MULTILAYER LINING FABRIC WITH IMPROVED PROPERTIES AND CLOTHES COMPRISING SAME

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ABSTRACT

Disclosed is a multilayer lining fabric comprising at least two warp-knitted fabric layers of at least one polymer thread material having a weight of ≥100 g/m². The number of weft threads per centimeter of length is larger than the number of warp threads per centimeter of width of the fabric layers and, in the plane of the layers of the fabric, the direction of warp threads of one layer is twisted with respect to the direction of warp threads of an adjacent layer by an angle of at least 20°. Clothing comprising the multilayer lining fabric is also disclosed.

8 warp-knitted fabric layers

Surrounding envelope (preferably stitched at both ends, e.g. by sewing)

Textile pad
8 layers in different directions:
- one layer vertical 40°
- one layer horizontal 40°
Alternating layers made of DYNEEMA

In addition, lining fabric in between layer 7 and 8.

Figure 5 A
Figure 5 B

Surrounding envelope (preferably stitched at both ends, e.g. by sewing)

Textile pad

8 warp-knitted fabric layers
Figure 5 D

8 warp-knitted fabric layers

Surrounding envelope (preferably stitched at both ends, e.g. by sewing)

Shell fabric (preferably stitched to envelope)

Textile pad
MULTILAYER LINING FABRIC WITH IMPROVED PROPERTIES AND CLOTHES COMPRISING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS


BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention
[0003] The present invention relates to a multilayer lining fabric having improved properties in respect of elasticity and stretchability. Moreover, the present invention relates to a multilayer lining fabric which improves safety features of the fabric. In a further embodiment, the invention relates to clothes, in particular working clothes, comprising a multilayer lining fabric.
[0004] 2. Discussion of Background Information
[0005] Lining fabrics, in particular for clothes used in a specific area as, for example, clothes worn in sports or clothes worn in a working environment, must satisfy certain requirements concerning the wearer’s comfort: Due to the fact that such clothes often need to protect the wearer against inclement weather conditions (low temperature, external wetness resulting from snow or rain), they have to comprise an outer layer protecting against such conditions. On the other hand, the physical conditions of sports or working in the open air are characterized to a large extent by body movements (or movements of certain parts of the body only, e.g. the arms, the upper part of the body, the legs and/or the lower part of the body) and, in connection to that, to the moisture of the body.
[0006] Both of those may cause discomfort to the wearer of the clothes, if the clothes’ outer (protecting) layer is cushioned with an inner lining fabric: One example of such a lining fabric is the warp-knitted fabric available on the market from the company Engtex AB, Mullsjö, Sweden, under the Trade Name “ENGTEX”. The lining allows such easy body movements only to a limited extent (or even prevents such movements), due to a lack of elasticity and stretchability of the lining fabric. This is particularly true for linings made of the above warp-knitted fabrics, which are placed inside the protecting layer in two or more layers one above the other, conventionally, with the warp directions of one layer parallel to those of the other lining layer.
[0007] Moreover, sweat produced by the body under sport conditions or working conditions is removed from the wearer’s skin in only a decelerated manner, or not at all. As a result, a wet lining rubs against the skin during the body movements, causing, in addition to discomfort to the wearer, irritation of the wearer’s skin or even worse conditions like skin inflammation.
[0008] One of the specific properties of such lining fabrics placed one above the other in a plurality of layers is that such a multilayer lining fabric can be used as a protective fabric for chainsaw operators: If all layers were positioned parallel to each other (i.e. the warp direction of each layer is parallel to the warp direction of each other layer) and were well attached to each other by seams, the resulting multilayer lining fabric could prevent chainsaw operators in their working environment from injuries by their chainsaw. This is due to the fact that, after cutting through the outer protective layer of the operators’ working cloth pants, the threads of the lining layers are drawn into the chainsaw and can stop the chainsaw’s operation within a few moments, thereby preventing the operator from being injured by the motor-driven chainsaw.
[0009] What remains, however, is the apparent lack of elasticity and stretchability of the lining fabric, which causes a non-acceptable lack of wearing comfort to the wearers of the clothes when worn in a sports or working environment.
[0010] Hence, it would be advantageous to be able to enhance the elasticity and stretchability of a multilayer lining fabric so as to provide more comfort to the wearers of clothing including such multilayer lining fabric.
[0011] Moreover, it would also be advantageous to be able to improve the humidity transport (resulting from sweating by the wearer) from the wearer’s skin to the environment through the multilayer lining fabric, thereby preventing skin irritation or even inflammation from occurring.
[0012] In addition, it would be advantageous to be able to improve the protecting properties of the multilayer lining fabric against chainsaw injuries of a chainsaw operator, thereby making working accidents less probable if working clothes provided with the multilayer lining fabric of the invention are worn in a chainsaw working environment.
[0013] Finally, it would be advantageous to provide clothing comprising the multilayer lining fabric set forth above, thereby allowing better wearing comfort to the wearer, for example in the case of sports clothes or working clothes and, in particular, working clothes for chainsaw operators and forest workers.

SUMMARY OF THE INVENTION

[0014] According to the present invention, it has surprisingly been found that the above objects can be achieved altogether by a multilayer lining fabric wherein two or more layers of a warp-knitted fabric are combined to a lining fabric by a stack of said two or more warp-knitted fabric layers, the warp directions of which are twisted, from one layer to the next, by a certain angle. If a stack of such twisted lining fabrics is stitched loosely-fitting, the resulting multilayer lining fabric in a piece of clothing has a largely enhanced elasticity and may stretch during the movements of the wearer of the clothes, thereby providing an improved comfort.
[0015] Moreover, it was found that working clothes comprising the multilayer lining fabric of the invention provide a surprisingly better protection against chainsaw injuries due to a better blocking behavior of the chainsaw by the threads of the multilayer lining fabric: The chainsaw is, better than in the case of prior art linings, stopped by the multilayer lining fabric of the invention not only in cases of chainsaw cuts perpendicular to the axis of the legs of the pants, but also in cases of chainsaw cuts in a direction diagonal to the axis of the legs of the pants: The European and National standards of the Personal Protective Equipment (PPE) requirements and of DIN (EN) 381-2 and -5 are met by the multilayer lining fabric and clothes of the present invention, and diagonal cuts standardizing newly developed tests for the twisted direction linings of the present invention are under evaluation.
[0016] Hence, the present invention provides a multilayer lining fabric comprising at least two warp-knitted fabric layers of at least one polymer thread material having a weight of ≥100 g/m² (per layer of material) wherein the number of weft threads is larger than the number of warp threads, and
wherein, in the plane of the layers of the fabric, the direction of warp threads of one layer is twisted with respect to the direction of warp threads of an adjacent layer by an angle \( \alpha \) of at least 20°.

[0017] In one aspect of the fabric, the angle \( \alpha \) of twist of the direction of warp threads of one layer with respect to the direction of warp threads of an adjacent layer may be at most 120°, e.g., may be within a range of 50°±\( \alpha \)±110°, within a range of 60°±\( \alpha \)±100°, within a range of 70°±\( \alpha \)±90°, or within a range of 80°±5°.

[0018] In another aspect of the fabric, with respect to the direction of warp threads of one of the lining layers as a reference layer, directions of warp threads of other layers may be twisted by angles \( \alpha \), \( \alpha' \), \( \alpha'' \) which are different or are identical. For example, with respect to the direction of warp threads of one of the lining layers as a reference layer, directions of warp threads of the two adjacent layers may be twisted by the identical angle \( \alpha \), while directions of warp threads of the subsequent two adjacent layers may be parallel to those of the reference layer.

[0019] In yet another aspect of the fabric, the number of the at least two warp-knitted fabric layers may be 2, 3, 4, 5, 6, 7, 8 or 9, e.g., may be is ±5, or may be 6, 7, 8 or 9.

[0020] In a still further aspect, the weight of each layer may be in a range of from 120 to 180 g/m², e.g., in a range of from 140 to 160 g/m², or a range of 160±5 g/m²; and/or in each layer, the number of warp threads may be 4.5±0.5 threads/cm and/or the number of weft threads may be 6.5±0.5 threads/cm.

[0021] In another aspect of the multilayer lining fabric according the present invention, the polymer thread material may be a polyester or polyamide or a combination thereof. For example, the polymer thread material may be a polyester, e.g., a polyethylene terephthalate (PET); and/or the material thickness may be within a range of from 0.4 to 1.0 mm, e.g., within a range of from 0.6 to 0.8 mm, within a range of from 0.65 to 0.75 mm, or may be about 0.7 mm.

[0022] In another aspect of the fabric, 2, 3, 4, 5, 6, 7, 8 or 9 layers may be in an arrangement one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle \( \alpha \) of at least 20° (and preferably at most 120°), e.g., within a range of 50°±\( \alpha \)±110° and may be fixed together loosely, e.g., seamed by loose stitching, to form a loosely fixed stack of twisted layers.

[0023] In another aspect, the fabric may be included in a textile pad comprising a surrounding envelope and an inner stack of 2, 3, 4, 5, 6, 7, 8 or 9 loosely stitched fabric layers in an arrangement one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle \( \alpha \) of at least 20°.

[0024] The present invention also provides clothing which comprises at least one multilayer lining fabric as set forth above (including the various aspects thereof) and a shell layer.

[0025] In one aspect, the multilayer lining fabric may be present in or on only a part of the clothing.

[0026] In another aspect of the clothing, a plurality of layers of the multilayer lining fabric of the present invention as set forth above may be arranged one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle \( \alpha \) of at least 20° (and preferably at most 120°) e.g., by an angle \( \alpha \) within a range of 50°±\( \alpha \)±110°; such arrangement of said plurality of layers being symmetrical to a manufacturing direction of the clothing shell layer, e.g., being symmetrical to a longitudinal axis of parts of said clothing extending in a longitudinal direction.

[0027] In yet another aspect of the clothing, the loosely stitched stack of twisted layers or the textile pad of the surrounding envelope and the inner stack of 2, 3, 4, 5, 6, 7, 8 or 9 loosely stitched fabric layers in an arrangement one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle \( \alpha \) of at least 20° may be separately stitched to the inner side of the clothing shell layer without additionally stitchingly fixing the twisted layers to the clothes.

[0028] In still further aspect of the clothing, the clothing may further comprise an additional knee protection area, e.g., made of an imprintable cushioning material, or an imprintable polymer material selected from melt-printable polyurethanes, optionally improved in its adherence to the clothing shell layer by an adherence improver.

[0029] In another aspect, the clothing may be present in the form of clothing for sports or for working.

[0030] In another aspect, the clothing may be present as chainsaw protection clothing, preferably as chainsaw protection pants.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0031] The invention is further explained by referring to the attached Figures. However, the subsequent description, and the Figures as well, are not intended to restrict the invention to the preferred embodiments shown or explained in detail; such description and Figures show, as examples only, preferred embodiments of the invention serving a better understanding of the principles of the invention. In the Figures:

[0032] FIG. 1 shows an exemplary example of the basic pattern of warp-knitting of the prior art;

[0033] FIGS. 2A and 2B show two thread material layers side by side and in a superimposed arrangement, allowing to recognize the twist angle \( \alpha \) of their different directions of the warp thread in the superimposed arrangement;

[0034] FIG. 3 shows another example of a plurality of thread material layers side by side and in a superimposed arrangement, allowing to recognize the twist angles \( \alpha \), \( \alpha' \), etc., of their different directions of the warp thread in the superimposed arrangement;

[0035] FIG. 4 shows one embodiment of the invention where a plurality (four) of thread material layers of a multilayer lining fabric M of the invention are twisted by respective angles \( \alpha \) of 80°±5° and 90°±5°.

[0036] FIGS. 5A to 5D show specific embodiments of the stacks of multilayer lining fabrics used in manufacturing clothes in accordance with, and as explained in, the working example, wherein FIG. 5A shows an arrangement of an exemplary plurality layers for the left leg front side of working pants for chainsaw workers, FIG. 5B shows a similar arrangement as FIG. 5A, but for the front and back sides of working pants for chainsaw workers; FIG. 5C shows the arrangement of a stack of a plurality of lining fabric layers included into a textile pad; and FIG. 5D shows the textile pad of FIG. 5C included by e.g. stitching in a part of clothing, e.g. a portion of a pair of working pants for a chainsaw worker.

**DETAILED DESCRIPTION OF THE PRESENT INVENTION**

[0037] The particulars shown herein are by way of example and for purposes of illustrative discussion of the embodi-
ments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the present invention. In this regard, no attempt is made to show details of the present invention in more detail than is necessary for the fundamental understanding of the present invention. The description in combination with the drawings making apparent to those of skill in the art how the several forms of the present invention may be embodied in practice.

[0038] The term "comprise", "comprises" or "comprising" as used in the present specification and claims, for example in claim 1 (multi-layer lining fabric claim) or in the description of the fabric, is defined to have the meaning that said fabric of the invention may comprise (or include) (i) at least one component of the fabric following said term "comprise" or "comprises" or "comprising" or may comprise (or include) (ii) two or more components of the fabric following said term "comprise" or "comprises" or "comprising", or that (iii) further components (more specifically defined below) may also be comprised by the fabric of the invention. The same is applicable also to the clothes claims and description of the clothes of the present invention, mutatis mutandis.

[0039] The term "comprise", "comprises" or "comprising" as used in the present specification and claims is, however, also defined for the present invention to optionally include cases where the multi-layer lining fabric of the invention mainly (or even exclusively) consists of (i) at least one component of the fabric following said term "comprise" or "comprises" or "comprising" or mainly (or even exclusively) consists of (ii) two or more components of the fabric following said term "comprise" or "comprises" or "comprising", optionally together with any necessary component a skilled person may optionally additionally include into such a fabric in order to achieve the object of the invention, or may even include cases where the component of the fabric following said term "comprise" or "comprises" or "comprising" exclusively consists of (i) at least one component named or exclusively consists of (ii) two or more components named, optionally together with any necessary component a skilled person may include into such a fabric in order to achieve the object of the invention. The same is applicable also to the clothes claims and description of the clothes of the present invention, mutatis mutandis.

[0040] In other words: The term "comprise" or "comprises" or "comprising" may have, in the present specification and claims, the meanings of describing, or claiming, an exhaustive or, alternatively, a non-exhaustive enumeration of elements, without that, in the former case, embodiments are excluded which, for example in sub-claims of the present application and corresponding parts of the specification, claim (and describe) further features, which are beneficial or advantageous but not essential for the present invention.

[0041] The present invention provides a multi-layer lining fabric. The term "lining fabric" as used in the present specification and the appended claims is defined to mean a textile material made in the form of a plurality of layers each of which consists of textile material threads. Such thread layers, in the case of the present invention, are manufactured by a process of warp-knitting. As is generally known in this technical field, the process of warp-knitting is a knitting method in which the thread zigzags along the length of the fabric and, hence, follows adjacent columns of knitting, i.e. a knitting direction which follows the length direction of the knitted textile material. In an exemplary manner, this is shown in FIG. 1, wherein the arrow shows the direction of the warp thread. Such a textile material or fabric is used as a lining under a surface layer or as a protective fabric layer (e.g. of a piece of clothing) in order to generate an underlayer having specific properties.

[0042] In accordance with the present invention, the lining fabric is a multi-layer lining fabric, i.e. has a number of layers of at least two: in accordance with the invention, at least two warp-knitted fabric layers of a polymeric thread material are comprised.

[0043] The number of layers is not restricted to "two" and may comprise, in preferred embodiments of the invention, 2, 3, 4, 5, 6, 7, 8 or 9 or even more warp-knitted fabric layers. There is, in within the framework of the present invention, no restriction to the number of the layers of the multi-layer lining fabric. An exception is the fact that a larger number of layers increases the overall weight of the multi-layer lining fabric of the invention, the latter being contrary to the object of providing a multi-layer lining fabric enhancing the wearing comfort for the wearer of the fabric or of the clothes comprising said fabric, because the fabric's weight increase makes movements in the wearer's sport or working environment more cumbersome. A number of layers of 2-5 is preferred, and even more preferred is a number of 6, 7, 8 or 9 warp-knitted fabric layers.

[0044] The polymeric thread material may be a polymeric thread material which is identical in all layers of the multi-layer lining fabric or may comprise two or more polymeric thread materials in different layers of the multi-layer lining fabric. A person skilled in the art may select such one (or two or even more) polymeric thread materials from a large number of materials, which are known in the art per se, in accordance with the specific requirements of each single case. In accordance with the invention, one single polymeric thread material for all layers of the multi-layer lining fabric of the invention is preferred; this does, however, not restrict the invention to this preferred embodiment.

[0045] In accordance with the invention, the material of the (at least two) warp-knitted fabric layers is a polymer thread material. Polymers for threads which may be employed for knitting the warp-knitted fabric layers of the present invention are well-known to a skilled person and may be selected from a large number of polymer materials in accordance with the requirements of a specific case, subject to the parameters of the material. One of those parameters is, naturally, that the polymer must be capable of being formed into threads which are suitable for the machine knitting process. Another criterion is the requirement that the material, in the form of a thread, must be capable of being knitted into a fabric material by a warp-knitting process.

[0046] In accordance with the invention, the polymer material, after being warp-knitted into a fabric layer, has a weight of >100 g/m². Polymer material fabrics having a weight of >100 g/m² may be warp-knitted into light-weight lining fabrics having good mechanical properties, for example excellent stretchability, light weight and high humidity-dissipating properties.

[0047] There is basically no upper limit of the fabrics' polymer material weight, with the exception of the requirement that, in view of the object to provide a light-weight material promoting the wearer's comfort, the material should not be of too high a weight. In preferred embodiments of the invention, which may be realized alone or in combination
with one or several other features of the invention and which should not be construed to restrict the invention, the materials used in each fabric layer may have a weight in the range of from 120 to 180 g/m², preferably in a range of from 140 to 160 g/m², more preferably in a range of 160±5 g/m². Exemplary (but not restricting) weights of the polymer material after being warp-knitted into a fabric layer are 132 g/m² or 162 g/m² or 114 g/m² or 148 g/m² or 171 g/m², and such specific weights may be used in combination with others, while having advantageous properties for the invention. Materials having the aforesaid-mentioned weight were found to be particularly suitable for the multilayer lining fabric of the present invention.

In preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the materials have a thickness in the range of from 0.4 to 1.0 mm, preferably within a range of from 0.6 to 0.8 mm, more preferably within a range of from 0.65 to 0.75 mm, most preferably about 0.7 mm. Materials having the aforesaid-mentioned thickness were found to be particularly suitable for the multilayer lining fabric of the present invention.

In preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the polymer thread material is a polyester or polyamide. Polymers are particularly preferred materials, since they result in multilayer lining fabrics which are convenient for the wearer and provide, in addition, good safety properties, as will be shown below in detail. A person skilled in the art is familiar with polyesters and polyamides, particularly with polyesters, as polymer thread materials known in the present field and may select such polyesters from a large group thereof in accordance with the requirements of a specific case. More preferably, the polymer thread material may be poly(ethylene terephthalate) (PET). One specific material available on the market has turned out to be a particularly suitable material, which material is available from the Company Engtex AB, Mullsjö, Sweden, under the Trade Name “ENGTEX Dynesma”.

In accordance with the invention, the warp-knitting of the fabric layers may be carried out to result in a number of weft threads per centimeter length of the fabric layers which is larger than the number of warp threads per centimeter width of the fabric layers, which number ratio represents the density of knitting of the fabric layer material.

In preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, in each layer the number of warp threads is 4.5±0.5 threads/cm and/or the number of weft threads is 6.5±0.5 threads/cm. Fabric layers of a polymer thread material having been warp-knitted on warp-knitting machines into fabrics having thread densities in the above ranges show particularly good improvements of their properties.

In accordance with the present invention, the multilayer lining fabric comprises at least two warp-knitted fabric layers of at least one polymer thread material, which layers are superimposed on each other, and the number of warp-knitted fabric layers may be 2, 3, 4, 5, 6, 7, 8 or 9 or even more warp-knitted fabric layers may be present, as mentioned above. In preferred embodiments of the invention, 2, 3, 4, 5, 6, 7, 8 or 9 even more warp-knitted fabric layers, are superimposed on each other, and even more preferable is a number of 6, 7, 8 or 9 warp-knitted fabric layers, for example 7, 8 or 9 warp-knitted fabric layers, and most preferable 9 warp-knitted fabric layers which are superimposed on each other.

In preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the direction of warp threads of one layer, in the plane of the layers of the fabric, is twisted, with respect to the direction of warp threads of an adjacent layer, by an angle α of at least 20°. In other words: if two layers of a warp-knitted polymer thread material are formed into a stack of two thread material layers, they are not stacked one upon another in parallel (i.e. with parallel warp thread directions, as in the prior art) but are stacked in a twisted manner so that their warp thread directions are positioned at an angle α to each other of at least 20°.

This is, for example, shown in FIG. 2. Two thread material layers 1, 2, each manufactured by warp-knitting are shown side by side in FIG. 2A, and are shown in FIG. 2B in a superimposed arrangement and twisted, with respect to their warp thread directions (represented by darker lines), by an angle α of, for example, 80°.

The technical effect of the feature of a superimposed arrangement of the at least two (and preferably ≥2) warp-knitted thread material layers twisted by an angle α of at least 20° with respect to their directions of the warp threads is twofold: from a safety point of view, the blocking of the operation of a chainsaw cutting into the cloth provided with the multilayer lining fabric in a (for example) vertical or diagonal direction (of pant legs) is in a short time range comparable to, or even better than, corresponding values of prior art clothes, but the elasticity and stretchability of the multilayer lining fabric (comprising said warp-knitted thread material layers) is enhanced considerably. Even in multilayer lining fabrics having more than the minimum two warp-knitted thread material layers (e.g. ≥5 or ≥6, 8, 9, 10 or more, for example 7, 8 or 9 warp-knitted thread material layers), the comfort for the user (particularly due to the still enhanced elasticity and stretchability) is remarkable. A motion of the legs under heavy working duty and, hence, including a lot of sweating of the wearer in the pants provided with the multilayer lining fabric is achievable without the appearance of irritation on the wearer’s skin.

In addition, if a multilayer lining fabric of the above type, as it is in accordance with the present invention, is fixed in pants of chainsaw operators, and the pants are subjected to the standardized chainsaw cutting tests in the directions perpendicular and parallel to the pant legs (so-called PPE test (or in German: EU PSA-Baunust-Prüfung)), the multilayer lining fabric is capable of blocking the chainsaw’s operation better than in cases of prior art pants provided with lining layers superimposed in parallel, with respect to their twisted directions of warp threads of the plurality of layers. Details are described below in the experimental section.

In preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the angle α of twist of the direction of warp threads of one layer with respect to the direction of warp threads of an adjacent layer, is at most 120°. If this upper limit value of the twist angle α is observed, the
elasticity and stretchability of the multilayer lining fabric is also still enhanced. In multilayer lining fabrics having more than the minimum two warp-knitted thread material layers (e. g. having, for example, 6, 7 or 8 layers of the polymer thread material), the comfort for the user (particularly due to the enhanced elasticity and stretchability) is even better. A motion of the legs under heavy working duty and, hence, including a lot of sweating of the wearer in pants provided with the multilayer lining fabric is achievable without the appearance of irritation or even inflammation on the wearer’s skin.

[0058] Moreover, the standard tests of these multilayer lining fabrics retaining their twist of the directions of their warp threads below the upper limit value resulted in a better blocking of the chainsaw’s operation by the threads of the multilayer lining fabric.

[0059] In more preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the angle α of a twist of the direction of warp threads of one layer with respect to the direction of warp threads of an adjacent layer, is within a range of 50°≤α≤110°. It is even more preferable in accordance with the present invention that the angle α of a twist of the direction of warp threads of one layer with respect to the direction of warp threads of an adjacent layer, is within a range of 60°≤α≤100°. By retaining the twist angle in the above preferred ranges, the above properties of wearing comfort and chainsaw operation safety blocking could be further improved, compared to the prior art.

[0060] In further more preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the angle α of a twist of the direction of warp threads of one layer with respect to the direction of warp threads of an adjacent layer, is within a range of 70°≤α≤90°. In mostly preferred embodiments, the angle α of twist of the direction of warp threads of one layer with respect to the direction of warp threads of an adjacent layer is within a range of 80°≤α≤5°. Particularly in the latter case, the elasticity and stretchability of the multilayer lining fabric is enhanced to a surprising extent. In multilayer lining fabrics having more than the minimum two warp-knitted thread material layers (e. g. having, for example, 6, 7, 8 or 9 layers of the polymer thread material), the comfort for the user (particularly due to the enhanced elasticity and stretchability) is excellent, compared to the prior art. A motion of the legs under heavy working duty and, hence, including heavy sweating of the wearer in trousers provided with the multi-layer lining fabric is achievable without that irritations or even inflammations on the wearer’s skin could be observed.

[0061] Moreover, the standard tests of these multilayer lining fabrics retaining their twist of the directions of their warp threads in the range of 80°≤5° resulted in a blocking of the chainsaw’s operation by the threads of the multilayer lining fabric even exceeding the values obtained with prior art multilayer lining fabrics having a relatively parallel arrangement of their directions of the warp threads.

[0062] In further preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, directions of warp threads of certain layers of the multilayer lining fabric M, with respect to the direction of warp threads of one of the lining layers as a reference layer, are twisted by angles α, α', α" which are different from each other or which are identical to each other. In other words: In superimposed arrangements of more than two (for example five) thread material layers, all twist angles α, α', α", α‴ (etc.) of directions of the warp threads of one layer, relative to the respective superimposed adjacent layer, are different from each other. The respective differences may be different in the absolute value of the angle (i. e. |α|) or may also (or instead only) be different in view of the clockwise or counterclockwise directions. As an alternative, all warp thread direction angles α of different layers may be identical to each other.

[0063] FIG. 3 shows an example for the above first case where directions of warp threads of certain layers of the multilayer lining fabric M, with respect to the direction of warp threads of one of the lining layers as a reference layer, are twisted by angles α, α', α" which are different from each other: In accordance with FIG. 3, the angles α of the twist of the direction of warp threads change from one layer couple (layers 1−2) of thread material to the next couple of layers, i. e. adjacent, layers 2→3 layers 3→4, of thread material in their absolute values (e. g. α=−40°; α"=−80°; α′=−60°). In another preferred embodiment of the invention (described below with respect to FIG. 4), the twist angles α of another arrangement are identical in their (absolute) values, but are varied with respect to the clockwise and counterclockwise directions (e. g. α=−90°; α′=−90°; α"=−90°). The above values are exemplary examples only and do not restrict the invention.

[0064] In further preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, directions of warp threads of two directly adjacent layers, with respect to the direction of warp threads of one of the lining layers as a reference layer, are twisted by the identical angle α (i. e. |α| is always the same), while directions of warp threads of the following two adjacent layers are parallel to those of the reference layer, and the angles α are different “only” in their clockwise or counterclockwise directions.

[0065] This case is shown in FIG. 4: The reference layer of the multilayer lining fabric M has the reference numeral 1; its direction of the warp threads is represented by a darker line. The directly adjacent layer 2 of the multilayer lining fabric M has a direction of its warp threads (also represented by a darker line) which is twisted, with respect to the reference layer’s (1) warp thread direction, by the angle α, e. g. by 80°±5°. The layer 3 directly adjacent to layer 2 of the multilayer lining fabric M has a direction of its warp threads (also represented by a darker line) which is twisted by an angle α identical to the angle α between layers 1 and 2 in its value, but having a counter-clockwise direction, e. g. −80°±5°. The same is applicable to layer 4 directly adjacent to the above layer 3 of the multilayer lining fabric M; and so forth. In other words: In the preferred embodiment of the multilayer lining fabric shown in FIG. 4, the layers having an odd number (e. g. 3, 5, etc.) each have directions of their warp threads (represented by darker lines) which are parallel to the reference layer’s (1) warp thread direction, while the layers having an even number (e. g. 2, 4, 6 etc.) have directions of their warp threads (represented by darker lines) which are in an angle α off, for example 80°±5°, to the warp thread directions of the odd-numbered layers (1, 3, 5 etc.).

[0066] In the latter case, a kind of “zig-zag” arrangement of the respective adjacent layers’ relative twist angle α of their
relative directions of the warp thread is established. Such an arrangement is highly advantageous, because the elasticity and stretchability of the multilayer lining fabric is maintained at an enhanced level, to a surprising extent. In multilayer lining fabrics having, for example, 6, 7, 8 or 9 layers of the polymer thread material, the comfort for the user (particularly due to the enhanced elasticity and stretchability) is excellent, compared to the prior art. A motion of the legs under heavy working duty and, hence, including heavy sweating by the wearer in pants provided with the multilayer lining fabric is achievable without irritation or even inflammation on the wearer’s skin being observed.

Moreover, the standard tests (according to the technical standard EN/DIN 381-2 and 381-5 for chainsaw trousers) of these multilayer lining fabrics retaining their twist of the directions of their warp threads in the range of 80°±2° and having the above “zig-zag” configuration of their angles α of the warp thread directions, relative to the warp thread directions of the reference layer of the multilayer lining fabric, resulted in a blocking of the chainsaw’s operation by the threads of the multilayer lining fabric which even exceeds the values obtained with prior art multilayer lining fabrics having a relatively parallel arrangement of their directions of the warp threads, in the chainsaw cuts in a direction perpendicular to the trouser leg axis and even more in the direction parallel to the trouser leg axis.

Further preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention are directed to multilayer lining fabrics according to the invention, wherein 2, 3, 4, 5, 6, 7, 8 or 9 layers are in an arrangement one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle α of at least 20° and preferably at most 120° and more preferably within a range of 50°≤α≤110°; and are fixed together loosely to form a stack of loosely fixed, e.g. loosely stitched, twisted layers.

Such a fixing of the lining fabric layers, preferably such stitching thereof, may be effected preferably at the edges of the lining fabric layers, so as to form a loosely connected, flexible stack thereof. Hence, in accordance with these preferred embodiments of the invention, such stacks of a plurality of loosely connected/fixed fabric layers are designed to form, and practically form, flexible and stretchable “pillows” comprising such a plurality of the warp-knitted material layers, wherein the relative position of the layers is not tightly fixed, but only loosely and flexibly connected. Thereby, a substantial contribution to the desired flexibility of the lining fabric can be made.

The preferred way of loose fixation known to a skilled person is seaming by loosely stitching, although the invention is not restricted to this type of loose fixation.

In a further preferred embodiment of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, such a stack of loosely fixed, e.g. loosely stitched, twisted layers of the lining fabric material may be included into a textile pad, and such a pad comprises a surrounding envelope and an inner stack of 2, 3, 4, 5, 6, 7, 8 or 9 loosely fixed, e.g. loosely stitched, fabric layers in an arrangement one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle α of at least 20°.

The textile pad is defined, for the present specification and claims, to be a textile material in a sheet form and capable of forming the envelope needed for surrounding the fabric layer stack, capable of maintaining said envelope shape under the conditions of use of the pad, and capable of being fixed, by textile fixation processes as, for example, stitching, to other textile sheet materials. The material of which the pad is formed may be any material known to a skilled person for the desired purpose of surrounding the plurality of loosely fixed or loosely stitched fabric layers, and such a material may be selected by a skilled person from a number of suitable materials according to the parameters which must be observed.

In further preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the textile material of the pad envelope is selected from knitted or woven textile materials, which—in more preferred embodiments—will have to have, or to retain, a high elasticity. Polymer materials like polyamides and—even more preferred—polymers are preferred materials. Polymers are even more preferred, because they retain their elasticity; “skin-friendly”, i.e. do not undergo any changes in their mechanical properties and are capable of being treated with a “wicking” finish material capable of wicking sweat away from the skin. Particularly preferred materials are the materials known under the commercial names ELASTAN® or LYCRA®.

The resulting pad comprises or includes said stack of a plurality of lining fabric layers the directions of the warp threads of which are twisted by a certain angle α as explained above, and loosely connected to a stack of textile layers, preferably by loosely stitching said layers, preferably at their edges.

Such a pad, in accordance with the invention, is required to be capable of being fixed, by any conceivable textile fixation process, to another textile material, for example to a textile material forming a piece of clothing, of which a piece of clothing (e.g. pants) for sport purposes of the working purposes are two examples, only. A suitable textile fixation process may be selected by a person skilled in this field in accordance with the requirements needed. Such a fixation process may be a step of stitching the pad to a sheet of a textile material, preferably by machine stitching the borderline or the edges of the pad to said sheet of textile material.

As a result, the sheet of textile material comprises the pad fixed (e.g. stitched, preferably machine-stitched) to the sheet, and its position on the sheet is clearly defined. On the other hand, the pad itself comprises included, and loosely connected, the flexible stack of lining textile layers, which stack, inside the envelope, provides the desired stretchability, resulting into the wearer’s comfort.

In another aspect, the invention relates to clothes which comprise at least one multilayer lining fabric according to the present invention as described above in detail, as well as a shell layer. Such a shell layer may be a layer directed to the outer side of the clothes and may additionally have certain functions such as, for example, a water repelling function, a safety signal color, without restricting the invention to those functions.

Hence, with respect to the clothes of the invention, the above description of the multilayer lining fabric of the present invention can be referred to in all details, and all features of the multilayer lining fabric of the invention, i.e.
one feature of the above-described features alone or several or all features of the above-described features in combination, as well as its/their objects and advantages, are also applicable to the clothes comprising such multilayer lining fabric.

[0079] The clothes of the invention may comprise at least one of the multilayer lining fabrics of the invention or may comprise two or three or even more of the multilayer lining fabrics. In a preferred embodiment of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the clothes of the invention comprise the multilayer lining fabric according to the invention (one multilayer lining fabric or two or even three or more multilayer lining fabrics, preferably one multilayer lining fabric) in only a part thereof. This means that the clothes comprise parts where no multilayer lining fabric of the invention is applied. One of the reasons is that the purposes of said multilayer lining fabric (in particular the safety feature of being capable of blocking a chainsaw operation cutting into said cloth) are needed only in parts of the piece of clothing.

[0080] In a further preferred embodiment of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the clothes of the invention comprising the multilayer lining fabric are selected from sports clothes and working clothes. In these preferred types of clothes, the advantages of the invention, particularly the advantages afforded by the multilayer lining fabric, can ideally be achieved: both types of clothes are worn by people who have to move their bodies very much, which fact is closely connected to sweating. Hence, these wearers need clothes adapted to multi-movement types of activities and, hence, must be comfortable in their wearing properties, e.g. must provide elasticity and stretchability.

[0081] In addition, in the case of working clothes, safety aspects have to be observed. As a specific feature, the clothes of the invention, equipped with the multilayer lining fabrics of the invention, allow a blocking capability for chainsaws which surprisingly exceeds similar properties as tested in standard procedures described below in the experimental part of this description.

[0082] In a further preferred embodiment of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the clothes are chainsaw protection clothes, preferably for forest workers, which surprisingly exceed all expectations not only with respect to the wearing comfort, but also with respect to the safety aspect: in chainsaw cutting tests according to the EU standard EN 381-2 and 381-5, the clothes according to the invention and comprising the multilayer lining fabric of the invention achieved very good results: The preferred clothes of the invention, working pants for forest workers, achieved good, in part even considerably better test results (more rapid stopping of the chainsaw’s operation by the threads of the lining fabric layers) not only in chainsaw cuts perpendicular to the pants leg axis, but also in chainsaw cuts in a direction diagonal to the pants leg axis). Details thereof are described below in the experimental part of the description.

[0083] In particularly preferred embodiments of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the clothes of the present invention comprise the multilayer lining fabric according to the above-described preferred embodiments of the multilayer lining fabric of the invention, wherein the densely stitched stack of twisted layers or the textile pad of the surrounding envelope and the inner stack of 2, 3, 4, 5, 6, 7, 8 or 9 loosely fixed, preferably loosely stitched (for example along their edges) fabric layers in an arrangement one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle $\alpha$ of at least 20°, and preferably at most 120° and more preferably within a range of 50° $\leq \alpha \leq 110°$, is separately stitched to the inner side of the clothes’ shell layer, without additionally stitchingly fixing the twisted layers to the clothes’ shell layer. As mentioned above, such multilayer lining fabric according to the invention may be applied to the whole inner side of the clothes’ shell layer or may be applied only to a part thereof.

[0084] The shell layer may be of any suitable material known to a skilled person for purposes of sports clothes, working clothes etc. and, hence, may be selected from any suitable material in accordance with the specific requirements of a single case. Typical examples of a material selected as the shell layer material include a material selected from materials having a sufficient durability, weather resistance, wicking properties and tear strength, which is essential for sports clothes and working clothes. A skilled person knows such materials for shell layers of sports and working clothes and, hence, may select such materials in accordance with the requirements of a specific case. Particularly preferred materials are polyamides and polyesters, and polyesters are even better preferred. Exemplary (although not restricting) materials are those known under the commercial names ELASTAN® and LYCRA®.

[0085] In a further preferred embodiment of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the clothes of the present invention comprise advantageous and, hence, preferred embodiments, wherein a plurality of layers of the multilayer lining fabric of the above detailed description is arranged one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle $\alpha$ of at least 20° and preferably at most 120° and more preferably within a range of 50° $\leq \alpha \leq 110°$ wherein such arrangement of said plurality of layers is symmetrical to a manufacturing direction of the clothes’ shell layer. Said clothes’ manufacturing direction may be the lengthwise direction of knitting or weaving (i.e. the warp thread direction). In other preferred embodiments, such arrangement of said plurality of layers is symmetrical to a longitudinal axis of parts of said clothes extending in a longitudinal direction, e.g. to the longitudinal axis of the pants’ legs. In other words: The plurality of layers is arranged, with respect to the manufacturing direction or longitudinal axis direction in such a manner that angle $\alpha$’s half angle ($\pm \alpha/2$) is located exactly on the working direction or longitudinal pants leg axis, thereby achieving that the elasticity of the overall material (i.e. multilayer lining fabric with its plurality of layers plus shell layer) is retained on a high level, while achieving good safety standards in working
clothes' safety tests (particularly the diagonal cut of the chainsaw safety test; see the experimental section below).

[0087] In a further preferred embodiment of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the clothes of the invention comprising the multilayer lining fabric of the invention (as described above in all details), particularly the working pants, may additionally comprise an additional knee protection area, affording an additional protection effect to the wearer's body when working on the knees or including movements where a touch to the knee is involved.

[0088] Such an additional knee protection area may be made in accordance with usual prior art knee protection means, but, in accordance with the invention, it is preferably made of an imprintable cushioning material applied to the knee area of the pants leg or even to both knee protection areas of both pants legs. Such protective cushioning may be made of any material a skilled person is aware of for the desired purposes.

[0089] However, in a further preferred embodiment of the invention, which may be realized alone or in combination with one or several other features of the invention and which should not be construed to restrict the invention, the clothes of the invention comprising the multilayer lining fabric additionally comprise an additional knee protection area to which is applied, directly onto the shell material, an imprintable cushioning material made of an imprintable polymer material, wherein—even more preferably—the polymer may be selected from the group of melt-printable polymers, particularly from polyurethanes. Optionally, the adherance of such a polymer material, preferably the adherance of such a polyurethane material, to the clothes' shell layer is improved by means of the application onto the area between the clothes and the additional knee protection material, of an adherance improver. A skilled person knows such adherance improving materials and may select them in accordance with the nature of the polymer and clothes' materials based on the general skill.

[0090] The additional imprintable cushioning material may be applied to the outside surface of the piece of clothing, preferably of the working or protection pants of the invention, in any conceivable shape. In particularly preferred embodiments of the invention, the application may comprise small spot patterns or small line patterns or small picture patterns, which may either have the same appearance (e.g., color) as the fabric sheet onto which they are applied or may be different in appearance (e.g., color) so that they are silhouetted against the fabric base. In the latter case, the manufacturer of the working clothes may show a logo or a safety sign by such an imprintted cushioning material.

[0091] In the following, the multilayer lining fabric of the present invention as well as the clothes comprising such a multilayer lining fabric of the invention, are in more detail explained by referring to specific examples. It has to be noted that the examples are given only for allowing a better understanding of the invention and should not be construed to limit the invention to the specific examples.

Examples

[0092] Chainsaw operators' pants subjected to the tests described below comprised an outer water protection fabric made of ELASTAN® and an inner lining consisting of 8 warp-knitted fabric layers and an additional lining fabric made of LYCRA® between layers Nos. 7 and 8 (calculated from the inner to the outer side of the lining fabric stack (see FIGS. 5A to 5D). In each layer, the number of warp threads was 4.5±0.5 threads/cm and the number of weft threads was 6.5±0.5 threads/cm.

[0093] The direction of warp threads of warp-knitted fabric layer 2 was twisted, with respect to the direction of warp threads of layer 1, by an angle of +80°; the direction of warp threads of warp-knitted fabric layer 3 is twisted, with respect to the direction of warp threads of layer 2, by an angle of −80° (i.e., the same as the direction of warp threads of layer 1); the direction of warp threads of warp-knitted fabric layer 4 is twisted, with respect to the direction of warp threads of layer 3, by an angle of +80°; the direction of warp threads of warp-knitted fabric layer 5 is twisted, with respect to the direction of warp threads of layer 4, by an angle of −80° (i.e., the same as the direction of warp threads of layer 1); etc. This arrangement of the layers under the water protection fabric shell layer is shown by way of example in FIG. 5A.

[0094] The eight layers shown in FIG. 5A were packed into an envelope made of ELASTAN® without stitching them together, and the surrounding envelope was stitched at both ends by sewing; any other stitching method instead of sewing could have been employed.

[0095] The resulting “textile pad” was applied to the left leg front side of the chainsawer’s working pants. The resulting pants were evaluated by the wearers to provide the desired elasticity and stretchability and did not cause any discomfort even under hard-sweating work conditions.

[0096] The same pants were subjected to the EU PPE standard test by cutting on a test stand with a chainsaw cut perpendicular to the pants legs’ axis and stopped the chainsaw under conditions identical to the usual EU PPE standard test (speed of the chains, cutting angle).

[0097] Moreover, the same pants were subjected to a modified test under the Industrial Standard EN 381-2 and 381-5. This standard has a test stand which is being modified for the multilayer lining fabrics due to their twisting of the warp directions in the plane of the multilayer fabric layers. First results (to be confirmed in further tests) showed that the chainsaw chain stopping by entangling the chain with the warp threads is better than the conventional multilayer fabrics having parallel directions of their warp threads, thereby surprisingly showing a better fit for safety requirements for such type of clothes, in addition to better wearing comfort for the wearers.

[0098] Working pants made of the above materials for chainsaw workers were subjected to a 4 week-longtime field test under relatively high temperature (summer) and high humidity (rain) conditions and were found by the workers to be better adapted to the requirements and more convenient to wear under high load sweating conditions (mountain forest) than all other materials available on the market; particularly the desired elasticity and sweat-dissipating properties were found to be outstanding.

[0099] It is noted that the foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention. While the present invention has been described with reference to exemplary embodiments, it is understood that the words which have been used herein are words of description and illustration, rather than words of limitation. Changes may be made, within the purview of the appended claims, as presently stated and as amended, without departing from the
the scope and spirit of the present invention in its aspects. Although the present invention has been described herein with reference to particular means, materials and embodiments, the present invention is not intended to be limited to the particulars disclosed herein; rather, the present invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims.

What is claimed is:

1. A multilayer lining fabric, wherein the fabric comprises at least two warp-knitted fabric layers of at least one polymer thread material having a weight of \( \geq 100 \text{ g/m}^2 \), wherein a number of weft threads per centimeter of length of the fabric layers is larger than a number of warp threads per centimeter of width of the fabric layers, and wherein, in a plane of the fabric layers, a direction of warp threads of one layer is twisted with respect to a direction of warp threads of an adjacent layer by an angle \( \alpha \) of at least 20°.

2. The multilayer lining fabric of claim 1, wherein \( \alpha \) is at most 120°.

3. The multilayer lining fabric of claim 1, wherein \( \alpha \) is within a range of 50° \( \leq \) \( \alpha \leq \) 110°.

4. The multilayer lining fabric of claim 1, wherein \( \alpha \) is within a range of 80° \( \leq \) \( \alpha \leq \) 90°.

5. The multilayer lining fabric of claim 1, wherein, with respect to the direction of warp threads of one of the lining layers as a reference layer, directions of warp threads of other layers are twisted by angles \( \alpha, \alpha', \alpha'' \) which are different or identical.

6. The multilayer lining fabric of claim 5, wherein with respect to the direction of warp threads of one of the lining layers as a reference layer, directions of warp threads of the two adjacent layers are twisted by an identical angle \( \alpha \), while directions of warp threads of subsequent two adjacent layers are parallel to those of a reference layer.

7. The multilayer lining fabric of claim 1, wherein the number of the at least two warp-knitted fabric layers is 2, 3, 4, 5, 6, 7, 8 or 9.

8. The multilayer lining fabric of claim 7, wherein the number of the at least two warp-knitted fabric layers is 6, 7, 8 or 9.

9. The multilayer lining fabric of claim 1, wherein a weight of each layer is in a range of from 120 to 180 g/m² and/or wherein, in each layer, the number of warp threads is \( 4.5 \pm 0.5 \text{ threads/cm} \) and/or the number of weft threads is \( 6.5 \pm 0.5 \text{ threads/cm} \).

10. The multilayer lining fabric of claim 1, wherein the polymer thread material is a polyester or polyamide or a combination thereof and/or wherein a material thickness is within a range of from 0.4 to 1.0 mm.

11. The multilayer lining fabric of claim 1, wherein 2, 3, 4, 5, 6, 7, 8 or 9 layers are in an arrangement one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle \( \alpha \) of at least 20° and fixed together loosely to form a loosely fixed stack of twisted layers.

12. The multilayer lining fabric of claim 1, wherein the fabric is included in a textile pad comprising a surrounding envelope and an inner stack of 2, 3, 4, 5, 6, 7, 8 or 9 loosely stitched fabric layers in an arrangement one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle \( \alpha \) of at least 20°.

13. A piece of clothing, comprising at least one multilayer lining fabric of claim 1 and a shell layer.

14. The piece of clothing of claim 13, comprising the multilayer lining fabric in or on only a part of the piece of clothing.

15. The piece of clothing of claim 13, wherein a plurality of layers of the multilayer lining fabric is arranged one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle \( \alpha \) of at least 20°, such arrangement of plurality of layers being symmetrical to a manufacturing direction of the piece’s shell layer.

16. The piece of clothing of claim 13, comprising the multilayer lining fabric wherein a loosely stitched stack of twisted layers or a textile pad of a surrounding envelope and an inner stack of 2, 3, 4, 5, 6, 7, 8 or 9 loosely stitched fabric layers in an arrangement one on top of the other with their directions of warp threads of adjacent fabric layers twisted by an angle \( \alpha \) of at least 20° is separately stitched to an inner side of the piece’s shell layer without additionally stitchingly fixing the twisted layers to the piece of clothing.

17. The piece of clothing of claim 13, further comprising an additional knee protection area.

18. The piece of clothing of claim 13, which is suitable for sports or work purposes.

19. The piece of clothing of claim 13 in a form of chainsaw protection clothing.

20. The piece of clothing of claim 19 in a form of chainsaw protection pants.

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