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(54) **NEEDLE FELT**

NADELFILZ

FEUTRE AIGUILLETÉ

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Description

[0001] The invention relates to a binderless needle felt of mineral wool, comprising a plurality of fibers arranged predominantly in parallel to the large areas of the needle felt, and individual fibers at needling points which are arranged predominantly transversely to the large areas by a needling process and by which the fibers of the needle felt are felted such that the needle felt is adapted to be handled as one element, in accordance with the preamble of claim 1.

[0002] Such needle felts are frequently used in systems or devices in which they are subject to substantial thermal strain. Heating systems, electric ovens or the like have to be mentioned as examples. The binderless design of the needle felt renders it substantially free of organic components, so that a binder decomposition by the effect of temperature is excluded. Consequently, odor nuisance associated therewith does not occur, either.

[0003] On the other hand, such needle felts must, as a matter of fact, also have sufficient inherent stability to be adapted to be handled as one element. To this end, they are subject to a needling process, so that the fibers within the needle felt are felted among each other. An example of such a needle felt, which is moreover also intended for further applications, has become known by DE 22 32 785 A.

[0004] The fibers for such a needle felt are produced in a per se conventional manner by a defibration process of a mineral melting and are subsequently deposited on a collecting member. In doing so, a primary fleece is formed in which the individual fibers are arranged predominantly in parallel to the large areas of the needle felt. Since no binder is added to the fibers, the structural coherence in this primary fleece is restricted. In a subsequent needling process, a plurality of needles is then introduced into the primary fleece through the large areas at predetermined needling points. These needles comprise barbed hooks by which individual fibers are seized and taken along. The fibers pulled more deeply into the needle felt in this manner produce a fiber mingling of the fleece and arrange themselves predominantly transversely to the large areas. Such a needling process is, as a rule, performed as a double needling at both large areas so as to ensure the structural integrity of the needle felt. The puncture density of the needling points is typically 11.5 needling points per square centimeter on each side. In this process, these needles are introduced in grid-type by means of so-called needle bars, wherein the number of needles per centimeter working width, i.e. the width of the primary fleece web, is typically 20 needles per centimeter.

[0005] Additionally, needle felts may be lined so as to ensure sufficient handling ability, which is predominantly done with needle felts having low bulk density under approximately 50 kg/m³. Since high temperature resistance is, as a rule, important in the fields of use of such needle felts, the lining is typically made of aluminum or an aluminum alloy and fixed by means of an inorganic glue. A needle felt lined in this way is, for instance, used for the insulation of electric ovens. It has, however, turned out in practice that absolutely relevant disadvantages may be associated therewith.

[0006] Thus, the effort associated with the production of the lining is substantial. Irrespective of the fact that additional working steps are required for this purpose, both the lining foil as such and the special inorganic glue used are relatively expensive. A disadvantage that is particularly essential for the practical utilizability lies, however, in the fact that the usually applied aluminum lining is electrically conductive. This leads to problems with the electric control systems of the devices insulated with this lined needle felt since the lining may interfere with possible sensor elements. Moreover, there is a problem of possible short circuits caused by this lining, so that additional effort has to be undertaken to encounter this problem. For these reasons, lining is only performed when the mechanical properties of an unlined product are insufficient from handling aspects.

[0007] In practice, due to the steadily increasing demands on energy efficiency in general, in particular of electric ovens as an important field of use of needle felts, there is a demand for needle felts having improved insulating behavior as compared to the products presently available in the market.

[0008] Document US 5,290,522 discloses a catalytic converter including a nonwoven mat comprising shot-free, high-strength, magnesium aluminosilicate glass fibers.

[0009] Further, JP H7-96563 A refers to a vacuum insulation panel including a needle felt as a heat-insulating member.

[0010] The European patent application EP 0 498 276 A1 discloses a method and device for the production of mineral wool boards. The mineral wool material will be needle punched during the production process stepwise from a large area to the opposite large area of the needle felt. However, the mineral wool product provided here has a binder.

[0011] Finally, document EP 1 669 485 A2 discloses a glass wool shaped article and a method of formation thereof in the form of a binderless needle felt of mineral wool according to the preamble of claim 1.

[0012] It is therefore an object of the invention to improve such a needle felt of mineral wool such that the above-mentioned drawbacks can be avoided and that the needle felt has improved insulating effect with at least equivalent handling properties.

[0013] This object is solved by a binderless needle felt of mineral wool with the features of claim 1.

[0014] In the scope of the present invention the needling process is specifically adapted to achieve sufficient structural inherent stability of the needle felt. In the scope of the invention it was found that it would not be productive to merely increase the number of needling points per unit area to thus achieve a higher degree of fiber mingling. It is of importance that the fibers arranged predominantly transversely to the large areas by the needling process each form a kind of

thermal bridge, i.e. increase the heat conductivity in this region. A simple increase of the needling density would thus only result in the insulating properties of the needle felt being impaired.

[0015] Instead, the present invention now provides for the first time to specifically control the number of fibers arranged transversely to the large areas by the needling process across the thickness of the needle felt so as to positively influence the insulating properties. In this way, a product is provided in which the number of fibers arranged transversely to the large areas decreases from one large area toward the opposite large area of the needle felt.

[0016] Thus, the result is a needle felt which has different insulating properties across the thickness thereof. It can be positioned in a particularly advantageous manner at the device to be insulated such that it enfolds a particularly good insulating effect. In this respect, it is provided to arrange the large area with the near-surface region with a larger amount of fibers arranged transversely to the large areas on the side facing away from the device to be insulated, and to orientate the near-surface region substantially free from fibers arranged transversely to the large areas in the direction of the device to be insulated. Here at the heat source the best insulating effect will then be provided since the per se laminar fiber orientation in this layer is not or at the most hardly disturbed by the needling process.

[0017] Since the needle felt according to the invention is, however, at the same time needled with a needling density that is increased in comparison with prior art, namely at least 15 needling points per square centimeter, i.e. has a higher degree of fiber mingling, an element is nevertheless produced which is adapted to be handled as one piece and in which the fiber coherence does not loosen.

[0018] Furthermore, the near-surface region at the second large area, which is substantially free from fibers arranged transversely to the large areas, has a layer thickness of 15 to 50 % of the overall thickness of the needle felt. Then, this region is substantially free from disturbances in the laminar fiber course and/or of fibers arranged in the direction of the heat flow, so that a particularly good insulating effect is achieved. This contradicts the expectation of an increase of the insulating effect with an increase of the thickness of the layer that is substantially free from fibers arranged transversely to the large areas.

[0019] The needle felt according to the invention exhibits excellent insulating values with good handling ability since it comprises a near-surface region at a large area which is substantially free from fibers arranged transversely to the large areas.

[0020] It must indeed be noted that one-side needling of a primary fleece is actually known per se, as is evidenced by WO 94/01608 A1; here, however, the needling step is used on other prerequisites and with a completely different aim. This document discloses a method for manufacturing a bonded mineral wool product in which the needling process is specifically used for forming a compacted surface region. The needles used penetrate by a predetermined degree into a near-surface region of the primary fleece and provide for a fiber mingling of this near-surface layer with simultaneous compacting thereof. In addition, by means of a group of longer subsequent needles, a fiber mingling of the outer compacted surface region with the adjacent inner, uncompacted region of the mineral wool web is produced to improve the tear resistance of these layers. The major thickness region of the mineral wool fleece which is not in connection with the outer compacted surface region, however, remains unaffected by the needling step. Accordingly, this needling step does not serve to produce the coherence of the individual fibers among each other and hence of the mineral wool product as a whole. This task is performed by the generally provided binder that is available in an uncured state during the needling process and is subsequently cured in a curing oven. A mineral wool product that is produced in this manner is no needle felt and is, already due to the binder content, not suited for purposes which have to be odor-free.

[0021] Advantageous further developments of the needle felt according to the invention are the subject matter of the dependent claims 2 to 9.

[0022] Thus, the number of fibers arranged transversely to the large areas may decrease continuously from one large area toward the opposite large area of the needle felt. In this way, a continuous heat insulation gradient is achieved across the thickness of the needle felt, with which the heat insulation effect varies from a very high degree to a lower degree. Such configuration can be produced with relatively little effort since the needles typically used, with increasing penetration depth, take along less and less fibers with their barbed hooks and hence the disturbance of the originally laminar fiber course which is caused thereby decreases more and more.

[0023] Alternatively, it is also possible that the number of fibers arranged transversely to the large areas decreases stepwise from one large area toward the opposite large area of the needle felt. Thus, it is possible to provide several zones across the thickness of the needle felt which exhibit different insulating behaviors. In the course of the needling process, needles of different lengths and/or groups of needles with different densities of the needling points are used to produce this configuration.

[0024] It is further possible that the density of the needling points is at least 20 needling points per square centimeter, so that an even more reliable coherence of the fibers in the needle felt is achieved. Thus, the needle felt can be handled even better. Preferably, the density of the needling points is at least 23 needling points per square centimeter, which has turned out in practical tests to be particularly suitable for achieving a product that is good to process.

[0025] A further improved insulating effect is achieved if the near-surface region, in accordance with a particularly preferred embodiment, is available in a layer thickness of 20 to 30% of the overall thickness of the needle felt. It has

turned out in practical tests that a reliable coherence and hence a suitable handling ability of the needle felt can be achieved nevertheless. This is controlled by the puncture depth of the needles in the course of the needling process.

[0026] It is of further advantage if the fibers have a fiber fineness with a micronaire of less than 25 l/min, preferably less than 20 l/min and particularly preferred less than 15 l/min, which is determined pursuant to the method described in WO 2003/098209. It has turned out in practical tests that even better insulating effects can be achieved therewith in particular with respect to the heat insulating effect.

[0027] In another embodiment it is further possible that the needle felt is designed with several layers, wherein the fibers of the individual layers are of different design. In practical tests it has turned out that the heat insulating behavior of the needle felt according to the invention can still be improved thereby. This is due to the fact that, caused by the different fibers in the individual layers, a further optimization of the properties of the needle felt according to the invention is possible in particular with respect to the insulating effect and to the inherent stability thereof.

[0028] The fibers in a layer facing the second large area of the needle felt may be designed to be finer than in at least one further layer of the needle felt. In practical tests it has turned out that even better insulating properties in particular with respect to heat insulation can be achieved with finer fibers. It is thus possible to achieve a layer construction that is optimized with regard to the respective application. A needle felt of this construction has therefore even better product properties. The finer fibers preferably have a micronaire that is by at least 5 l/min better, i.e. smaller, than that of the coarser fibers, so that particularly good insulating properties are achieved.

[0029] The relationship of the thicknesses of a layer of finer fibers and at least one layer of coarser fibers is variable in wide ranges and may range between 10:90% and 90:10% of the thickness of the needle felt. For achieving a sufficient strength of such a multi-layer needle felt in the border area of the at least two layers it is preferred that a certain needling takes place in this border area.

[0030] Moreover, the needle felt according to the invention may have a bulk density ranging between 25 kg/m² and 120 kg/m². With such a bulk density range it is particularly suited for the insulation of electric ovens, heating systems or the like. Preferably, the bulk density ranges between 40 kg/m² and 100 kg/m², and in particular from 60 to 80 kg/m².

[0031] The invention will be explained in the following in embodiments by means of the Figures of the drawing. There show:

Fig. 1 an embodiment of the needle felt according to the invention in section;

Fig. 2 the temperature profile curve of a pyrolysis oven with needle felt insulation according to the invention as compared to an insulation with a conventional needle felt;

Fig. 3 the influence of the fiber fineness on the insulating effect for an electric oven; and

Fig. 4 the influence of the layer thickness that is substantially free from fibers arranged transversely to the large areas on the insulating effect for an electric oven.

[0032] Fig. 1 illustrates a detail of a needle felt 1 of mineral wool in section, said needle felt being free from binder and having a first large area 2 and a second large area 3. At the first large area 2, the needle felt 1 is needled with a puncture depth of approx. 50%. In the needled regions, fibers are oriented transversely to the large areas and felt the mineral wool of the needle felt 1.

[0033] For testing the insulating effect, the examples of needle felts summarized in the following Table were produced with the respectively indicated parameters. Embodiments (E) of a needle felt have been designed in accordance with the invention, whereas comparative examples (CE) relate to a conventional needle felt. In the Table, the puncture depth in percent of the product thickness is additionally indicated as an operating parameter.

Table 1: Technical parameters of the embodiments and comparative examples

	Bulk density [kg/m ³]	Thick-ness [mm]	Micronaire [l/min]	Needle density/cm ² (first/second large area)	Layer thickness of the non-needled layer	Puncture depth (first/second large area)
CE 1	80	20	24	11.5/11.5	0%	100%/100%
CE 2	80	20	9	11.5/11.5	0%	100%/100%
CE 3	80	20	24	11.5/11.5	0%	50%150%

(continued)

	Bulk density [kg/m ³]	Thick- ness [mm]	Micronai re [l/min]	Needle density/cm ² (first/second large area)	Layer thickness of the non-needed layer	Puncture depth (first/second large area)
E 1	80	20	24	23/0	50%	50%/0%
E 2	80	20	9	23/0	50%	50%/0%
E 3	80	20	24	23/0	25%	75%/0%
E 4	80	20	24	23/0	75%	25%/0%

[0034] All the comparative examples CE 1 to CE 3 were needled from both sides with a needle density of 11.5 needles/cm². While the comparative examples 1 and 2 were needled to pierce through from both sides (100%/100%), the comparative example 3 was needled from both sides to the respective half product thickness (50%/150%). Only comparative example 1 is a commercially available needle felt product, the other comparative examples 2 and 3 were manufactured especially for the tests.

[0035] Fig. 2 shows in comparison the temperature curve of a pyrolysis oven insulated with a needle felt according to embodiment 1 (E 1) and a needle felt according to comparative example 1 (CE 1). During pyrolysis operation the oven heats at full capacity for two hours. The energy consumption during the pyrolysis process is thus necessarily always the same, irrespective of the insulation. The improved insulating performance of the needle felt according to the invention (E1) is exhibited by the maximum temperature that is increased by about 5 K, and by the fact that it is achieved distinctly earlier, namely approx. 10 min. The consequence of this is that the pyrolysis process takes place more efficiently and may hence be shorter on the whole, which has an advantageous effect on the energy consumption for the pyrolysis process.

[0036] Fig. 3 illustrates the result of a test of the influence of the fiber fineness, indicated as a micronaire value, on the accumulated energy consumption of an electric oven (manufacturer Gorenje) with the operating parameters of 250°C inside temperature and air circulation. At intervals of 10 seconds, the voltage and current intensities available were measured with a measurement device (CM 1000 Professional+, manufacturer Christ Elektronik), and the relevant energy consumption was calculated therefrom. The accumulated energy consumption was integrated over the test time. A total of eight measurements were carried out, two measurements each with an insulation of the oven with a needle felt with coarse and with fine fiber structure each (comparative examples 1 and 2), and a needle felt according to the invention with coarse and with fine fiber structure each (embodiments 1 and 2).

[0037] Fig. 3 directly reveals the control mode of the oven. Starting out from a first heating-up phase to the reaching of the predetermined temperature the oven heats at full capacity, then the temperature is maintained at reduced performance until, after falling below a temperature threshold, heating is again carried out at full capacity, etc. The two respective series of measurements showed good reproducibility of the results.

[0038] Fig. 3 reveals directly that, with equal fiber fineness (E 1 and CE 1; E 2 and CE 2), the embodiments have a reduction of consumption of approximately 10% after 60 minutes of test operation and thus prove the positive influence of the fiber structure on the insulating effect.

[0039] Due to the strong disturbance of the fiber structure by the needling on both sides, the influence of the fiber fineness is small with the two comparative examples 1 and 2 and lies within the scope of measurement accuracy. A positive influence of the increasing fiber fineness, apparently due to the at least partially undisturbed fiber structure, can be recognized in the direct comparison of the two embodiments 1 and 2 according to the invention in that the heating periods start later with increasing operating time, so that a difference in the accumulated energy consumption may result, depending on whether the oven is switched off. By this effect, up to about 10% of the accumulated energy consumption may again be saved if, for instance, the oven had been switched off after 56 minutes. Fig. 3 illustrates that both effects, the needling gradient and the increase of fiber fineness, cooperate cumulatively.

[0040] Fig. 4 illustrates the influence of the layer thickness on the accumulated energy consumption. In this case, the oven was operated with an inside temperature of 275°C in the upper and lower heat mode.

[0041] The oven has the highest accumulated energy consumption in the case of an insulation with the material of comparative example 1. With an insulation on the basis of comparative example 3, a first efficiency gain of up to 10% already results as compared to comparative example 1. The three curve progressions for the embodiments 3, 1 and 4 illustrate the influence of the increasing layer thickness of the layer that is largely undisturbed by the needling process. Embodiment 3 with a layer thickness of 25% in relation to the overall thickness of the embodiment, which is substantially free from fibers arranged transversely to the large areas, enables a reduction of the accumulated energy consumption by approximately 20% with an operating time of 90 minutes. Embodiments 1 and 4 also constitute a substantial improvement as compared to comparative example 1.

[0042] All embodiments 1 to 4 had sufficient strength for handling and could be processed without problems.

[0043] Moreover, the invention leaves room for further configurations.

[0044] While the needle felt 1 in the embodiment variant of Fig. 1 is needled down to a depth of approx. 50% of the thickness of the needle felt 1, another needling depth may also be chosen, as results, for instance, from the embodiments.

[0045] In further embodiments it is moreover possible that the number of fibers arranged transversely to the large areas decreases continuously from the first large area 2 toward the opposite second large area 3 of the needle felt 1.

[0046] In each of the embodiments explained, a needling density of 23 needling points per square centimeter is provided. Depending on the application it is, however, also possible to deviate therefrom and to use other needling densities.

[0047] Furthermore, the needle felt may also be designed to have several layers, wherein the fibers of the individual layers are of different design. They may be fibers of different fiber fineness, material composition.

[0048] The bulk density of the needle felt 1 has to be chosen in correspondence with the requirements in the respective application; typically, bulk densities between 25 kg/m² and 120 kg/m² are common.

[0049] It is further possible, in particular in the case of low bulk densities of approximately less than 50 kg/m³, to provide a lining of the first large area to provide sufficient strength for processing. A lining in the form of an aluminum foil fixed in particular with inorganic, odor-free glue, is preferred.

Claims

1. A binderless needle felt (1) of mineral wool, comprising a plurality of fibers arranged predominantly in parallel to the large areas of the needle felt (1), and individual fibers at needling points which are arranged predominantly transversely to the large areas by a needling process and by which the fibers of the needle felt

(1) are felted such that the needle felt (1) is adapted to be handled as one element, wherein the density of the needling points at a first large area (2) is at least 15 needling points/cm², the number of the fibers arranged transversely to the large areas decreases from the first large area (2) toward an opposite second large area (3) of the needle felt (1), and a near-surface region at the second large area (3) is substantially free from fibers arranged transversely to the large areas,

characterized in that

the near-surface region at the second large area (3) which is substantially free from fibers arranged transversely to the large areas has a layer thickness of 15 to 50% of the overall thickness of the needle felt (1).

2. The needle felt according to claim 1, **characterized in that** the number of fibers arranged transversely to the large areas decreases continuously from the first large area (2) toward the opposite second large area (3) of the needle felt (1).

3. The needle felt according to claim 1, **characterized in that** the number of the fibers arranged transversely to the large areas decreases stepwise from the first large area (2) toward the opposite second large area (3) of the needle felt (1).

4. The needle felt according to any of claims 1 to 3, **characterized in that** the density of the needling points is at least 20 needling points/cm² and preferably at least 23 needling points/cm².

5. The needle felt according to any of claims 1 to 4, **characterized in that** the near-surface region at the second large area (3) which is substantially free from fibers arranged transversely to the large areas has a layer thickness of 20 to 30 % of the overall thickness of the needle felt (1).

6. The needle felt according to any of claims 1 to 5, **characterized in that** the fibers have a micronaire of less than 25 l/min, preferably less than 20 l/min, and particularly preferred less than 15 l/min.

7. The needle felt according to any of claims 1 to 6, **characterized in that** it is designed to have several layers, wherein the fibers of the individual layers are of different design.

8. The needle felt according to claim 7, **characterized in that**, in a layer facing the second large area (3) of the needle felt (1), the fibers are finer than in at least one further layer of the needle felt, and preferably have a micronaire that

is by at least 5 l/min smaller than that of the fibers of the at least one further layer.

9. The needle felt according to any of claims 1 to 8, **characterized in that** it has a bulk density in the range of between 25 kg/m² and 120 kg/m², preferably a bulk density of between 40 kg/m² and 100 kg/m², and in particular a bulk density of 60 to 80 kg/m².

Patentansprüche

1. Bindemittelfreier Nadelfilz (1) aus Mineralwolle, mit einer Vielzahl vorwiegend parallel zu den Großflächen des Nadelfilzes (1) angeordneten Fasern, sowie einzelnen Fasern an Nadelungspunkten, die durch einen Nadelungsvorgang vorwiegend quer zu den Großflächen angeordnet sind, und durch welche die Fasern des Nadelfilzes (1) derart verfilzt sind, dass der Nadelfilz (1) als ein Element handhabbar ist, wobei die Dichte der Nadelungspunkte an einer ersten Großfläche (2) mindestens 15 Nadelungspunkte/cm² beträgt, die Anzahl der quer zu den Großflächen angeordneten Fasern von der ersten Großfläche (2) zu einer gegenüberliegenden zweiten Großfläche (3) des Nadelfilzes (1) hin abnimmt, und ein oberflächennahe Bereich an der zweiten Großfläche (3) im Wesentlichen frei ist von quer zu den Großflächen angeordneten Fasern.
dadurch gekennzeichnet, dass der oberflächennahe Bereich an der zweiten Großfläche (3), der im Wesentlichen frei ist von quer zu den Großflächen angeordneten Fasern, eine Schichtdicke von 15 bis 50 % der Gesamtdicke des Nadelfilzes (1) aufweist.
2. Nadelfilz nach Anspruch 1, **dadurch gekennzeichnet, dass** die Anzahl der quer zu den Großflächen angeordneten Fasern stetig von der ersten Großfläche (2) zur gegenüberliegenden zweiten Großfläche (3) des Nadelfilzes (1) hin abnimmt.
3. Nadelfilz nach Anspruch 1, **dadurch gekennzeichnet, dass** die Anzahl der quer zu den Großflächen angeordneten Fasern schrittweise von der ersten Großfläche (2) zur gegenüberliegenden zweiten Großfläche (3) des Nadelfilzes (1) hin abnimmt.
4. Nadelfilz nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die Dichte der Nadelungspunkte mindestens 20 Nadelungspunkte/cm² und vorzugsweise mindestens 23 Nadelungspunkte/cm² beträgt.
5. Nadelfilz nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** der oberflächennahe Bereich an der zweiten Großfläche (3), der im Wesentlichen frei ist von quer zu den Großflächen angeordneten Fasern, eine Schichtdicke von 20 bis 30 % der Gesamtdicke des Nadelfilzes (1) aufweist.
6. Nadelfilz nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** die Fasern einen Micronaire von weniger als 25 l/min, bevorzugt weniger als 20 l/min und besonders bevorzugt kleiner 15 l/min aufweisen.
7. Nadelfilz nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** er mehrlagig ausgebildet ist, wobei die Fasern der einzelnen Lagen unterschiedlich ausgestaltet sind.
8. Nadelfilz nach Anspruch 7, **dadurch gekennzeichnet, dass** die Fasern in einer Lage, die der zweiten Großfläche (3) des Nadelfilzes (1) zugewandt ist, feiner als in wenigstens einer weiteren Lage des Nadelfilzes ausgebildet sind und vorzugsweise einen um mindestens 5 l/min geringeren Micronaire als die Fasern der wenigstens einen weiteren Lage aufweisen.
9. Nadelfilz nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** er eine Rohdichte im Bereich zwischen 25 kg/m² und 120 kg/m², vorzugsweise eine Rohdichte zwischen 40 kg/m² und 100 kg/m², sowie insbesondere eine Rohdichte von 60 bis 80 kg/m² aufweist.

Revendications

1. Feutre aiguilleté sans liant (1) de laine minérale, comprenant une pluralité de fibres agencées principalement en parallèle aux faces principales du feutre aiguilleté (1), et des fibres individuelles, à des points d'aiguilletage, qui sont agencées principalement transversalement aux faces principales par un procédé d'aiguilletage et par lesquelles les

fibres du feutre aiguilleté (1) sont feutrées de telle sorte que le feutre aiguilleté (1) soit adapté pour être manipulé comme un élément singulier, dans lequel

la densité des points d'aiguilletage dans une première face principale (2) est au moins 15 points d'aiguilletage/cm², le nombre des fibres agencées transversalement aux faces principales diminue à partir de la première face principale (2) vers une seconde face principale opposée (3) du feutre aiguilleté (1), et une région de surface proche sur la seconde face principale (3) est sensiblement dépourvue de fibres agencées transversalement aux faces principales,

caractérisé en ce que

la région de surface proche sur la seconde face principale (3) qui est sensiblement dépourvue de fibres agencées transversalement aux faces principales présente une épaisseur de couche de 15 à 50 % de l'épaisseur totale du feutre aiguilleté (1).

2. Feutre aiguilleté selon la revendication 1, **caractérisé en ce que** le nombre de fibres agencées transversalement aux faces principales diminue en continu à partir de la première face principale (2) vers la seconde face principale opposée (3) du feutre aiguilleté (1).

3. Feutre aiguilleté selon la revendication 1, **caractérisé en ce que** le nombre des fibres agencées transversalement aux faces principales diminue progressivement à partir de la première face principale (2) vers la seconde face principale opposée (3) du feutre aiguilleté (1).

4. Feutre aiguilleté selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** la densité des points d'aiguilletage est au moins 20 points d'aiguilletage/cm² et de préférence au moins 23 points d'aiguilletage/cm².

5. Feutre aiguilleté selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** la région de surface proche sur la seconde face principale (3), qui est sensiblement dépourvue de fibres agencées transversalement aux faces principales, présente une épaisseur de couche de 20 à 30 % de l'épaisseur totale du feutre aiguilleté (1).

6. Feutre aiguilleté selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** les fibres présentent un micronaire inférieur à 25 l/min, de préférence inférieur à 20 l/min, et de façon particulièrement préférée inférieur à 15 l/min.

7. Feutre aiguilleté selon l'une quelconque des revendications 1 à 6, **caractérisé en ce qu'il** est conçu pour posséder plusieurs couches, dans lequel les fibres des couches individuelles sont de conception différente.

8. Feutre aiguilleté selon la revendication 7, **caractérisé en ce que**, dans une couche faisant face à la seconde face principale (3) du feutre aiguilleté (1), les fibres sont plus fines que dans au moins une couche supplémentaire du feutre aiguilleté, et de préférence présentent un micronaire qui est au moins 5 l/min inférieur à celui des fibres de l'au moins une couche supplémentaire.

9. Feutre aiguilleté selon l'une quelconque des revendications 1 à 8, **caractérisé en ce qu'il** présente une densité apparente dans la plage entre 25 kg/m² et 120 kg/m², de préférence une densité apparente entre 40 kg/m² et 100 kg/m², et en particulier une densité apparente de 60 à 80 kg/m².

FIG. 1

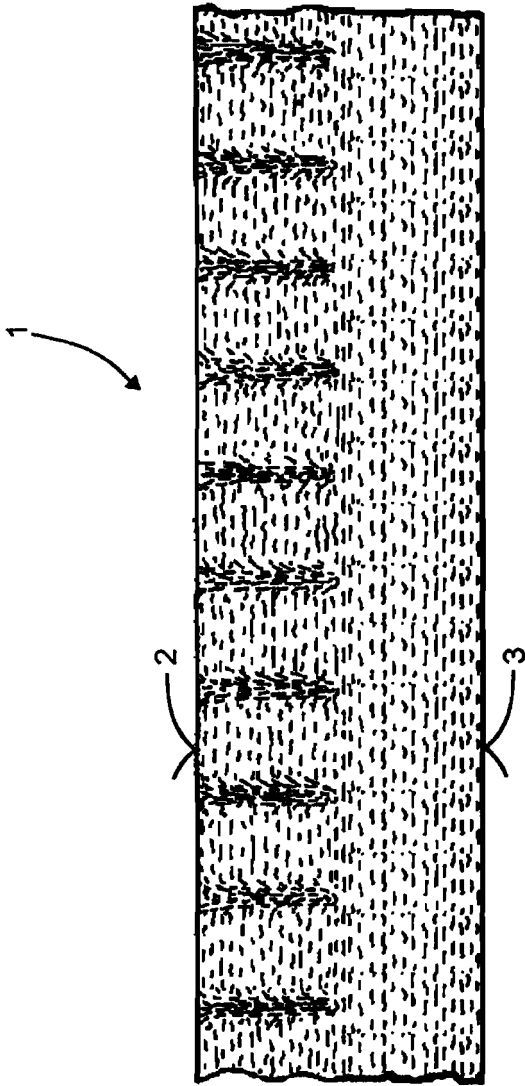


FIG. 2

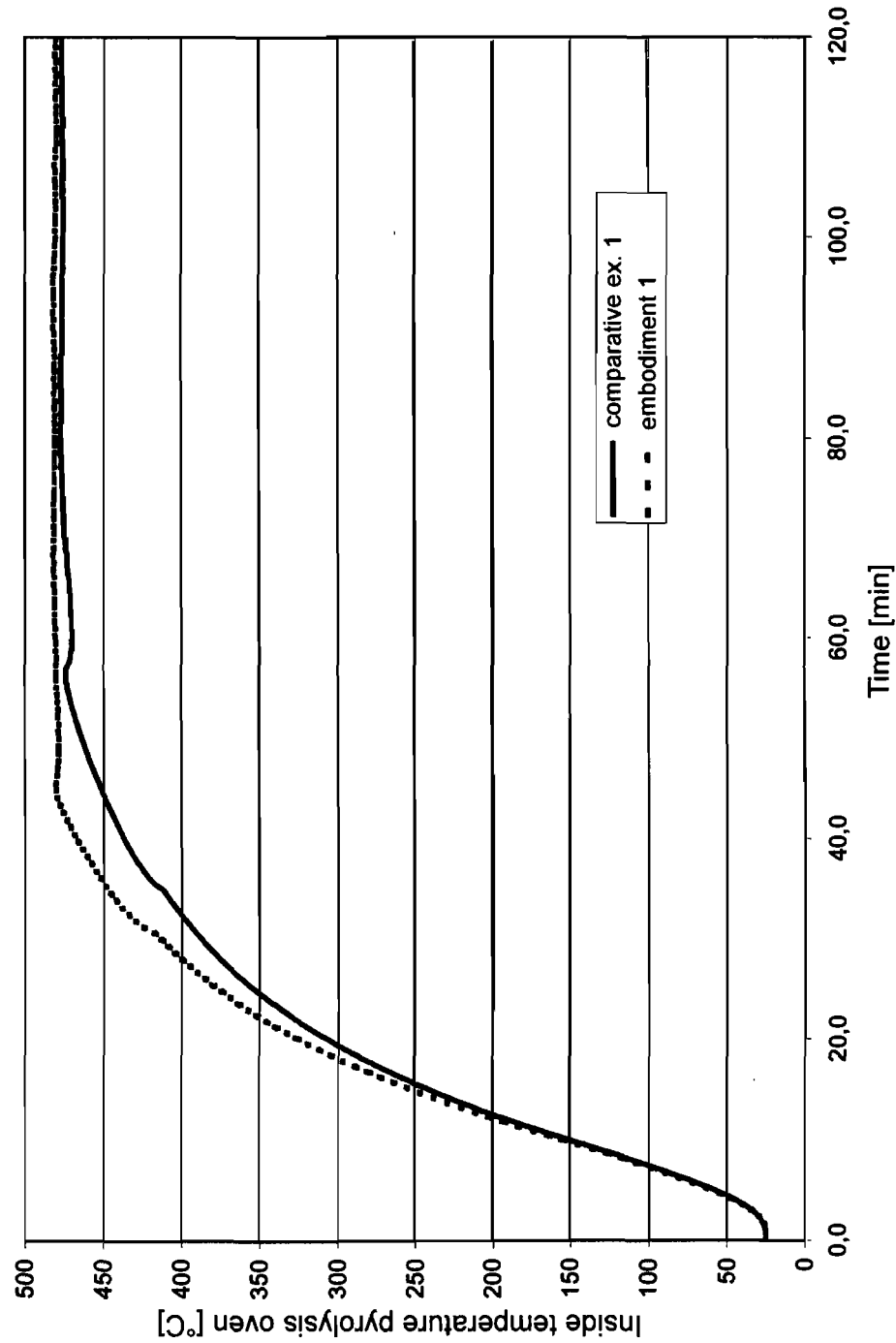


FIG. 3

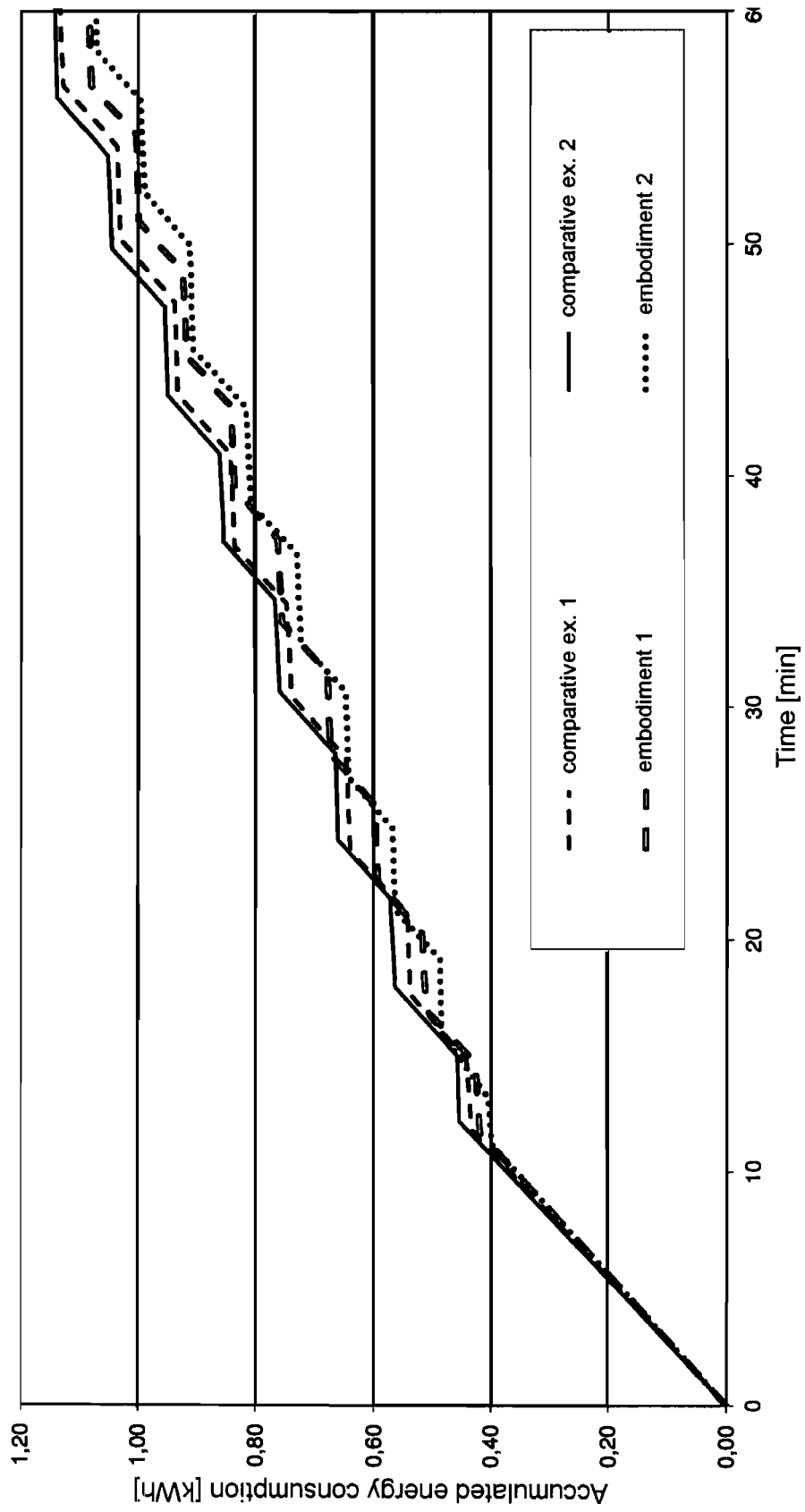
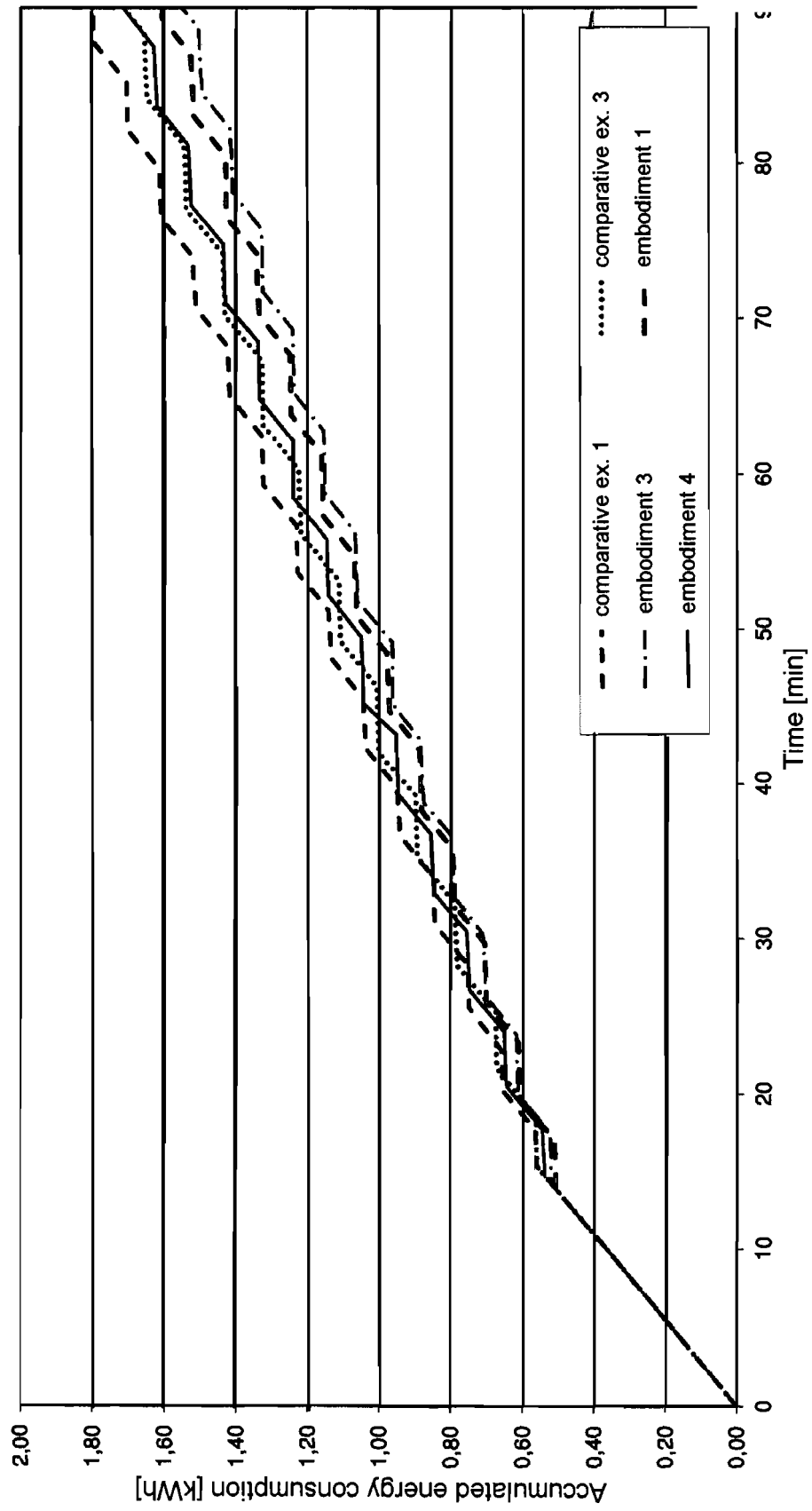


FIG. 4



REFERENCES CITED IN THE DESCRIPTION

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