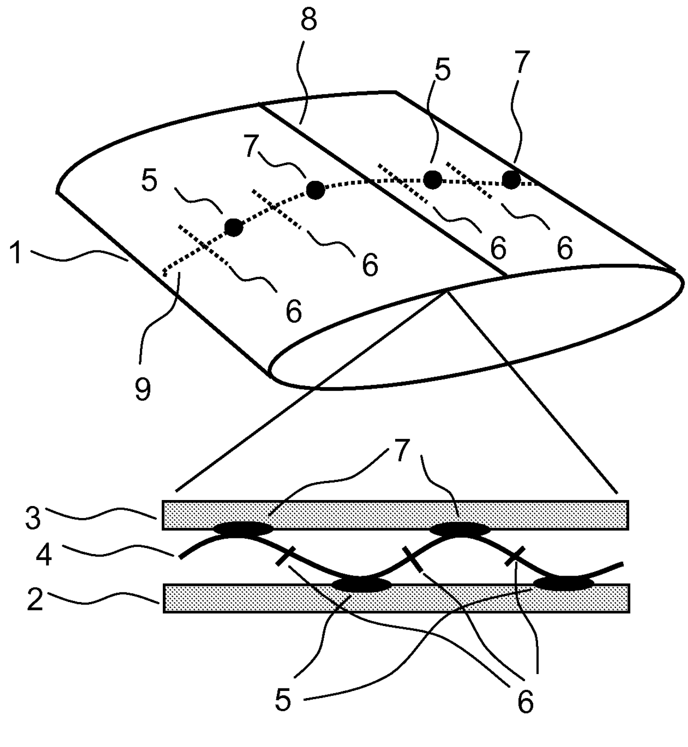

FIGURE 2

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Description

Technical Field of the Invention

[0001] The present invention relates to the field of vented sacks and the provision thereof.

Background Art

[0002] Kraft paper is a general term for paper produced from wood pulp by the Kraft process. This process removes almost all lignin from the wood resulting in almost pure cellulose fibers. The produced Kraft paper is characterized by overall good strength properties and high porosity. An important application of Kraft paper is the manufacture of sacks, e.g. multi-wall valve sacks. These sacks are used for shipping and storage of powdery material, such as cement or other building materials, chemicals, food, animal feed and pet food.

[0003] During filling and storing of powdery material, valve sacks are required to meet high standards. Firstly, valve sacks need to hold a considerable material weight, i.e. have high tensile energy absorption. For this purpose, Kraft paper is suitable as sack material and valve sacks are typically manufactured as multi-walled sacks of one or more layers, or plies, of paper to further strengthen the sack construction. Secondly, a material such as cement is sensitive to deterioration, such as deterioration caused by moisture penetration during storage. Hence, valve sacks also require a protection against atmospheric vapor penetration through the sack plies into the sack interior. This may be achieved by a moisture barrier incorporated as an intermediate layer in the valve sack, e.g. between the inner and outer plies of a two-ply paper sack. The moisture barrier is typically a plastic film, e.g. of polyethylene (PE), that is moisture resistant and provided to avoid contact with the filling material of the sack. The plastic film may also improve resistance to grease and prevent contamination by microorganisms.

[0004] Furthermore, valve sacks are usually filled with powdery materials through the valve. During the filling process, when the material is delivered at high speed by filling machines that run at high throughput rates, the air that accompanies the powdered material must vent from the sack. This severely limits the rate at which the sacks can be filled and air trapped in the sack might also lead to under-weight packs, sack rupture and problems when sacks are stacked for transportation. During the filling process, the only way for air to escape from the interior of the sack is in most sack constructions through the walls of the sack. Kraft paper of high porosity is often used in the manufacture of sacks to facilitate air permeability, but an increased porosity of the paper normally results in a decrease in the overall strength of the paper. Furthermore, the use of a moisture or water barrier as an intermediate layer tends to severely reduce the deaeration of the sacks during filling, since most barriers are highly impermeable to air. The moisture barrier may therefore be provided with slits to facilitate deaeration of the sack. Hence, if the air permeability of valve sack walls is further improved, filling pressure and filling speed may be increased.

[0005] To help increase deaeration, or air permeability, of sacks during filling, the moisture barrier can be perforated in different ways to modify the escape routes of air during filling. This is exemplified in US5988881, which discloses a sack constituted by a paper inner wall, surrounded by a vapor barrier and a paper outer wall. The sack has a plurality of perforations on the broad faces of the sack. These perforations are also found on the moisture barrier and allows for deaeration while the sack is being filled. However, the extended number of perforations also decreases the water-resistant properties of the moisture barrier.

[0006] Another solution for the deaeration of sacks has been to incorporate venting channels as part of the sack. EP0498047B1 discloses a sack with a single venting window with a filter that allows trapped gas in the sack interior to escape to the exterior. WO97/46460 discloses a sack with a plurality of venting channels provided in the walls in order to allow the escape of air from the interior during filling.

[0007] Another method for venting of sacks is disclosed in WO2006/092335**,** where the sack has an inner and an outer layer and an intermediate imperforated barrier film that is cut from top to bottom, thereby forming two free edges of the barrier film. Only one free edge of the barrier film is fixed to the inner layer by means of an adhesive line and allows for venting of the sack, since air can escape between the free edges during filling. This is probably an alternative method to perforating the barrier layer. EP1657180 discloses a multi-ply paper sack with a gap in the intermediate barrier film. An additional air impermeable strip is attached on the inner ply under the gap in the barrier film, thereby constraining the air escaping from the sack to follow a deflected path through the gap in the film to the outside of the sack.

[0008] Thus, methods for deaeration of sacks during filling have involved the incorporation of perforations in the moisture barrier film or rather complex sack constructions. Hence, there is a need in the art for a solution to deaeration of sacks that is easy to construct but still allows for improved filling rates without reducing the water repellant properties of the sack.

Summary of the Invention

[0009] It is an object of the present invention to provide a deaeration concept for sacks. Further objects of the invention are to provide a sack, a sack material and a method to provide such a sack in accordance with the inventive concept. The present invention is defined by the appending claims.

[0010] As a first aspect of the invention, there is provided a sack, wherein: at least part of a sack wall of the sack comprises an inner ply, an outer ply and an air permeable moisture barrier film arranged between the inner ply and the outer ply, and a parameter of the outer ply relates to the parameter of the inner ply so as to form an interply space between the inner and outer ply if an overpressure is present inside the sack; and the sack is adapted to form at least one film-ply deaeration space between the moisture barrier film and the outer ply within the at least part of the sack wall if the overpressure is present inside the sack.

[0011] The "ply" of this disclosure may be any air permeable sheet suitable for constituting a sack wall ply. For example, the ply may be a porous polymeric sheet, e.g. a porous polymeric sheet having a Gurley air permeability of 10 s or less, such as 5 s or less. An example of such a porous polymeric sheet is disclosed in US6861132**.**

[0012] In a preferred embodiment of the first aspect, at least one of said inner ply and said outer ply is a paper ply. In a more preferred embodiment, said inner ply and said outer ply are paper plies.

[0013] In the context of the present disclosure, "paper" refers to a material manufactured in sheets from the pulp of wood or other fibrous substances, which material may comprise additives such as synthetic fibers or biodegradable fibers. As an example, the paper may be Kraft paper. The air permeable moisture barrier film may be any moisture barrier film allowing transport of air from one side of the film to the other. For example, the moisture barrier film may comprise slits or perforations allowing such transport. In one embodiment, the air permeable moisture barrier film is adapted to restrict the passage of air to such slits or perforations. As an alternative or complementing embodiment, the air permeable moisture barrier film may comprise an air permeable material, i.e. a material being air permeable without mechanical modification. For example, the slits may be 5-200 mm long, such as 10 - 100 mm long, such as 15-70 mm long, such as 20-60 mm long, such as 30-50 mm long. Further, the distance between the slits in the direction perpendicular to their extension, may be 10-200 mm, such as 20-100 mm, such as 30-70 mm, such as 40-60 mm. As an example, the film may comprise a polymer material, e.g. polyethylene (PE). In one embodiment, the film material comprises at least 95 % PE.

[0014] An overpressure inside the sack refers to higher air pressure inside the sack compared to outside the sack. The parameter may be any parameter, provided that a difference in the parameter between the outer ply and the inner ply may give rise to an interply space if an overpressure is present inside the sack. In the context of the present disclosure, an interply space refers to a space caused by a separation of the plies in a direction being perpendicular to the planes of the plies, wherein the separation is larger than the thickness of the moisture barrier film. Furthermore, in the context of the present disclosure, a film-ply deaeration space refers to a space between the moisture barrier film and the outer ply that assists deaeration of the sack during filling. As an example, the rate of deaeration of a sack according to the present disclosure forming the film-ply space during filling is higher than the deaeration rate of a corresponding sack not forming the film-ply space during filling.

[0015] This first aspect of the invention is based on the inventor's insight that the formation of an interply space and a space between the outer ply and the intermediate moisture barrier film increases the deaeration rate during filling of the sack. Consequently, selecting an outer ply and an inner ply having parameters causing a separation of the plies during filling of the sack, and adapting the sack to form a space between the outer ply and the moisture barrier film during the filling, gives a sack which may be filled at a high rate. This deaeration concept is exemplified in Examples 1 and 2, which show the efficiency and advantages of embodiments of the deaeration concept.

[0016] When selecting the parameter of the outer ply and the parameter of the inner ply such that the interply space between the inner ply and the outer ply is formed if an overpressure is present inside the sack, it may be necessary to consider the pressure drop over the inner ply, the air permeable moisture barrier film and the outer ply, respectively. Typically, the largest pressure drop occurs over the moisture barrier film. The pressure drop over the inner ply and the outer ply may be different. Guided by the teachings of the present disclosure, the person skilled in the art understands how to adapt the relation between the parameter of the outer ply and the parameter of the inner ply so as to achieve the desired interply space.

[0017] In one embodiment of the first aspect, the parameter may be an expandability parameter. In the context of the present disclosure, the expandability parameter may be any parameter relating to the expansion, in any direction or directions, of a paper sheet at an applied force. To form the interply space, the expandability parameter of the outer ply is higher than the expandability of the inner ply, i.e. the outer ply expands more than the inner ply if an overpressure is applied inside the sack.

[0018] As an example, the expandability parameter of a ply may be defined as an area expansion (ΔA) of the ply at an increase of the pressure (ΔP) inside the sack. The area expansion (ΔA) at an increase of the pressure (ΔP) may be calculated by means of the following procedure: measuring the area A_0 of a part of a ply at a defined air pressure inside the sack; increasing the air pressure by ΔP; and measure the area A_1 of the part of the ply. ΔA is then calculated as the difference in measured area (A_1-A_0) when the air pressure was increased by ΔP. Thus, if the area expansion of the outer ply is higher than the area expansion of the inner ply during filling, an interply space assisting in the deaeration of the sack may be formed.

[0019] The area expansion of a sack may also be described in terms of the applied pressure and material properties of the sack. Without being bound by any specific scientific theory or calculation model, an approximate method for defining a parameter of a ply material is provided below. For a spherical sack, it follows that the area deformation (ΔA/A) may be defined as

$$\frac{\Delta A}{A}=\frac{pr}{Ed}$$

wherein *p* = internal pressure of the sack, *r* = radius of curvature of the sack, *E* = Young's modulus of the sack material and *d* = thickness of the sack wall.

[0020] If the sack is assumed to have a cylindrical shape, it follows that the area expansion (ΔA/A) may be defined as

$$\frac{\Delta A}{A}=\frac{3}{2}\frac{pr}{Ed}$$

where p = internal pressure of the sack, *r* = radius of curvature of the sack, E = Young's modulus of the sack wall material and *d* = thickness of the sack wall.

[0021] Assuming a spherical or cylindrical shape, the area deformation (ΔA/A) is proportional to the pressure *p* and inversely proportional to *E*d*, and approximately the same relations may also apply to a ply of a sack according to the present invention. Consequently, in one embodiment, the parameter may be *E*d*. As a spring constant, *E*d* has the unit N/m.

[0022] As an example, *E*d* of the inner ply is higher than *E*d* of the outer ply, such as at least 5 % higher than *E*d* of the outer ply, such as at least 10 % higher than *E*d* of the outer ply, such as at least 20 % higher than *E*d* of the outer ply, such as at least 30 % higher than *E*d* of the outer ply, such as at least 40 % higher than *E*d* of the outer ply, such as at least 50 % higher than *E*d* of the outer ply, such as at least 60 % higher than *E*d* of the outer ply, such as at least 75 % higher than *E*d* of the outer ply, such as at least 100 % higher than *E*d* of the outer ply.

[0023] If *E*d* of the inner ply is higher than *E*d* of the outer ply, the area expansion at an internal pressure *p* inside the sack may be higher for the outer ply than for the inner ply. Hence, an interply space may be formed that assists in the deaeration in the presence of a filling pressure. The same effect may be achieved if the thickness *d* of the inner ply is higher than the thickness *d* of the outer ply. Thus, in another embodiment of the invention d of the inner ply is higher than d of the outer ply.

[0024] In another embodiment of the first aspect, the basis weight of the inner ply may be higher than the basis weight of the outer ply. The basis weight may be defined as the weight of a certain surface or area of the paper, e.g. have the unit g/m^2. If the basis weight of the inner ply is higher than the basis weight of outer ply, the inner ply may expand to a lesser degree if there is an overpressure inside the sack. Thus, an interply space may be formed during filling if an overpressure is present inside the sack.

[0025] The tensile energy absorption of a paper may be measured as the maximum pulling force a paper will stand before it breaks. The stretch level of a paper may be defined as the elongation of the paper that will occur before the paper is ruptured, i.e. defined as the difference in the length of a paper at a certain load or stretch at which the paper breaks or rips divided by the original length of the paper. The term extensible may be used to describe paper which have been given enhanced machine direction stretch properties. The increase of stretch may be performed in the papermaking. Extensibility levels of a paper may be divided into three categories; natural (N), semi-extensible (SE) or fully extensible (E) paper. In the context of the present disclosure, natural paper (N) has a stretch level of 2 - 4 %, such as 3 %, semi-extensible (SE) paper has a stretch level of 4 - 6 %, such as 5 %, and fully extensible (E) paper has a stretch level of above 6 %, such as 7.5 %. In an embodiment of the first aspect, the inner ply may consist of a natural (N) grade paper, and the outer ply may consist of a paper selected from semi-extensible (SE) and fully extensible (E) grade paper. In yet another embodiment, the inner ply may consist of semi-extensible (SE) grade paper and the outer ply may consist of fully extensible (E) grade paper. Thus, when an overpressure is present inside the sack, an interply space between the inner and outer plies may be formed.

[0026] In one embodiment of the first aspect, the moisture barrier film may be attached to said inner ply at at least one position so as to form said film-ply deaeration space if said overpressure is present inside said sack. For example, the moisture barrier film may be attached to the inner ply at at least 1 discrete position, such as at least 3 discrete positions, such as at least 5 discrete positions, such as at least 10 discrete positions. According to an alternative or complementary embodiment of the first aspect, the moisture barrier film may be attached to the inner ply at at least one position, such as at least 3 discrete positions, such as at least 5 discrete positions, such as at least 10 discrete positions, different from overlapping sections of the sack so as to form the film-ply deaeration space if the overpressure is present inside the sack. In the context of the present disclosure, overlapping sections refers to sections of the sack having one part of the sack wall material, e.g. the inner ply, the moisture barrier film and the outer ply, overlapping another part of the sack wall material. An example of an overlapping section is a longitudinal seam of a sack, which may be seen in Figure 1 and Figure 2. The moisture barrier film may be attached to the inner ply at random positions throughout the whole moisture barrier film or at random positions at a part of the moisture barrier film. Furthermore, the moisture barrier film may be attached at discrete positions, spaced a predetermined length apart, throughout the whole moisture barrier film or at discrete positions, spaced a predetermined length apart, at a part of the moisture barrier film. According to one embodiment of the first aspect, the air permeable moisture barrier film of the sack may be a film having at least one slit provided between two attachment positions attaching the moisture barrier film to the inner paper layer, e.g. such that the slit intersects an imaginary, straight line drawn between attachment positions in the plane of the moisture barrier film. As examples of such an embodiment, the film may have at least 3 slits, such as at least 5 slits, such as at least 10 slits provided between attachment positions. As an alternative or complementary example, the moisture barrier film may have at least one slit and be attached to the inner ply at attachment positions provided, in the plane of the moisture barrier film, in both the perpendicular directions of the extension direction of each slit, e.g. as described in Figure 1. In one embodiment, repeats of such attachment position arrangement may form a row, wherein the extension of the slits is approximately perpendicular to the extension of the row. As an example, the row may be provided along a circumference of the sack and attachment positions are provided between each pair of adjacent slits. When an overpressure is present inside the sack, the attachment positions attaching the moisture barrier film to the inner ply will prevent the moisture barrier film from sticking to the outer ply and a film-ply deaeration space between the outer ply and the moisture barrier film may thus be formed. Further, the parts of the moisture barrier film that is not attached to the inner ply may be forced in the direction towards the outer ply when an overpressure is present inside the sack. If these parts of the moisture barrier film, i.e. the parts between the attachment positions, are provided with slits, e.g. as described in Figure 1, the slits may open as a result of the overpressure present inside the sack and the deaeration of the sack may be aided. However, if no overpressure is present inside the sack, the opening of the slits may be minor, and the moisture barrier properties of the film may be retained.

[0027] According to another embodiment of the first aspect, the moisture barrier film is further attached to the outer ply at at least 3 discrete positions, such as at least 5 discrete positions, such as at least 10 discrete positions. According to an alternative or complementary embodiment of the first aspect the moisture barrier film is further attached to the outer ply at at least one position different from overlapping sections of the sack. The moisture barrier film may be attached to the outer ply at random positions throughout the whole moisture barrier film or at random positions at a part of the moisture barrier film. Furthermore, the moisture barrier film may be attached at discrete positions, spaced a predetermined length apart, throughout the whole moisture barrier film or at discrete positions, spaced a predetermined length apart, at a part of the moisture barrier film. According to one embodiment of the first aspect, the air permeable moisture barrier film of the sack may be a film having at least one slit provided between an attachment position attaching the film to the inner ply and the outer ply, e.g. such that the slit intersects an imaginary, straight line drawn between the attachment positions if the overpressure is present inside the sack and the interply space is formed. As examples of such an embodiment, the film may have at least 3 slits, such as at least 5 slits, such as at least 10 slits provided between attachment positions to the inner and outer plies, respectively. As an alternative or complementary example, the moisture barrier film may have at least one slit and be attached alternatively to the inner and outer plies at attachment positions provided, in the plane of the moisture barrier film, in both the perpendicular directions of the extension direction of each slit, e.g. as described in Figure 2. In one embodiment, repeats of such attachment position arrangements may form a row, wherein the extension of the slits is approximately perpendicular to the extension of the row. As an example, the row may be provided along a circumference of the sack. When an overpressure is present inside the sack, the attachment positions attaching the moisture barrier film to the inner and outer plies may prevent the moisture barrier film from sticking to the outer ply and a film-ply deaeration space between the outer ply and the moisture barrier film may thus be formed. When an overpressure is present inside the sack and the parts between the attachment positions are provided with slits, e.g. as described in Figure 2, the slits may open as a result of the overpressure present inside the sack and the deaeration of the sack may be aided. Thus, when an overpressure is present inside the sack, film-ply deaeration spaces may be formed between the outer ply and the moisture barrier film so that air can flow through the slits and via the film-ply deaeration spaces through the outer ply to the outside of the sack and hence increase the deaeration rate of the sack.

[0028] In an embodiment of the first aspect, the moisture barrier film is attached by means of an adhesive. The adhesive may for example be glue, starch and modified starch based adhesives or hotmelt adhesives.

[0029] In an alternative embodiment of the first aspect, the outer ply may have a friction pattern. In the context of the present disclosure, a "friction pattern" refers to small bulges provided on one or both sides of the ply, or to ridges or grooves that may be irregularly spaced or forming a pattern. In a preferred embodiment, the friction pattern of the present disclosure is bulges provided on one or both sides of the ply. Regarding paper plies, such bulges are sometimes referred to as the friction quality of the paper. If the outer ply is a paper ply and provided with a friction pattern, it may expand more when the overpressure is present inside the sack and thus contribute to the formation of the interply space. An outer ply having a friction pattern may preferably have the bulges facing the moisture barrier film. In addition to the expandability of the outer ply, bulges facing the moisture barrier film may also aid in the formation of the film-ply space. Guided by the teachings of the present disclosure, the person skilled in the art understands how to adapt the relation between the friction pattern of the outer ply and the friction pattern of the inner ply so as to achieve the desired interply space.

[0030] In yet another embodiment of the first aspect, wherein the plies are paper plies, the outer paper ply may be creped, such as micro-creped. In the context of the present disclosure, "creping" refers to subjecting a paper to a wet creping process which may give the paper a greater machine direction stretch, thus making it more flexible than a paper not being subjected to the wet creping process. Further, in the context of the present disclosure, "micro-creping" refers to a creping process which leads to a paper that is mechanically crimped, or compacted. Normally, micro-creping results in a barely visible creping in the machine direction, giving a better machine direction stretch. Hence, a micro-creped paper may for example be a paper having alternate ridges or grooves, that may or may not be parallel. The paper ply may for example be micro-creped by machinery well known to the skilled man. If an outer micro-creped paper ply is combined with an inner paper ply that is not micro-creped, the outer paper ply may expand more if an overpressure is present inside the sack and thus aid in the formation of the interply space. If both the inner and outer paper ply is micro-creped, the person skilled in the art understands, from the teachings of the present disclosure, how to adapt the relation between the micro-creping of the outer paper ply and the micro-creping of the inner paper ply so as to achieve the desired interply space.

[0031] In an embodiment of the first aspect, the outer ply has an inner and an outer surface, and the inner surface of the outer ply comprises protrusions so as to from the film-ply deaeration space if the overpressure is present inside the sack. In this context, protrusions refer to extensions or projections of the inner surface of the outer ply. The protrusions may prevent the moisture barrier film from sticking tight against the outer ply when an overpressure is present inside the sack. Hence, a film-ply deaeration space may be formed during filling of the sack. The protrusions may either be an integrated part of the ply, such as the paper ply (e.g. a surface roughness of the paper ply), or provided as an extra feature to the ply, such as the paper ply, such as a material other than paper that has been added or coated onto the surface of the ply.

[0032] In one embodiment of the first aspect, the overpressure is at least 10 mbar. In other embodiments, the overpressure is at least 10 mbar, such as at least 20 mbar, such as at least 30 mbar, such as at least 40 mbar, such as at least 50 mbar, such as at least 60 mbar, such as at least 70 mbar, such as at least 80 mbar, such as at least 90 mbar, such as at least 100 mbar, such as at least 120 mbar, such as at least 140 mbar, such as at least 160 mbar, such as at least 180 mbar.

[0033] In one embodiment of the first aspect, the sack is suitable for holding a powdery or granularly material, such as cement.

[0034] As another aspect of the present invention, there is provided the use of the sack according to any embodiment or example of the first aspect for holding a powdery or granularly material. For example, the powdery or granularly material may be cement, building materials, powdered goods for the construction industry, ready-mix building materials, chemicals or garden fertilizers.

[0035] As a related aspect thereof, there is provided the use of the sack according to any embodiment of the first aspect for holding a material selected from food, animal feed or pet food. For example, such material may be sugar, flour, rice, potatoes, or seeds.

[0036] As another aspect of the present invention, there is provided the use of a paper having a friction pattern in the manufacture of a sack according to any embodiment or example of the first aspect. In an embodiment, the paper having a friction pattern may be used for the outer ply of the sack. As a related aspect thereof, there is provided the use of a paper having no friction pattern in the manufacture of a sack according to any embodiment or example of the first aspect. In an embodiment, the paper having no friction pattern is used for the inner ply of the sack.

[0037] As another aspect of the invention there is provided a material for the manufacture of a sack according to any embodiment or example of the first aspect, comprising a first ply, a second ply and an air permeable moisture barrier film sandwiched between the first ply and the second ply, wherein a parameter of the second ply relates to the parameter of the first ply so as to form an interply space between the second and first ply if the material separates a space of overpressure from a space of atmospheric pressure and the material is adapted to form at least one film-ply deaeration space between the moisture barrier film and the first ply if the second ply faces the separated space of overpressure. In connection with the material aspect of the invention, the same definitions as in connection with the first aspect are used. However, some definitions are further explained so as to fit the material aspect of the invention. In this context, a space of overpressure refers to a defined space where the air pressure is higher than atmospheric pressure. The overpressure may for example correspond to a typical overpressure inside a sack during filling. The separation of a space of overpressure from a space of atmospheric pressure refers to restricting the transport of air between the two spaces to be through the material. "If the second ply faces the separated space of overpressure" refers to the case where any air flowing from the space of overpressure through the material first has to pass the second ply before it can pass the first ply.

[0038] In a preferred embodiment, at least one of said first ply and said second ply is a paper ply. In a more preferred embodiment, said first ply and said second ply are paper plies.

[0039] Similar as to what is described in connection with the first aspect of the invention, if a space is formed between the two plies and a film-ply deaeration space is formed between the first ply and the intermediate air permeable moisture barrier film, the flow of air from the space of overpressure to the space of atmospheric pressure may be increased if the second ply faces the space of overpressure.

[0040] The material according to the material aspect of the invention may be formed in several ways. There are numerous ways to form an interply space between the first and second ply if the material separates a space of overpressure from a space of atmospheric pressure and the second ply faces the separated space of overpressure, similar to what is discussed in connection with the first aspect above. In one embodiment, the parameter is an expandability parameter. In another embodiment, the expandability parameter of a ply is defined as an area expansion (ΔA) of the ply at an increase of the overpressure. The area expansion (ΔA) at an increase of the pressure (ΔP) may be calculated by means of the following procedure: measuring the area A_0 of a part of a ply at a defined air pressure on one side of the ply; increasing the air pressure by ΔP; and measure the area A_1 of the part of the ply. ΔA is then calculated as the difference in measured area (A_1-A_0) when the air pressure was increased by ΔP. Thus, if the area expansion of the first ply is higher than the area expansion of the second ply and the material separates a space of overpressure from a space of atmospheric pressure and the second ply faces the separated space of overpressure, an interply space assisting in the flow of air through the material may be formed.

[0041] In yet another embodiment, *E*d* of the second ply is higher than *E*d* of the first ply, where *E* is Young's modulus of the ply and d is the thickness of the ply. As examples, *E*d* of the second ply is higher than *E*d* of the first ply, such as at least 5 % higher than *E*d* of the first ply, such as at least 10 % higher than *E*d* of the first ply, such as at least 20 % higher than *E*d* of the first ply, such as at least 30 % higher than *E*d* of the first ply, such as at least 40 % higher than *E*d* of the first ply, such as at least 50 % higher than *E*d* of the first ply, such as at least 60 % higher than *E*d* of the first ply, such as at least 75 % higher than *E*d* of the first ply, such as at least 100 % higher than *E*d* of the first ply. In yet another embodiment d of the second ply is higher than d of the first ply, where d denotes the thickness of the ply.

[0042] The basis weight of the two plies may also be different. The basis weight may be defined as in the first aspect of the disclosure above. In one embodiment of the material aspect the basis weight of the second ply is higher than the basis weight of the first ply in order to form an interply space when the material separates a space of overpressure from a space of atmospheric pressure and the second ply faces the separated space of overpressure. Moreover, the same effect may be achieved if the plies are of papers of different stretch levels. In another embodiment of the first aspect, the second ply is consists of a natural (N) grade paper, and the first ply consists of a paper selected from semi-extensible (SE) and fully extensible (E) grade paper. In yet another embodiment, the second ply may consist of semi-extensible (SE) grade paper and the first ply may consist of fully extensible (E) grade paper.

[0043] The air permeable moisture barrier film sandwiched between the first and second plies of the material may be attached in similar ways to what is described in connection with the first aspect of the invention above. In one embodiment of the material aspect, the moisture barrier film is attached to the second ply at at least one position so as to form the film-ply deaeration space if the material separates a space of overpressure from a space of atmospheric pressure. The moisture barrier film may be attached to the second ply at random positions throughout the whole moisture barrier film or at random positions at a part of the moisture barrier film. Furthermore, the moisture barrier film may be attached at discrete positions, spaced a predetermined length apart, throughout the whole moisture barrier film or at discrete positions, spaced a predetermined length apart, at a part of the moisture barrier film. According to one embodiment of the material aspect, the air permeable moisture barrier film of the sack may be a film having at least one slit provided between two attachment positions attaching the moisture barrier film to the second paper layer, e.g. such that the slit intersects an imaginary, straight line drawn between attachment positions in the plane of the moisture barrier film. As an example of such an embodiment, the film may have at least 3 slits, such as at least 5 slits, such as at least 10 slits provided between attachment positions. As an alternative or complementary example, the moisture barrier film may have at least one slit and be attached to the second ply at attachment positions provided, in the plane of the moisture barrier film, in both the perpendicular directions of the extension direction of each slit, e.g. as described in Figure 1. In one embodiment, repeats of such attachment position arrangements may form a row, wherein the extension of the slits are approximately perpendicular to the extension of the row and attachment positions are provided between each pair of adjacent slits. When the material separates a space of overpressure from a space of atmospheric pressure and the second ply faces the separated space of overpressure, the attachment positions attaching the moisture barrier film to the second ply may prevent the moisture barrier film from sticking to the first ply and a film-ply deaeration space between the first ply and the moisture barrier film may thus be formed. Further, the parts of the moisture barrier film that is not attached to the second ply may be forced in the direction towards the first ply when an overpressure is present inside the sack. If these parts of the moisture barrier film, i.e. the parts between the attachment positions, are provided with slits, e.g. as described in Figure 1, the slits may open as a result of the overpressure and the transport of air through the material may be aided.

[0044] According to another embodiment of the material aspect, the moisture barrier film is further attached to the first ply at at least one position so as to form the at least one film-ply deaeration space between said moisture barrier film and said first paper ply if said second paper ply faces said separated space of overpressure. According to an alternative or complementary embodiment of the material aspect, the moisture barrier film is further attached to the first ply at at least 3 discrete positions, such as at least 5 discrete positions, such as at least 10 discrete positions. The moisture barrier film may be attached to the first ply at random positions throughout the whole moisture barrier film or at random positions at a part of the moisture barrier film. Furthermore, the moisture barrier film may be attached at discrete positions, spaced a certain length apart, throughout the whole moisture barrier film or at discrete positions, spaced a certain length apart, at a part of the moisture barrier film. According to one embodiment of the material aspect, the air permeable moisture barrier film of the material may be a film having at least one slit provided between an attachment position to the first ply and the second ply, e.g. such that the slit intersects an imaginary, straight line drawn between an attachment position to the first ply and the nearest attachment position to the second ply in the plane of the moisture barrier film. As an example of such an embodiment, the film may have at least 3 slits, such as at least 5 slits, such as at least 10 slits, provided between attachment positions to the first and second ply. As an alternative or complementary example, the moisture barrier film may have at least one slit and be attached alternatively to the first and second plies at attachment positions provided, in the plane of the moisture barrier film, in both the perpendicular directions of the extension direction of each slit, e.g. as described in Figure 2. In one embodiment, repeats of such attachment position arrangements may form a row, wherein the extension of the slits is approximately perpendicular to the extension of the row. When the material separates a space of overpressure from a space of atmospheric pressure, the attachment positions attaching the moisture barrier film to the first and second plies may prevent the moisture barrier film from sticking to the first ply and a film-ply deaeration space between the first ply and the moisture barrier film may thus be formed if the second ply faces the separated space of overpressure. Moreover, the slits may open as a result of the overpressure and the transport of air through the material may be aided. In an embodiment of the material aspect, the moisture barrier film is attached by means of an adhesive. The adhesive may for example be glue, starch and modified starch based adhesives or hotmelt adhesives.

[0045] In an embodiment, the first ply has an inner and an outer surface, and the inner surface of the first ply comprises protrusions so as to from the film-ply deaeration space if the second ply faces the separated space of overpressure.

[0046] In an embodiment of the material aspect, the overpressure is at least 10 mbar. In other embodiments, the overpressure is higher than 10 mbar, such as at least 20 mbar, such as at least 30 mbar, such as at least 40 mbar, such as at least 50 mbar, such as at least 60 mbar, such as at least 70 mbar, such as at least 80 mbar, such as at least 90 mbar, such as at least 100 mbar.

[0047] According to another embodiment of the material aspect, the first ply may have a friction pattern. This may form an interply space if the material separates a space of overpressure from a space of atmospheric pressure and the second ply faces the space of overpressure.

[0048] The first paper having a friction pattern may be provided with the bulges facing the moisture barrier film, so as to form a film-ply deaeration space additionally to the interply space.

[0049] According to yet another embodiment, the first ply may be a paper ply which is micro-creped. The paper ply may be micro-creped either by machinery or manually. If the first micro-creped paper ply is combined with a second paper ply that is not micro-creped, the first paper ply may expand more compared to the second paper ply if the material separates a space of overpressure from a space of atmospheric pressure and the second ply faces the space of overpressure, and thus form the desired interply space.

[0050] According to another aspect of the present invention, there is provided a method for deaeration of a sack having an inner ply, an outer ply and an air permeable moisture barrier film arranged between the plies during a filling of the sack causing an overpressure inside the sack, comprising the steps of:

a) forming an interply space between the plies at at least part of a sack wall of the sack; and
b) forming a film-ply deaeration space between the moisture barrier film and the outer ply at the at least part of the sack wall.

[0051] The benefits of forming the interply space and the film-ply deaeration space are described above in connection with the first aspect.

[0052] In a preferred embodiment, at least one of said inner ply and said outer ply is a paper ply. In a more preferred embodiment, said inner ply and said outer ply are paper plies.

[0053] According to another aspect of the present invention, there is provided a method for the manufacture of a sack adapted to form at least one film-ply deaeration space between a moisture barrier film and an outer ply within at least part of a sack wall of the sack if an overpressure is present inside the sack, comprising the steps of:

a) providing a first ply, a second ply and a moisture barrier film;
b) arranging the moisture barrier film between the first and the second ply to form a sack material;
c) tubing and cutting the sack material from step c) to form a tubular piece with two open ends, wherein the first ply is forming an outer ply and the second

ply is forming an inner ply of the tubular piece, and
d) closing at least one end of the tubular piece to form the sack,

wherein a parameter of the first ply relates to a parameter of the second ply so as to form an interply space between the inner and outer ply if the overpressure is present inside the sack.

[0054] As an example, step d) may involve closing both ends of the sack. Consequently, a valve sack may be manufactured. As another example, step d) may involve closing only one end so as to form an open-mouth sack.

[0055] In a preferred embodiment, at least one of said first ply and said second ply is a paper ply. In a more preferred embodiment, said first ply and said second ply are paper plies. In one embodiment, the parameter is an expandability parameter.

[0056] The arrangement of the moisture barrier film between the first and second ply may lead to an arrangement where the plies sandwich the moisture barrier film. Tubing the sack material refers to forming a tubular piece of a sack material having two opposite edges by overlapping the two edges. An adhesive may be applied to the overlapping portions of the inner and outer ply such that the overlap forms a tight seal, such as a longitudinal seam. The operations of arranging the moisture barrier film between the first and second ply, tubing and cutting the sack material and closing one end of the formed tubular piece may be performed manually or by machinery.

[0057] In an embodiment, step b) further comprises attaching the moisture barrier film to the second ply. As an example, step b) comprises applying an adhesive to the second ply and the attachment of the moisture barrier film to the second ply is achieved by bringing the moisture barrier film into contact with the adhesive applied to the second ply. The adhesive may be applied to the second ply randomly throughout the whole ply or at random positions to at least part of the ply. Furthermore, the adhesive may be applied to the second ply at discrete positions, spaced with a predetermined interval, such as 3-20 cm, such as 5-15 cm, throughout the whole ply or over at least part of the ply. As another example, the adhesive may be applied to the moisture barrier film, followed by bringing the second ply into contact with the adhesive applied to the moisture barrier film. The adhesive may be applied to the moisture barrier film ply randomly throughout the whole moisture barrier film or at random positions to at least part of the moisture barrier film. Furthermore, the adhesive may be applied to the moisture barrier film at discrete positions, spaced with a predetermined interval, such as 3-20 cm, such as 5-15 cm, throughout the whole moisture barrier film or over at least part of the moisture barrier film. As an example, the moisture barrier film may be attached to the second ply so as to form the sack described in Figure 1, wherein adhesive is applied to either the second ply or the moisture barrier film at discrete attachment positions.

[0058] In general, the adhesive may be applied manually or by machinery. As an example, the adhesive may be applied in the same machinery that is arranging the moisture barrier film between the first and second ply. As another example, the adhesive may be applied in the same machinery that is tubing the sack material. Also, the machinery that is arranging the moisture barrier film between the first and second ply may be the same as the same machinery that is tubing the sack material. The adhesive may for example be glue, starch and modified starch based adhesives or hotmelt adhesives

[0059] In another embodiment, step b) further comprises attaching the moisture barrier film to the first ply. As an example, step b) comprises applying an adhesive to the first ply and the attachment of the moisture barrier film to the first ply is achieved by bringing the moisture barrier film into contact with the adhesive applied to the first ply. The adhesive may be applied as is described for the second ply above. For example, the adhesive may be applied to the first ply randomly throughout the whole ply or at random positions to at least part of the ply. Furthermore, the adhesive may be applied to the first ply at discrete positions, spaced with a predetermined interval, such as 3-20 cm, such as 5-15 cm, throughout the whole ply or over at least part of the ply. As another example, the adhesive may be applied to the moisture barrier film, followed by bringing the first ply into contact with the adhesive applied to the moisture barrier film. The adhesive may be applied to the moisture barrier film ply randomly throughout the whole moisture barrier film or at random positions to at least part of the moisture barrier film. Furthermore, the adhesive may be applied to the moisture barrier film at discrete positions, spaced with a predetermined interval, such as 3-20 cm, such as 5-15 cm, throughout the whole moisture barrier film or over at least part of the moisture barrier film. As an example, adhesive may be applied to the second and first ply so that an arrangement as described in Figure 2 is formed, i.e. so that the moisture barrier film is alternatively attached at discrete attachment positions to the first and second plies, respectively.

[0060] In another embodiment, the method may be further comprising the step of: aa) forming air permeable openings in the moisture barrier film from step a). As an example, the formation of air permeable openings of step aa) may comprise cutting slits in the moisture barrier film. As an example, slits may be cut manually or by machinery. For example, the slits may be 5-200 mm long, such as 10 - 100 mm long, such as 15-70 mm long, such as 20-60 mm long, such as 30-50 mm long. Further, the distance between the slits in the direction perpendicular to their extension, may be 10-200 mm, such as 20-100 mm, such as 30-70 mm, such as 40-60 mm. The slits may be cut in between discrete attachment positions to the inner ply as seen in Figure 1 or cut in between the attachment positions to the first ply and the attachment positions to the second ply as seen in Figure 2.

[0061] In one embodiment, the application of the adhesive is adapted to the slits, so as to provide an attachment point between slits of at least one pair of adjacent slits, e.g. such that at least one slit intersects an imaginary line drawn in the plane of the plies between two adjacent attachment points. For example, the moisture barrier film is attached alternatively to the first and second ply or only to the second ply. In another embodiment, the attachment points are provided randomly, independent of the slits of the pre-slitted moisture barrier film.

[0062] In yet another embodiment, the closing of step d) is performed by means of folding. Folding may be performed manually or by machinery. As an example, the folding may further involve the step of attaching an extra strip of paper on at least part of the folded area so as to increase the stability of the folded area. As another example, folding may involve folding and gluing the open end around a vent material, which may be a ply of higher basis weight compared to the inner ply or the an outer ply, so that an enforced vent may be formed that is adapted to fit a filling spout of a filling machine.

Brief description of the drawings/figures

[0063]

Figure 1. *Two-ply sack.* Figure 1 shows an example of free film attachment to inner ply of a sack according to the present disclosure. A two-ply sack (1) comprising an inner paper ply (2), an outer paper ply (3) and an intermediate moisture barrier film (4). The moisture barrier film (4) is attached to the inner paper ply (2) at various attachment positions (5). The moisture barrier film (4) has slits (6) provided between the attachment positions. The sack is provided with a longitudinal seam (8) that holds the free edges of the inner paper ply (2), the outer paper ply (3) and the intermediate moisture barrier film (4) together.

Figure 2. *Two-ply sack.* Figure 2 shows an example of free film attachment to inner and outer plies of a sack according to the present disclosure. A two-ply sack (1) comprising an inner paper ply (2), an outer paper ply (3) and an intermediate moisture barrier film (4). The moisture barrier film (4) is attached to the inner (2) and outer (3) plies at various inner (5) and outer (7) attachment positions. The moisture barrier film (4) has slits (6) provided between the attachment positions. The sack is provided with a longitudinal seam (8) that holds the free edges of the inner paper ply (2), the outer paper ply (3) and the intermediate moisture barrier film (4) together.

Figure 3. *Paper friction pattern effect on air permeability.* Figure 3 shows air-permeability (Gurley flow (m^3/h)) of two paper plies with or without an intermediate moisture barrier film as a function of pressure. Papers with different friction qualities were used: Corrugated papers without moisture barrier film (triangles, solid line); plain papers without moisture barrier film (open squares, solid line); corrugated papers with moisture barrier film (triangles, dotted line); plain papers with moisture barrier film (filled squares, dotted line).

Figure 4. *Paper stretch level effect on air permeability.* Figure 4 shows air-permeability (Gurley flow (m^3/h)) of two paper plies with an intermediate moisture barrier film attached to the plies as described in Fig. 2 as a function of pressure. Different types of papers with different stretch levels (N = natural paper or E = fully extensible paper) were used for the inner and outer ply, respectively. Three different combinations of inner and outer plies were used: Two samples of inner ply of N-paper and outer ply of E-paper (triangles, solid line); two samples of inner ply of E-paper and outer ply of N-paper (squares, dotted line); one sample of inner ply of E-paper and outer ply of E-paper (diamonds, dotted line).

Figure 5. *Paper stretch level effect on air permeability.* Figure 5 shows air-permeability (Gurley flow (m^3/h)) of two papers with an intermediate moisture barrier film attached to the plies as described in Fig. 2 as a function of pressure. Different types of papers with different stretch levels (N = natural paper, SE = semi-extensible paper) were used for the inner and outer ply, respectively. Two different combinations of inner and outer plies were used: Two samples of inner ply of N-paper and outer ply of SE-paper (triangles, solid line); two samples of inner ply of SE-paper and outer ply of N-paper (squares, dotted line).

Figure 6. *Paper stretch level effect on sack deaeration capacity.* Figure 6 shows air-permeability (Gurley flow (m^3/h)) of whole sacks as a function of pressure. The sacks were comprised by two paper plies and an intermediate free film attached to the plies as described in Fig 2. Different types of papers with different stretch levels (N = natural paper, SE = semi-extensible paper) were used for the inner and outer ply, respectively. Two different combinations of inner and outer plies were used: Inner ply of N-paper and outer ply of SE-paper (triangles, solid line); inner ply of SE-paper and outer ply of N-paper (squares, dotted line).

Figure 7. *Deaeration capacity of sacks with different deaeration concepts.* Figure 7 shows the normalized air permeability (m^3/m^2*h)) as a function of pressure drop through sacks with an intermediate free film between an inner and outer ply but with different deaeration concepts: A sack according to the disclosed deaeration concept and described in Figure 6 (triangles, solid line); a sack with multiple venting channels (squares, dotted line); a sack with a single venting channel (diamonds, dotted line); a sack having a barrier film with two opposite edges (opposite in the

plane), wherein only one edge of the barrier film is fixed to the inner ply (circles, dotted line).

Detailed Description of an Embodiment

[0064] With reference to Figure 1 and Figure 2, an embodiment of a sack according to the present disclosure is described:
The sack (1) comprises a sack wall comprising an inner paper ply (2), an outer paper ply (3) and an intermediate moisture barrier film (4). The inner ply (2) may be of paper having a stretch level of N and the outer ply (3) may be of paper having a stretch level of either SE or E. For example, the inner ply (2) may be of QuickFill® Xrun paper (Billerud AB, Sweden) and the outer ply (3) may be of QuickFill® SE paper (Billerud AB, Sweden). The intermediate moisture barrier film (4) may be a polyethylene (PE) film, such as a 50 μm thick film. Slits (6) are provided in the moisture barrier film (4). For example, the slits (6) are provided so that the each slit intersects an imaginary straight line, in the plane of the plies, drawn between two attachment points (5, 7), wherein attachment points (5, 7) and the slits (6) form a "row" (9) around the circumference of the sack (1). Further, the slits (6) may for example be 50 mm long and separated by 25 mm. The moisture barrier film (4) may be alternatively attached to the inner (2) and outer (3) ply between the slits (6) with an adhesive substance at inner (5) and outer (7) attachment positions, respectively, as is shown in Figure 2, i.e. one inner attachment position (5) may be flanked by two outer attachment positions (7), and vice versa. Alternatively, the moisture barrier film (4) may only be attached to the inner ply (2) between the slits (6) with an adhesive substance at attachment positions (5) as is shown in Figure 1.

[0065] The sack material may be folded into a flattened tube with two ends for example by gluing overlapping portions of the inner ply (2), the outer ply (3) and together so as to form a longitudinal seam (8). The sack may be closed in one end by means of folding. Folding of open sack ends is a well-known operation in paper sack manufacture and can be carried out on automatic machinery. Extra paper material may be glued to the folded end so as to strengthen the sack construction. One open end of the sack may be adapted to fit a filling spout of a filling machine, so as to allow automatic filling of the sack. This may for example involve folding and gluing the open end around a vent material, which may be a paper of higher basis weight compared to the inner paper ply (2) or the an outer paper ply (3), so that an enforced vent is formed that is adapted to fit a filling spout of a filling machine.

Examples

1) Air permeability of two-ply paper materials

a. Materials and Methods

[0066] A common method for measuring air permeability of a paper, a combination of papers, or a paper material (e.g. several plies and moisture barrier film) is the Gurley method, which is a standard procedure that measures the time for a defined volume of air to pass through a defined area of the test substrate at a constant pressure. The Gurley method is specified in ISO5636/5. In these examples an internally developed measurement system named the BigGurley equipment was used. The measurement area was 400 cm^2 (200x200 mm). The working principle was the same as in a larger MegaGurley equipment supplied by Haver & Boecker (Germany), i.e. the flow of air through the defined area (400 cm^2) was measured as volume flow per unit time at a given pressure difference.

b. Results - the effect of a moisture barrier film on the air permeability

[0067] The air permeability of a material containing two paper plies with different friction qualities, either corrugated paper or plain paper, was measured with the BigGurley equipment. The air permeability of a material having a moisture barrier film of polyethylene (PE) arranged between the two paper plies was also measured. Measurements were performed at 10, 20 and 30 mbar. The results are displayed in Figure 3. The presence of a moisture barrier film decreased the air permeability; for example at 30 mbar the air permeability was about four times lower when a moisture barrier film was used.

c. Results -air permeability vs. paper stretch levels

[0068] A polyethylene (PE) barrier was arranged between two paper plies. Papers with different stretch levels were used as the inner and outer ply, respectively. Either natural paper (N), semi-extensible (SE) or fully extensible (E) paper were used. Slits were created in the PE-film in two rows with four slits in each row. The slits were 40 mm long and spaced 50 mm apart. The PE-film was alternatively glued to the inner and outer ply between the slits; in total three times to the inner ply and two times to the outer ply in each row of slits. Thus, the paper plies and PE film constituted an arrangement similar to what is described in Figure 2. The air permeability was measured in the BigGurley equipment. The results for different combinations of inner and outer plies are seen in Figure 4 and Figure 5. The air permeability increased two to five times when the order of the plies ply was changed from E:N to N:E (inner:outer) (Fig. 4), i.e. when the paper with the highest stretch level was used as the outer ply. When both plies were of the same paper grade (E), the air permeability was similar as to when the combination E:N (inner:outer) was used. The air-permeability doubled when the combination of inner:outer ply was changed from SE:N to N:SE (Fig. 5). In practice, the material was simply turned between the measurements. Consequently, when the expandability of the outer ply is higher than the expandability of the inner ply, the air permeability of the tested material is substantially increased.

2) Air permeability of folded sacks

a. Materials and Methods

[0069] The MegaGurley equipment from Haver & Boecker (Germany) was used for testing the air-permeability of sacks. The working principle was the same as the BigGurley equipment described above, i.e. the flow of air (volume per unit time) was measured at a given, but adjustable, pressure difference. A valve sack was placed over the air-filling spout and an expandable rubber sleeve was activated assuring a tight, non-leaking fit between the sack and the filling spout. The flow of air was then regulated with a regulator until the desired pressure difference (i.e. the internal over pressure) and the flow of air through the sack walls could be measured.

b. Results

[0070] A sack comprising two paper plies with an intermediate 50 μm thick PE film was manually folded. The inner and outer plies were papers with different stretch levels; either normal (N) grade or semi-extensible (SE) grade. 50 mm long slits, separated by 25 mm, were created in the PE-film around a whole circumference area of the upper section of the sacks. Further, the PE-film was alternatively glued to the inner and outer paper plies between the slits in order to form an arrangement similar to what is described in Figure 2. The air permeability of two types of sacks is seen in Figure 6. The sack having an outer ply of higher stretch level than the inner (N:SE) had more than a twofold higher air permeability compared to a sack having an outer ply of lower stretch level than the inner (SE:N). Consequently, the positive effect on air permeability when having an outer ply of higher expandability is also present in folded sacks. Moreover, the deaeration concept disclosed herein was compared to other commercially available deaeration concepts. In Figure 7, the air permeability of sacks with different deaeration concepts is shown. The other tested sacks were: a sack with multiple venting channels; a sack with a single venting channel; and a sack with two free edges of the barrier film wherein only one free edge of the barrier film is fixed to the inner ply. The results are normalized to the area of the different sacks, so that the influence of the sack size on the air permeability is eliminated. The deaeration concept according to the present disclosure was superior to the other tested commercially available deaeration concepts. As an example, the sack according to the present disclosure had about 20 - 40 % higher air permeability compared to the multiple venting channels sack, roughly twice as high air permeability compared to the single venting channel sack and about three times higher air permeability compared to the sack with two free edges of the barrier film wherein only one free edge of the barrier film is fixed to the inner ply.

ITEMIZED LISTINGS OF EMBODIMENTS OF THE INVENTION

[0071] The following is a non-limiting and itemized listing of embodiments of the invention, presented for the purpose of providing further information regarding the various features and combinations provided by the invention.

1. A sack, wherein:

   at least part of a sack wall of said sack comprises an inner ply, an outer ply and an air permeable moisture barrier film arranged between said inner ply and said outer ply, and a parameter of said outer ply relates to said parameter of said inner ply so as to form an interply space between said inner and said outer ply if an overpressure is present inside said sack; and
   said sack is adapted to form at least one film-ply deaeration space between said moisture barrier film and said outer ply within said at least part of said sack wall if said overpressure is present inside said sack.

2. The sack according to item 1, wherein at least one of said inner ply and said outer ply is a paper ply.

3. The sack according to item 2, wherein said inner ply and said outer ply are paper plies.

4. The sack according to any preceding item, wherein said parameter is an expandability parameter, and the expandability of said outer ply is higher than the expandability of said inner ply.

5. The sack according to any preceding item, wherein said moisture barrier film is attached to said inner ply at at least one position so as to form said film-ply deaeration space if said overpressure is present inside said sack.

6. The sack according to item 5 wherein said moisture barrier film is further attached to said outer ply at at least one position.

7. The sack according to any one of items 5-6, wherein said moisture barrier film is attached by means of an adhesive.

8. The sack according to any one of items 4-7, wherein said expandability parameter of a ply is defined as an area expansion (ΔA) of said ply at an increase of the pressure (ΔP) inside said sack.

9. The sack according to any previous item, wherein said outer ply has an inner and an outer surface, and said inner surface of said outer ply comprises pro-

trusions so as to form said film-ply deaeration space if said overpressure is present inside said sack.

10. The sack according to any previous item, wherein said outer ply comprises a friction pattern.

11. The sack according to any previous item, wherein said outer ply is micro-creped.

12. The sack according to any previous item, wherein the basis weight of said inner ply is higher than the basis weight of said outer ply.

13. The sack according to any previous item, wherein *E*d* of said inner ply is higher than *E*d* of said outer ply.

14. The sack according to item 13, wherein *E*d* of said inner ply is at least 10 % higher than *E*d* of said outer ply.

15. The sack according to item 14, wherein *E*d* of said inner ply is at least 50 % higher than *E*d* of said outer ply.

16. The sack according to any one of items 13-15, wherein d of said inner ply is higher than d of said outer ply.

17. The sack according to any preceding item, wherein said overpressure is at least 10 mbar.

18. The sack according to any of the previous items, wherein said inner ply is consists of a natural (N) grade paper, and said outer ply consists of a paper selected from semi-extensible (SE) and fully extensible (E) grade paper.

19. Use of a sack according to any one of items 1-18 for holding a powdery or granularly material.

20. Use of a sack according to any one of items 1-18 for holding a material selected from food, animal feed and pet food.

21. Use of a paper having a friction pattern in the manufacture of a sack according to any one of items 1-18.

22. The use according to item 21, wherein said paper having a friction pattern is used for the outer ply of said sack.

23. Use of a paper having no friction pattern in the manufacture of a sack according to any one of items 1-18.

24. The use according to item 23, wherein said paper having no friction pattern is used for the inner ply of said sack.

25. Use of a micro-creped paper in the manufacture of a sack according to any one of items 1-18.

26. A material for the manufacture of a sack according to any one of items 1-18, comprising a first ply, a second ply and an air permeable moisture barrier film sandwiched between said first ply and said second ply, wherein a parameter of said first ply relates to said parameter of said second ply so as to form an interply space between said first and said second ply if said material separates a space of overpressure from a space of atmospheric pressure and said second ply faces said separated space of overpressure and
said material is adapted to form at least one film-ply deaeration space between said moisture barrier film and said first ply if said second ply faces said separated space of overpressure.

27. The material according to item 26, wherein at least one of said first ply and said second ply is a paper ply.

28. The material according to item 27, wherein said first ply and said second ply are paper plies.

29. The material according to item 28, wherein said parameter is an expandability parameter and the expandability of said first ply is higher than the expandability of said second ply.

30. The material according to any one of items 26-29, wherein said moisture barrier film is attached to said second ply at at least one position so as to form said film-ply deaeration space if said second ply faces said separated space of overpressure.

31. The material according to item 30, wherein said moisture barrier is further attached to said first ply at at least one position.

32. The material according to any one of items 30-31, wherein said moisture barrier film is attached by means of an adhesive.

33. The material according to any one of items 29-32, wherein said expandability parameter of a ply is defined as an area expansion (ΔA) of said ply at the provision of an overpressure (ΔP) at said separated space facing said second ply.

34. The material according to any one of items 26-33, wherein said first ply has an inner and an outer surface, and said inner surface of said first ply comprises protrusions so as to from said film-ply deaeration

space if said second ply faces said separated space of overpressure.

35. The material according to any one of items 26-34, wherein the basis weight of said second ply is higher than the basis weight of said first ply.

36. The material according to any one of items 26-35, wherein *E*d* of said second ply is higher than *E*d* of said first ply.

37. The material according to item 36, wherein *E*d* of said second ply is at least 10 % higher than *E*d* of said first ply.

38. The material according to item 37, wherein *E*d* of said second ply is at least 50 % higher than *E*d* of said first ply.

39. The material according to any one of items 36-38, wherein d of said second ply is higher than d of said first ply.

40. The material according to any one of items 26-39, wherein said overpressure is at least 10 mbar.

41. The material according to any one of items 26-40, wherein said second ply is consists of a natural (N) grade paper, and said first ply consists of a paper selected from semi-extensible (SE) and fully extensible (E) grade paper.

42. The material according to any one of items 26-41, wherein said first ply comprises a friction pattern.

43. The material according to item 42, wherein said second ply comprises no friction pattern.

44. A method for deaeration of a sack having an inner ply, an outer ply and an air permeable moisture barrier film arranged between said plies during a filling of said sack causing an overpressure inside said sack, comprising the steps of:

a) forming an interply space between said plies at at least part of a sack wall of said sack; and
b) forming a film-ply deaeration space between said moisture barrier film and said outer ply at said at least part of said sack wall.

45. The method according to item 44, wherein at least one of said inner ply and said outer ply is a paper ply.

46. The method according to item 45, wherein said inner ply and said outer ply are paper plies.

47. A method for the manufacture of a sack adapted to form at least one film-ply deaeration space between a moisture barrier film and an outer ply within at least part of a sack wall of said sack if an overpressure is present inside said sack, comprising the steps of:

a) providing a first ply, a second ply and a moisture barrier film;
b) arranging said moisture barrier film between said first and said second ply to form a sack material;
c) tubing and cutting said sack material from step b) to form a tubular piece with two open ends, wherein said first ply is forming an outer ply and said second ply is forming an inner ply of said tubular piece, and
d) closing at least one end of said tubular piece to form said sack,

wherein a parameter of said first ply relates to said parameter of said second ply so as to form an interply space between said inner and outer ply if said overpressure is present inside said sack.

48. The method according to item 47, wherein at least one of said inner ply and said outer ply is a paper ply.

49. The method according to item 48, wherein said inner ply and said outer ply are paper plies.

50. The method according to any one of items 47-49, wherein said parameter is an expandability parameter and the expandability of said first ply is higher than the expandability of said second ply.

51. The method according to any one of items 47-50, wherein step b) further comprises attaching said moisture barrier film to said second ply.

52. The method according to item 51, wherein step b) comprises applying an adhesive to said second ply or said moisture barrier film and said attachment of said moisture barrier film to said second ply is achieved by bringing said moisture barrier film into contact with said adhesive applied to said second ply.

53. The method according to any one of items 47-52, wherein step b) further comprises attaching said moisture barrier film to said first ply.

54. The method according to item 53, wherein step b) comprises applying an adhesive to said first ply or said moisture barrier film and said attachment of said moisture barrier film to said first ply is achieved by bringing said moisture barrier film into contact with said adhesive applied to said first ply.

55. The method according to any one of items 47-54, further comprising the step of:

aa) forming air permeable openings in said moisture barrier film from step a).

56. The method according to item 55, wherein step aa) comprises cutting slits in said moisture barrier film.

57. The method according to any one of items 47-56, wherein said closing of step d) is performed by means of folding.

Claims

1. A sack (1), wherein:

at least part of a sack wall of said sack (1) comprises an inner paper ply (2), an outer paper ply (3) and an air permeable moisture barrier film (4) arranged between said inner paper ply (2) and said outer paper ply (3), and an expandability parameter of said outer paper ply (3) relates to said expandability parameter of said inner paper ply (2) so as to form an interply space between said inner (2) and said outer (3) paper ply if an overpressure is present inside said sack (1); and
said sack (1) is adapted to form at least one film-ply deaeration space between said moisture barrier film (4) and said outer paper ply (3) within said at least part of said sack wall if said overpressure is present inside said sack (1).

2. The sack (1) according to claim 1, wherein said moisture barrier film (4) is attached to said inner paper ply (2) at at least one position so as to form said film-ply deaeration space if said overpressure is present inside said sack (1).

3. The sack (1) according to claim 2 wherein said moisture barrier film (4) is further attached to said outer paper ply (3) at at least one position.

4. The sack (1) according to any one of the preceding claims, wherein said expandability parameter of a paper ply is defined as an area expansion (ΔA) of said paper ply (2, 3) at an increase of the pressure (ΔP) inside said sack (1).

5. The sack (1) according to any one of the preceding claims, wherein said outer paper ply (3) comprises a friction pattern.

6. The sack (1) according to any one of the preceding claims, wherein E^*d of said inner paper ply (2) is higher than E^*d of said outer paper ply (3).

7. The sack (1) according to any one of the preceding claims, wherein d of said inner paper ply (2) is higher than d of said outer paper ply (3).

8. The sack (1) according to any one of the preceding claims, wherein said overpressure is at least 10 mbar.

9. The sack (1) according to any one of the preceding claims, wherein said inner paper ply (2) is consists of a natural (N) grade paper, and said outer paper ply (3) consists of a paper selected from semi-extensible (SE) and fully extensible (E) grade paper.

10. Use of a sack (1) according to any one of claims 1-10 for holding a powdery or granularly material.

11. A material for the manufacture of a sack (1) according to any one of claims 1-9, comprising a first paper ply (3), a second paper ply (2) and an air permeable moisture barrier film (4) sandwiched between said first paper ply (3) and said second paper ply (2), wherein an expandability parameter of said first paper ply (2) relates to said expandability parameter of said second paper ply (3) so as to form an interply space between said first (2) and said second paper ply (3) if said material separates a space of overpressure from a space of atmospheric pressure and said second paper ply (2) faces said separated space of overpressure and
said material is adapted to form at least one film-ply deaeration space between said moisture barrier film (4) and said first paper ply (3) if said second paper ply (2) faces said separated space of overpressure.

12. The material according to claim 11, wherein said expandability parameter of a paper ply is defined as an area expansion (ΔA) of said paper ply at the provision of an overpressure (ΔP) at said separated space facing said second paper ply (2).

13. A method for deaeration of a sack (1) having an inner paper ply (2), an outer paper ply (3) and an air permeable moisture barrier film (4) arranged between said paper (2, 3) plies during a filling of said sack (1) causing an overpressure inside said sack (1), comprising the steps of:

a) forming an interply space between said paper plies (2, 3) at at least part of a sack wall of said sack (1); and
b) forming a film-ply deaeration space between said moisture barrier film (4) and said outer paper ply (3) at said at least part of said sack wall.

14. A method for the manufacture of a sack (1) adapted to form at least one film-ply deaeration space between a moisture barrier film (4) and an outer paper ply (3) within at least part of a sack wall of said sack (1) if an overpressure is present inside said sack (1), comprising the steps of:

a) providing a first paper ply (3), a second paper ply (2) and a moisture barrier film (4);
b) arranging said moisture barrier film (4) between said first (3) and said second paper ply (2) to form a sack material;
c) tubing and cutting said sack material from step b) to form a tubular piece with two open ends, wherein said first paper ply (3) is forming an outer paper ply and said second paper ply (2) is forming an inner paper ply of said tubular piece, and
d) closing at least one end of said tubular piece to form said sack (1),

wherein an expandability parameter of said first paper ply (3) relates to said expandability parameter of said second paper ply (2) so as to form an interply space between said inner (2) and said outer (3) paper ply if said overpressure is present inside said sack (1).

15. The method according to claim 14, wherein step b) further comprises attaching said moisture barrier film (4) to said second paper ply (2).

16. The method according to any 14 or 15, wherein step b) further comprises attaching said moisture barrier film (4) to said first paper ply (3).

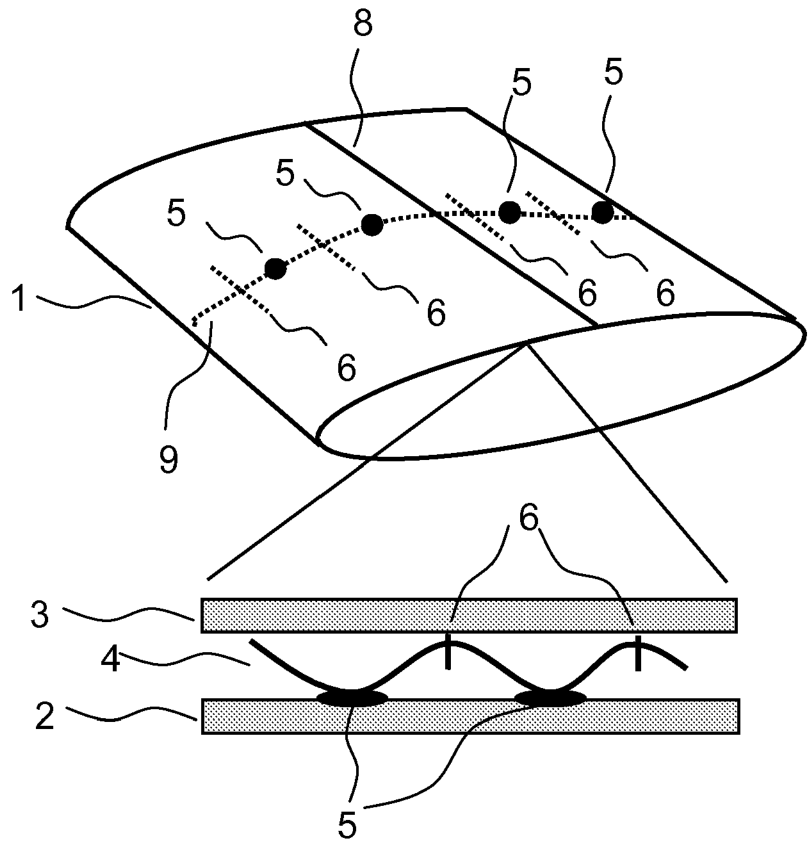

FIGURE 1

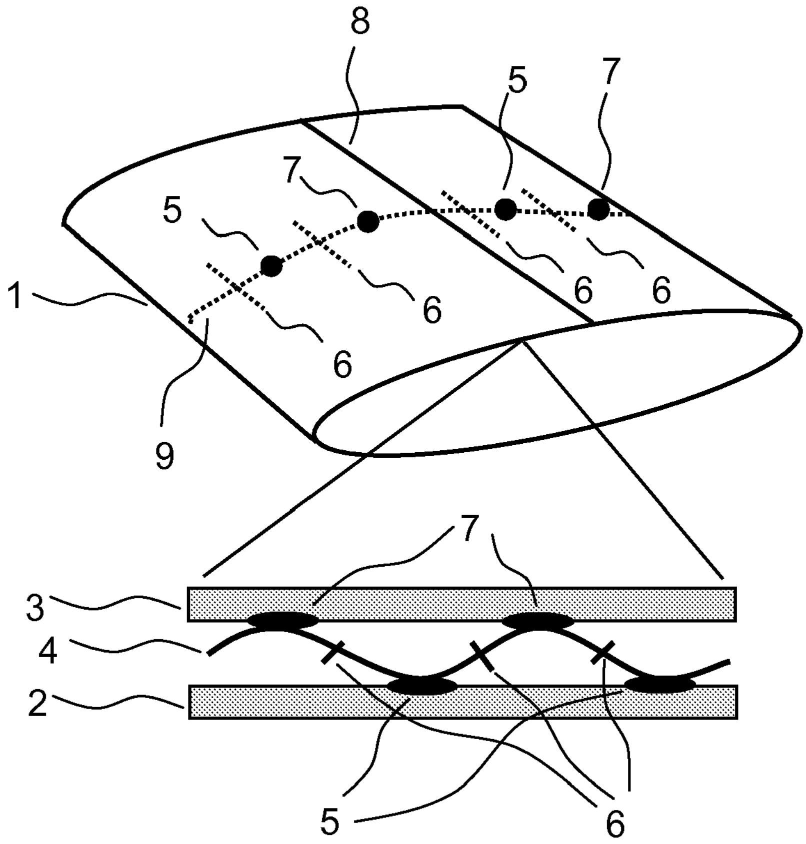

FIGURE 2

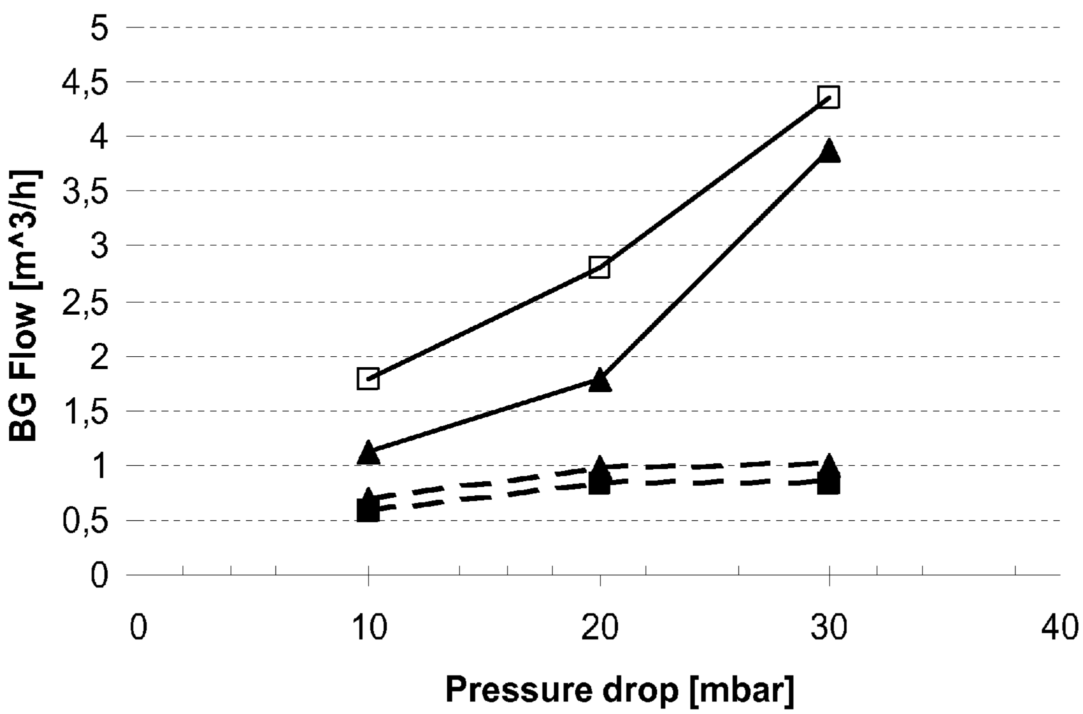
5
4,5
4
3,5
3
2,5
2
1,5
1
0,5
0
BG Flow [m^3/h]
0
10
20
30
40
Pressure drop [mbar]

FIGURE 3

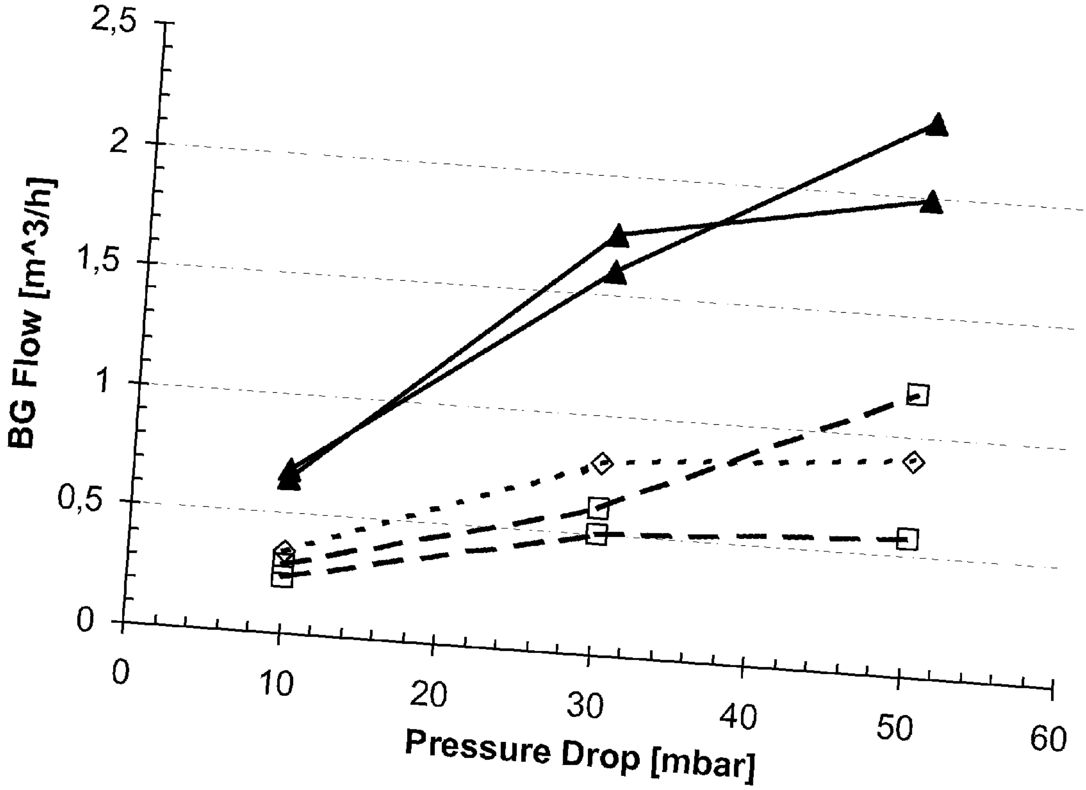

FIGURE 4

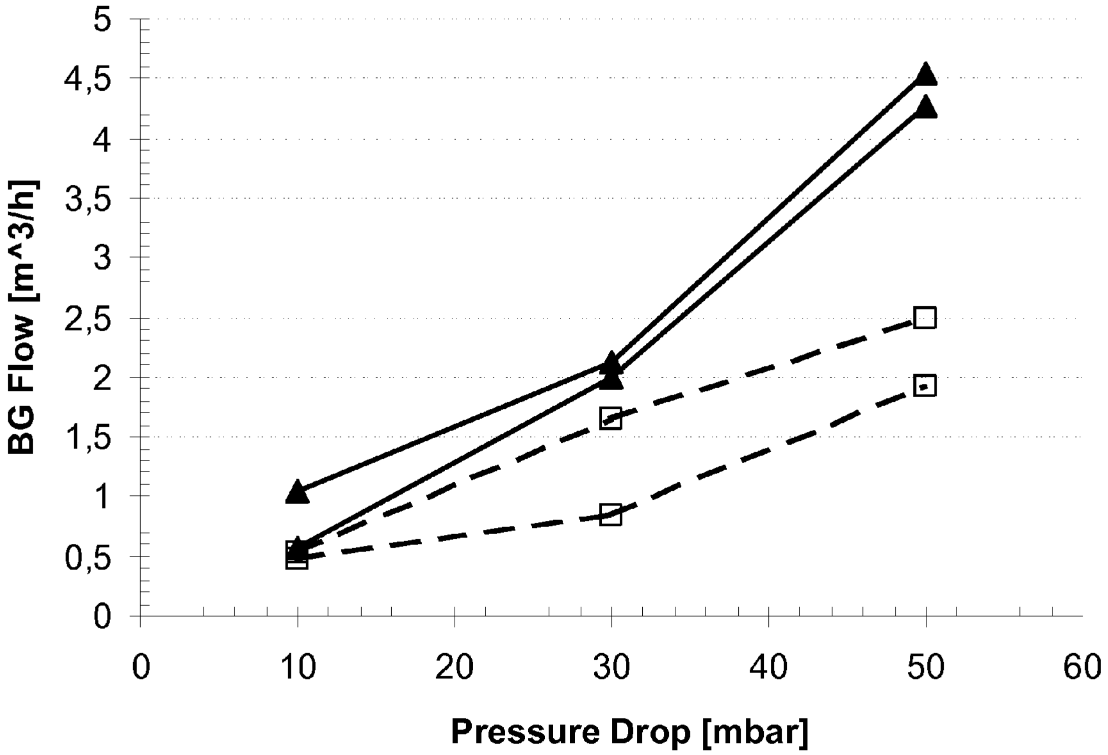
5
4,5
4
3,5
3
2,5
2
1,5
1
0,5
0
BG Flow [m^3/h]
0
10
20
30
40
50
60
Pressure Drop [mbar]

FIGURE 5

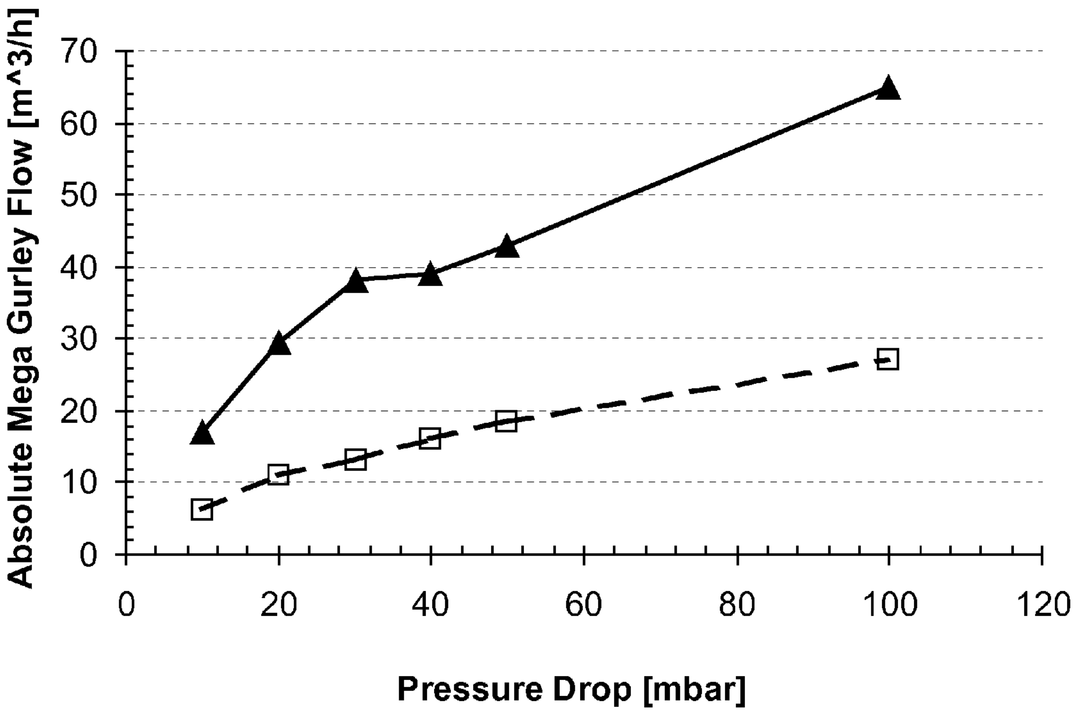
Absolute Mega Gurley Flow [m^3/h]
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
Pressure Drop [mbar]

FIGURE 6

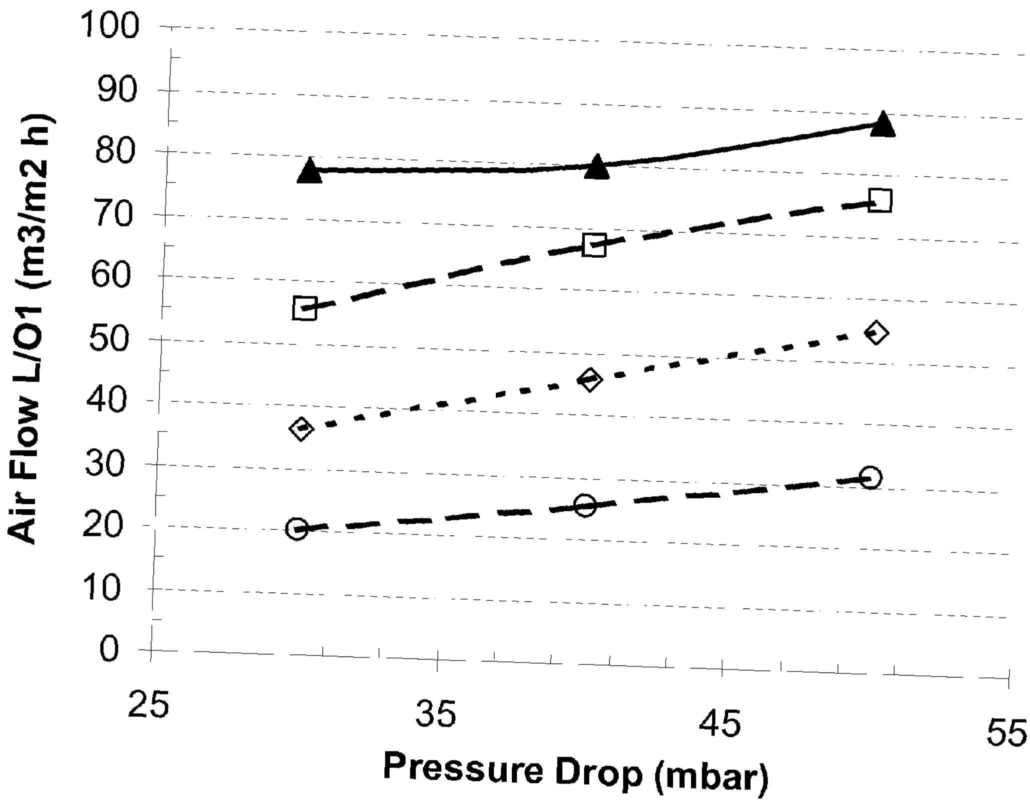
100
90
80
70
60
50
40
30
20
10
0
Air Flow L/O1 (m3/m2 h)
25
35
45
55
Pressure Drop (mbar)

FIGURE 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 15 2531

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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	5 August 2008	Segerer, Heiko

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05-08-2008

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