The textile laminate for providing thermal insulation is remarkable in that at least one of the walls (P1), and in particular the wall that is to be subjected first to heat, is suitable for shrinking under the effect of heat so as to cause link yarns (F) to stand up, thereby leading to an increase in the spacing between said walls (P1 and P2) that are made in full or in part to be thermostable.
FIG. 5

radiant heat

FIG. 6

convective heat
TEXTILE LAMINATE FOR THERMAL INSULATION

[0001] The invention relates to the technical field of textile articles that can be used as thermal insulators, in particular for making textile laminates for providing protection against risks associated with fire.

[0002] Advantageously, the invention applies to a textile laminate for making working and protective garments for firefighters. Naturally, this application should not be considered as being limiting.

[0003] Thus, the textile laminate of the invention is applicable in all circumstances when extreme characteristics are present, e.g. during a fire, and more generally when it is necessary to provide protection against a high temperature source.

[0004] In general, and as shown diagrammatically in FIG. 1, in order to make working and protective jackets, use is made in conventional manner of multilayer structures made up of the following four elements;

[0005] an outer fabric (A);
[0006] a waterproof breathing membrane, generally associated with a substrate (B);
[0007] a thermal barrier, generally constituted by a needle felt (C); and
[0008] a finishing lining (D).

[0009] This state of the art can be illustrated by the teaching of French patent No. 1 213 415.

[0010] It is also known that that type of protective garment needs to possess a certain number of characteristics, in particular protection against radiant heat and against convective heat, good thermal stability of the component materials, it must satisfy criteria concerning pure non-flammability, and it must possess good waterproofing characteristics.

[0011] It has also been found very important to be able to protect against the risk of heat stress, which is a physiological phenomenon that results from a rise in the internal temperature of a body that can no longer achieve temperature regulation. This can result in a loss of physical ability, a loss of lucidity, fainting, or indeed cardiac arrest.

[0012] It has also been found important to be able to protect an operator under extreme or accidental conditions, in particular so as to give the operator time to escape. Situations can arise in which a transition occurs very quickly in the development of a fire, leading to a very fast increase in temperature of 500°C to 600°C, for example, taking place in a few seconds, which corresponds to an incident heat flux of about 40 kilowatts per square meter (kW/m²). It is therefore important to be able to withstand such a sudden increase in temperature for long enough to be able to get away from the fire.

[0013] In an attempt to achieve these objects, textile laminates have been proposed that incorporate thermal insulation constituted by a three-dimensional knit, as taught by European patent No. 0 443 991, or by a felt suitable for holding air captive, as taught by European patent No. 0 364 370. The thermal insulation that results from the captive air provides considerable protection against heat flux. However, when the thermal insulation is made in that way (three-dimensional knit or felt), the feel and the appearance of the garment are not satisfactory. The garment is often considered as being unhygienic, disagreeable to wear, and ugly, which means that the resulting textile laminate must be associated with lining for cleanliness purposes. Such a solution nevertheless tends to make the laminate even heavier and complicates the preparation thereof.

[0014] It has also been found that three-dimensional knits or felts tend to restrict the exhaustion of the water vapor that results from sweating, thereby worsening heat stress phenomena.

[0015] In an attempt to remedy those drawbacks, proposals have been made to replace the thermal insulation constituted by three-dimensional knitting or by felt, by using other structures suitable for holding air captive. One solution is taught by patent application WO 99/35926 and relates to a membrane having spacers placed thereon at regular intervals so as to create a layer of air between the membrane and a textile surface acting as a lining, for example. The spacers are constituted by polymer studs fixed to said membrane and they tend to increase the abrasion sensitivity of the other layers of the laminate made in this way.

[0016] In international application WO 00/66823, proposals are made for padded piping of textile material on the surface of a lining. The piping creates air channels between a non-flammable textile sheet and the lining. The presence of the piping increases the abrasion sensitivity of the layer of the laminate that carries the piping.

[0017] Proposals have also been made for solutions implementing parallel layers that are spaced apart and secured to means suitable for causing the space between said layers to vary, thereby creating a corresponding thermal barrier. By way of example, mention can be made of the teaching of British patent No. 2 264 705 which discloses a textile article made up of two parallel layers constituted by a plurality of yarns. Each of the layers co-operates with means that need to be actuated manually in order to move them relative to each other, for the purpose of tilting or upstanding link yarns, which corresponds to said layers being moved towards each other when the yarns are in an inclined position and to the layers being moved apart from each other when the yarns are in an upstanding position. That solution requires manual action and applies solely to an application for providing protection against cold temperatures.

[0018] In international application WO 99/05926, the laminate comprises two layers that are completely independent of each other and that are disposed in two parallel planes so as to define a space for positioning a shape memory material. Under the effect of heat, the shape memory material causes the space between the two layers to vary. That solution therefore requires special means for its implementation and gives rise to a surfaces that is lacking in flexibility.

[0019] Starting from that state of the art, and in order to remedy the above-mentioned drawback, the problem which the invention seeks to solve is that of creating a thermal barrier that enables moderate insulation to be obtained in normal situations, corresponding to small thickness so as to obtain greater comfort in use, and to obtain greater insulation automatically and locally in places where heat is greatest in emergency situations.
To solve such a problem, a textile laminate has been devised and developed for providing thermal insulation, in particular for making protecting garments, the laminate presenting a woven or knitted structure and having at least two walls linked in spaced-apart manner by a plurality of yarns which tend naturally to lie flat, so that while in this position the spacing is small and shorter than the length of the link yarns. At least one of the walls, and in particular the wall that is to be subjected to heat, is suitable for shrinking under the effect of heat so as cause the link yarns to stand up, thereby increasing the spacing between said walls, which walls are made in full or in part so as to be temperature stable.

Advantageously, the link yarns are woven or knitted in part in both of the layers.

In an embodiment, each wall or layer is the result of interlacing warp yarns and weft yarns, the link yarns extending in the warp direction, and said yarns being folded down in the weft direction.

Given these dispositions, it can be seen that using a heat-shrink material in at least one of the layers in the weft direction of its outside face enables an advantageous reaction to heat to be obtained. When the temperature reached by the heat-shrink wall or layer becomes high enough, the weft shrinks, thereby causing the link yarns to stand up, with a corresponding increase in the thickness of the laminate as temperature rises, and consequently a corresponding increase in its insulating ability.

In addition, by selecting a link yarn that is made of para-aramid material, it is possible firstly to obtain good toughness and secondly to obtain sufficient compression strength when the thermal barrier has been partially carbonized, given the temperature stability characteristics of the link yarn.

Advantageously, the warp and the weft yarns of each wall are selected from yarns of the polyamide-imide family of the type known under the trademark “Kermel”, on their own or mixed with other fibers.

Each wall presents the same yarn density, or else the walls may present different yarn densities.

The laminate, as defined, may be combined with an outer sheet of fireproofing material and a waterproof and breathing membrane together with a substrate.

The invention is described below in greater detail with reference to the figures of the accompanying drawings, in which:

FIG. 1, as described, is a diagrammatic view showing a multilayer laminate of the type that is well known and is in use at present for making garments for personnel needing to act under dangerous conditions, and in particular garments for firefighters;

FIG. 2 is a perspective view of an embodiment of the textile laminate of the invention;

FIG. 3 is a purely diagrammatic perspective view showing the textile laminate while it is subjected to a temperature that is considered as being normal; in this position, the link yarns are lying down;

FIG. 4 is a view corresponding to FIG. 3, showing the shrinkage of one of the walls under the effect of a large amount of heat, causing the link yarns to stand up, thereby increasing the thickness of the laminate;

FIG. 5 is a graph showing the response of the laminate during a rise in temperature due to radiant heat; and

FIG. 6 is a graph showing the response of the laminate during a rise in temperature due to convective heat.

The principle of the textile laminate of the invention is shown in FIGS. 3 and 4 of the drawings. The laminate presents a woven or knitted structure having two walls or layers (P1 and P2) linked together in spaced-apart manner by a plurality of yarns (F). The link yarns (F) are woven or knitted in part in both of the layers.

It can be seen that the link yarns (F) have a natural tendency to lie down on their side, so that the thickness (c) of the laminate between the two layers (P1 and P2) is smaller than the length of the link yarns. As a result, when the link yarns stand up, that will lead to a corresponding increase in the size of the space (c).

In order to achieve this result, at least one of the walls, and in particular the wall (P1) that is to be subjected to high levels of heat, is suitable for shrinking under the effect of said heat. As a result, when the temperature reached by the layer (P1) is high enough, e.g. about 200°C to 300°C, said layer can shrink, as shown diagrammatically in FIG. 4, thus having the effect of causing the link yarns (F) to stand up and leading to an increase in the thickness (c) as the temperature rises. This leads naturally to an increase in the insulating ability of such a laminate.

Starting from this basic concept, various embodiments can be envisaged.

For example, each wall or layer (P1 and P2) results from interlacing warp yarns and weft yarns. The link yarns (F) are disposed in the warp direction, such that when they lie down they lie down in the weft direction. The way in which this type of laminate can be made by weaving or by knitting yarns is well known to the person skilled in the art.

As described below, the link yarns (F) are made of a para-aramide that is known for its very good temperature stability, thus making it possible firstly to obtain good toughness and secondly to obtain sufficient compression strength when the thermal barrier is partially carbonized.

It is recalled that at least one of the walls is woven or knitted from yarns comprising temperature-stable yarns.

The warp and weft yarns of each wall (P1 and P2) are advantageously selected from yarns of the pure or mixed meta-aramid family of the type known under the trademark “Kermel” (Rhodia) or “Nomet” (Du Pont), or “Conex” (Kicjin). In the example of FIG. 2, the wall (P1) is made out of warp and weft yarns (C1 and T1) that are made of heat-shrink material. Advantageously, only the weft yarn (T1) is a heat-shrink yarn. The wall (P2) is made of warp and weft yarns (C2, T2). The link yarns (F) are advantageously constituted by a warp yarn interconnecting weft yarns (T1 and T2) in both of the walls (P1 and P2).

The weaving or knitting in both walls (P1 and P2) may present the same yarn density. Alternatively, each wall may different yarn density.
For example, the denser weaving or knitting may constitute the wall that is to face towards the user, in which case it advantageously acts as a lining. The temperature-stable yarns used may be made of a natural or artificial synthetic material, or of a mixture. Preferably, yarns are used that are based on meta-aramid, e.g. on metaphtylene isophthalamide or on polyamide-imide, possibly in combination with fireproofed viscosle. It is also possible to use yarns based on a mixture of modacrylic fibers and fireproofed cotton.

As mentioned, the length of the spacing yarn between the walls (P1 and P2) defines the space (e) between said walls, and consequently the thickness of the cushion of air that is constituted in this way to provide thermal insulation. The length of the link yarn (F) preferably lies in the range 1 millimeter (mm) to 10 mm, approximately. The spacing yarn is advantageously a yarn based on para-aramid such as paraphenylene terephthlamide, e.g. "Kevlar" from Du Pont, "Iwaren" or "Technora" from Teijin.

The textile laminate as defined by the characteristics of the invention can be used on its own or in combination with other sheets of yarns or fibers for constituting a multilayer article of the type that is known to the person skilled in the art (FIG. 1).

For example, the laminate as defined can be combined with a sheet constituted by a fireproofed textile and a sheet constituted by a membrane. The membrane is preferably disposed between the fireproofed textile and the thermally insulating textile laminate of the invention. The fireproofed textile is intended to constitute the face or wall that does not come into contact with the user. For example, the fireproofed textile is preferably constituted by a fabric based on fibers or yarns of metaphtylene isophthalamide or polyamide-imide, optionally together with yarns or fibers of paraphenylene terephthlamide, and/or antistatic yarns or fibers or some other para-aramid fibers or yarns of the poly(paraphenylene-2,6-benzobisazo) (PBO) or the poly-benzimidazole (PBI) type.

The membrane may be constituted by a microporous or hyphophilic film, e.g. based on polytetrafluoroethylene, on fireproofed polyurethane, or on polyurethane. This membrane may be free in the laminate or it may be associated, for example, by being backed onto a textile support, such as a woven or non-woven fabric based on meta-aramid or on polyamide-imide fibers.

This effect of one of the layers shrinking may also be the result of the presence of a membrane fixed on the layer in question. For example, the membrane may be made of any material that is liable to shrink under the effect of heat, such as microporous polyurethane, hyphophilic polyurethane, hyphophilic polyester, . . .

The laminate of the invention in combination with a fireproofed textile and a membrane can be applied particularly advantageously in making garments for providing protection against the risks associated with fire, e.g. a jacket for a firefighter.

There follows a description of making a textile laminate of the invention, with the walls (P1 and P2) being the result of the weave shown in FIG. 2.

The warp yarns (C1) of the wall (P1) are constituted by spun yarns of polyamide-imide fibers weighing Nm 80/2 at a density of 13 yarns/cm;

The weft yarns (T1) of the wall (P1) are constituted by spun yarns of polyamide-imide fibers weighing Nm 60/1 at a density of 27 picks/cm;

The warp yarns (C2) and the weft yarns (T2) of the wall (P2) are constituted by spun yarns of polyamide-imide fibers weighing Nm 80/2 at respective densities of 20 and 27 yarns/cm and

The spacing warp yarns (F) are constituted by spun yarns of para-aramid fibers weighing Nm 80/2 at a density of 6 yarns/cm.

The weight per unit area of the article is about 240 grams per square meter (g/m²) and the spacing between the walls (P1 and P2) is about 2 mm in the normal position (links lying down).

Measurements of the heat flux protection provided by the laminate have given the following results:

In application of standard EN 366, a radian heat test: 28 seconds in t₁ and 7.3 seconds in t₂; reference can be made to the graph of FIG. 5; and

In application of standard EN 367, a convective heat test (FIG. 6):

HTI 24 (theoretical burn time) 18 seconds; and

HTI 24-HTI 12 (theoretical pain time) 5 seconds.

As can be seen from these graphs, surprisingly, the "escape time" type values, i.e. the difference between the theoretical burn times (t₁ or HTI 24) and the theoretical pain times (t₂ or HTI 12) are greater than the general average observed for laminates at this level. There can also be seen a significant increase in thickness under the effect of radiant heat, and an increase in the difference between (t₁ and t₂) which means a theoretical increase in protection after the pain threshold.

The advantages can be seen clearly from the description, in particular it should be emphasized that the laminate obtained presents excellent breathability, excellent visual appearance, and excellent thermal protection.

1. A textile laminate for thermal insulation, in particular for making protective garments, the laminate presenting a woven or knitted structure having at least two walls linked together in spaced-apart manner by a plurality of link yarns which tend naturally to lie down, such that when in this position, the spacing between the walls is small and less than the length of the link yarns, wherein at least one of the walls, and in particular the wall that is to be the first that is subjected to heat, is suitable for shrinking under the effect of the heat so as to cause the link yarns to stand up, thereby increasing the spacing between said walls, which walls are made in full or in part to be thermostable.

2. A textile laminate according to claim 1, wherein the link yarns are woven or knitted in part with each of the layers or walls.

3. A textile laminate according to claim 1, wherein the link yarns are based on para-aramid.
4. A textile laminate according to claim 1, wherein each wall is the result of interlacing warp yarns and weft yarns, the link yarns being disposed in the warp direction, said yarns lying down in the weft direction.

5. A textile laminate according to claim 1, wherein the warp yarns and the weft yarns of each of the walls are selected from those constituting meta-aramid family, on their own or in a mixture.

6. A textile laminate according to claim 1, wherein each wall presents the same yarn density.

7. A textile laminate according to claim 1, wherein the two walls present different yarn densities.

8. A textile laminate according to claim 1, the laminate being combined with an outer sheet of fireproofed material and a waterproof and breathing membrane with a substrate.

9. The use of a laminate according to claim 1 for making a protective garment, in particular for a firefighter.

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