

EMBOSSSED FLUID FILTER ELEMENT

BACKGROUND OF THE INVENTION

[0001] This invention relates to a fluid filter element and method of forming the same.

[0002] Fluid filter elements are well known and are widely used in fluid filters for varying areas of use, including hydrodynamic machines and air-conditioning engineering. Their meander-shaped or zig-zag structure provides a substantially increased filter area, in relation to a fixed afflux flow cross-section. In order to fix the fold walls of such a structure relative to each and to support them with respect to each other, various different kinds of design configurations have been developed. Filters with depressions which are embossed into the flat filter material and which, when the material is folded, bear against each other and support each other are known.

[0003] In the case of earlier fluid filter elements of that kind, the embossings of the fold walls were simply laid against each other when executing the folding operation and the filter element, which was finished as a kind of "fold pack" was externally fixed by being clamped in a box or frame. While such particularly simple fluid filter elements certainly operate satisfactorily at the beginning of their period of use and in areas of use which do not involve fluctuating pressure loadings worth mentioning, critical stability problems are found to occur in relation to certain degrees of filling with deposited dust particles, or dust loading, and in particular when used in relation to fluid-dynamic machines.

[0004] In order to resolve many of the above problems, US Patent Number 6,685,833 assigned to LPD technologies discloses a filter element comprising an embossed flat filter material which is folded so as to define a plurality of substantially adjacent walls, each wall having an embossing comprising a first embossing portion which extends from one side of said wall and a second embossing portion which is adjacent to said first embossing portion and which extends from the other side of said wall, and an adhesive connecting adjacent embossings of adjacent walls. The adhesive preferably has a substantially constant height. US Patent Number 6,685,833 is hereby incorporated by reference in its entirety.

SUMMARY OF THE DISCLOSURE

[0005] The primary object of the present disclosure is to provide a filter material with embossings that eliminate a rotation point within the pleat.

[0006] It is a further object of the present invention to provide a fluid filter element with an embossed flat filter material which is folded so as to define a plurality of substantially adjacent walls, each wall defining a planar surface between two adjacent fold lines, the wall having an embossing comprising: a first embossing row having a centrally located elongated positive embossment and a distal embossment at each end of the positive elongated embossment, wherein at least one distal embossment is negative; and a second embossing row spaced from and parallel to the first embossing row, the second embossing row having two elongated embossments, wherein one elongated embossment is negative and one is positive.

[0007] It is a further object of the present invention to provide a method for forming a fluid filter element, comprising the steps of: providing a flat filter material; forming a plurality of substantially parallel embossings in the filter material, the embossings comprising alternating first and second embossing rows, the first embossing row having a centrally located elongated positive embossment and a distal embossment at each end of the positive elongated embossment, wherein at least one distal embossment is negative; and the second embossing row spaced from and parallel to the first embossing row, the second embossing row having two elongated embossments, wherein one elongated embossment is negative and one is positive; applying an adhesive to at least a portion of the embossings; and folding the filter material in a zig-zag pattern so as to define walls of the filter material, each wall having the alternating first and second embossing rows, wherein the adhesive bonds the embossings of adjacent walls together.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] A detailed description of preferred embodiments of the present invention follows, with reference to the attached drawings, wherein:

[0009] Figure 1 illustratively depicts a side view of a filter material and embossed in accordance with US Patent Number 6,685,833;

[0010] Figure 2 illustratively depicts a side view of a filter material embossed with an intermediate embossment at the rotation point within the pleat;

[0011] Figure 2a illustratively depicts a top view of the filter material of Figure 2;

[0012] Figure 3 illustratively depicts a top view of the filter material and embossed in accordance with the present invention;

[0013] Figures 4a-4c illustratively depict side views of the filter material in accordance with the present invention;

[0014] Figures 5 and 6 illustratively depict the first embossing row in a view in section in a plane parallel to the fluid flow direction and perpendicular to the plane of the filter material, illustrating an embodiment of the filter element according to the invention;

[0015] Figure 7 illustratively depicts the second embossing row in a view in section in a plane parallel to the fluid flow direction and perpendicular to the plane of filter material, illustrating an embodiment of the filter element according to the invention;

[0016] Figures 8, 9 and 10 illustratively depict differing variations of filter material embossings;

[0017] Figure 11 illustratively depicts a top view of the filter material embossed in accordance with the present invention;

[0018] Figure 12 illustrates the accordion effect on embossed filter media;

[0019] FIG. 13 illustratively depicts a top view of the filter media of the present invention with a plurality of intermediate embossings;

[0020] FIG. 14 illustratively depicts a top view of the filter media of the present invention with a plurality of intermediate embossings and diagonal straight lines obtained; and

[0021] FIG. 15 illustratively depicts a top view of the filter media of the present invention with glue placement on a plurality of intermediate embossings.

DETAILED DESCRIPTION

[0022] This disclosure is drawn to a filter material with embossings that eliminate a rotation point within the pleat. Embossings, i.e. dimples, are formed on the filter material by any means which is well known within the art. One objective of the present invention is to reduce the pressure drop within the system by reducing the embossed surface area of the filter paper, i.e. standard intermediate embossings are removed, and by improving the aerodynamics, which keeps the pleat from deforming.

[0023] FIG. 1 illustrates a wall of filter material **4** and the structure of embossings **1** formed in filter material **4** in accordance with US Patent Number 6,685,833. FIG. 8 illustrates a side view of a folded series of the walls of FIG.1. FIG. 1 shows flat material **4** provided with a series of embossings **1** which would be arranged in parallel rows wherein each embossing **1** is substantially planar and has a first embossing portion extending from one side of material **4** and a second embossing portion extending from the other side of material **4**. These embossings can advantageously be formed in material **4** using embossing rollers or any other apparatus suitable for forming contoured structure in material **4** as desired. During use, pressure is exerted on the filter material **4**, and the material begins to bend at rotation point **2**, which is the point where the embossing **1** passes from one side of the material **4** to the other. This results in bending of the wall having embossings **1** in the

direction of arrows **5**. Rotation point **2** renders the complete pleating of the filter material **4** very difficult and also results in an unstable filter. Bending of the filter material **4** around the rotation point **2** also increases the pressure of the flow through the filter material **4** leading to a negative change in aerodynamics.

[0024] FIGS. 2, 2a and 9 depict the introduction of an intermediate embossing **3**. FIG. 9 illustrates a side view of a folded series of walls to illustrate the position of embossing **3**. FIGS. 2 and 2a further illustrate walls **4** having embossings **1** and intermediate embossing **3** of filter material **4**. The intermediate embossing **3** is positioned in an alternating position between embossings **1**. The placement of the intermediate embossing **3**, as shown in FIG. 2a, helps to avoid the undesirable characteristics described above by providing stiffness of the material **4** against bending around point **2** of the pleat. Intermediate embossing or dimple **3** stiffens the filter wall at the rotation point **2** of FIG. 1, but this extra embossing leads to more cost in preparation and can also reduce the effective filter area of the filter.

[0025] FIG. 3 depicts a preferred orientation of embossings **10**, **10a**, **12**, **14**, **14a** in accordance with the present invention. A first embossing row, **10**, **10a**, **12**, is shown having a centrally located elongated positive embossment **12** and distal embossment **10**, **10a** at each end of the positive elongated embossment **12**. At least one distal embossment **10a** in the first embossing row is negative, that is, it extends from the sheet of the filter material in a direction opposite to that of embossments **10**, **12**, which are considered positive. A second embossing row having two elongated embossments **14**, **14a** is also formed and positioned

at a location laterally spaced from embossments **10**, **12**, **10a**. The alternating embossment segments avoid locations where an embossment transitions between negative and positive and thereby avoids the formation of bending lines or rotation points **2** as are present in the prior art configurations. At least one elongated embossment **14a** is negative.

[0026] FIG. 4a and 4b depict the first embossing row **1-a** and the second embossing row **1-b**, respectively. When folded into a filter structure, the first embossing row **1-a** and the second embossing row **1-b** extend parallel to each other along the material and the overlap of the various embossed segments prevents the formation of a rotation point as was formed in the material **4** of FIG. 1.

[0027] FIGS. 5 and 6 illustrate a portion of a filter in accordance with the present invention drawn through embossings **14**, **14a**. The filter media **20** according to the invention is formed from a filter fleece or non-woven cloth material, typically made from glass fiber and plastic fiber components or the like. Fold edge regions **30**, **32** define walls **40** of material **20** therebetween, and embossing portions **14** and **14a** are advantageously defined in a single plane, and the plane of embossing portions **14** and **14a** is preferably oriented relative to the plane of walls **40** such that when material **20** is folded into the "V" pattern shown in FIGS. 5 and 6, embossing portions **14** and **14a** are substantially parallel to and equally spaced from embossing portions **14** and **14a** of adjacent walls **40**.

[0028] Hot melt adhesive threads **32** are applied on both sides in the region of the embossings **14** and **14a**. When folded to the position shown in FIGS. 5 and 6, the hot melt adhesive threads **32** join together to form interconnected

adhesive support portions. The mutually adjacent fold walls **40**, after the adhesive **32** has set, are respectively clamped firmly in position on both sides, by virtue of those adhesive support portions **32**, which is a substantial improvement over prior art configurations.

[0029] FIG. 7 illustrates a portion of a filter in accordance with the present invention drawn through embossings **10**, **12**, **10a**. The filter media **20** according to the invention is formed from a filter fleece or non-woven cloth material, typically made from glass fiber and plastic fiber components or the like. Fold edge regions **30**, **32** define walls **40** of filter media **20** therebetween, and embossing portions **10**, **10a**, and **12** are advantageously defined in a single plane, and the plane of embossing portions **10**, **10a**, and **12** is preferably oriented relative to the plane of walls **40** such that when material **20** is folded into the "V" pattern shown in FIG. 7, embossing portions **10**, **10a**, and **12** are substantially parallel to and equally spaced from embossing portions **10**, **10a**, and **12** of adjacent walls **40**.

[0030] Hot melt adhesive threads **34** are applied on both sides in the region of the embossing **10a** alone and embossings **10** and **12** in conjunction. When folded to the position shown in FIG. 7, the hot melt adhesive threads **34** join together to form interconnected adhesive support portions. The mutually adjacent fold walls **40**, after the adhesive **34** has set, are respectively clamped firmly in position on both sides, by virtue of those adhesive support portions **34**, which is a substantial improvement over prior art configurations.

[0031] An additional undesirable bending or accordion effect is illustrated in FIG. 12. The accordion effect

contributes to the deformation of the pleat, which in turn increases the pressure drop of the filter due to the bad aerodynamics of a deformed (not a perfect V shaped) pleat. The views of FIG. 12 illustrate this undesirable bending, which can happen when embossings spread laterally as shown. **x** represents the ideal configuration of a cross section of embossings. See FIG. 10 section **F12**. As air blows through filter media **20**, pressure increases and the embossings begin to laterally spread, as illustrated by **y**. The pleated filter media **20** will begin to flatten and lose resistance to bending. As a result of the continuing increase in pressure, the embossings will lose form, as illustrated by **x+y**. When the embossings stretch and lose form the pleats also will stretch and lose form, as shown in the third view of FIG. 12. Intermediate embossings positioned according to the invention leave unembossed zones of material that help resist lateral spreading of the embossments, because the flat, non-embossed portion of material helps to resist the lateral spreading. Preferably, the non-embossed portions are positioned so that, taken together, they define a diagonal line (See Figure 11) of embossing free filter media which helps to prevent stretching of the pleat and embossings.

[0032] The configuration of the embossings according to the invention eliminates both rotation point **2** of FIG. 1 and the accordion effect of FIG. 12. The filter portions shown in FIGS. 5-7 illustrate the orientation of the folded and glued filter media **20** as shown in FIGS. 3 and 11. The configuration of the dimples eliminates the horizontal rotation point **2** by creating a more desirable diagonal line **40** of unembossed portions of filter media **20**. This configuration of the unembossed to embossed portions of

filter media **20** reduces the accordion effect, wherein the embossings rest upon one another to support the filter media **20** as air is forced through it.

[0033] As seen in FIG. 11, the main intermediate embossing **12** is both above and below diagonal **40**. Intermediate embossing **12** is able to perform a double function. In order to sustain the pressure within the system, embossing **12** helps to keep the pleated filter media **20** as straight as possible and embossing **12** also helps to keep the accordion effect of material **20** to a minimum. Diagonal **40** helps to decrease the pressure flow through filter media **40** leading to less resistive aerodynamics through the system. The current design illustrated in FIGS. 3-7 reduces the pressure drop caused by deformation of the filter walls and thereby preserving the desired flow characteristics of the filter.

[0034] FIGS. 5 through 7 show fold lines **30** for material **20**, which are present along fold edges of material transverse to the embossings as shown for example in FIGS. 3 and 11. The preferred orientation of embossing rows **1-a** and **1-b** provide that when folded, first embossing portions **1-a** will face each other, and second embossing portions **1-b** will also face each other. Embossing rows **1-a** and **1-b** are positioned substantially parallel to each other so as to facilitate application of adhesive to embossing rows **1-a** and **1-b** at a constant flow-rate of adhesive, which provides for a constant height or amount of adhesive per length as desired in accordance with the present invention.

[0035] FIG. 13 depicts the filter media of the present invention with a plurality of intermediate embossings, i.e. positive embossments, negative embossments and combinations thereof. It has been found that an increase in the number

of intermediate embossings will increase the strength of the filter material and decrease the bending of the walls due to force exerted on the filter material by the air pressure.

[0036] FIG. 14 depicts the diagonal straight lines of non-embossed material that may be formed on filter media comprising a plurality of intermediate embossings. As shown, the intersecting diagonal lines of non-embossed material can provide a truss-like reinforcement to the wall to prevent accordion or spreading of the embossed portions.

[0037] FIG. 15 depicts the placement of the glue on filter media comprising a plurality of intermediate embossings.

[0038] It is to be understood that the present disclosure is not limited to the illustrations described and shown herein, which are deemed to be merely illustrative of the best modes of carrying out the invention, and which are susceptible of modification of form, size, arrangement of parts and details of operation. The present disclosure rather is intended to encompass all such modifications which are within its spirit and scope as illustrated by the figures and defined by the claims.

WHAT IS CLAIMED IS:

1. A fluid filter element comprising:

an embossed flat filter material which is folded so as to define a plurality of substantially adjacent walls, each wall defining a planar surface between two adjacent fold lines, said wall having an embossing comprising:

a first embossing row having a centrally located elongated positive embossment and a distal embossment at each end of the positive elongated embossment, wherein at least one distal embossment is negative; and,

a second embossing row spaced from and parallel to the first embossing row, the second embossing row having two elongated embossments, wherein one elongated embossment is negative and one is positive.

2. The filter element of claim 1, wherein spaces are defined along the first embossing row between the centrally located positive embossment and each of the distal embossments, wherein a space along the second embossing row between the two elongated embossments, and wherein the spaces of the first embossing row are not aligned with each other.

3. The filter element of claim 1, wherein the second embossings are substantially uniformly spaced.

4. The filter element of claim 1, wherein said walls define wall edges each having at least two fold lines.

5. The filter element of claim 1, wherein said first embossing row and said second embossing row are formed in alternating sequence.

6. The filter element of claim 1, wherein said first embossing row and said second embossing row define a straight diagonal line of embossing free filter material.

7. The filter element of claim 1, wherein said first embossing row further comprises a plurality of centrally located elongated embossment selected from the group consisting of positive embossment, negative embossment and combinations thereof.

8. A method for forming a fluid filter element, comprising the steps of:

 providing a flat filter material;

 forming a plurality of substantially parallel embossings in the material, the embossings comprising alternating first and second embossing rows:

 the first embossing row having a centrally located elongated positive embossment and a distal embossment at each end of the positive elongated embossment, wherein at least one distal embossment is negative; and,

 the second embossing row spaced from and parallel to the first embossing row, the second embossing row having two elongated embossments, wherein one elongated embossment is negative and one is positive;

 applying an adhesive to at least a portion of the embossings; and,

folding the material in a zig-zag pattern so as to define walls of the material, each wall having the alternating first and second embossing rows, wherein the adhesive bonds the embossings of adjacent walls together.

9. The method of claim 8, wherein spaces are defined along the first embossing row between the centrally located elongated positive embossment and each of the distal embossments, wherein a space along the second embossing row between the two elongated embossments, and wherein the spaces of the first embossing row are not aligned with each other.

10. The method of claim 8, wherein said first embossing row and said second embossing row define a straight diagonal line of embossing free filter material.

11. The method of claim 8, wherein the folding step positions the walls so that embossings of adjacent walls are substantially parallel.

12. The method of claim 8, wherein the applying step comprises applying a substantially constant amount of adhesive to the material per unit length of material.

13. The method of claim 8, wherein the applying step is selected from the group consisting of applying the adhesive as a continuous thread, applying the adhesive in spots, and combinations thereof.

14. The method of claim 8, wherein said first embossing row further comprises a plurality of centrally located

elongated embossment selected from the group consisting of positive embossment, negative embossment and combinations thereof