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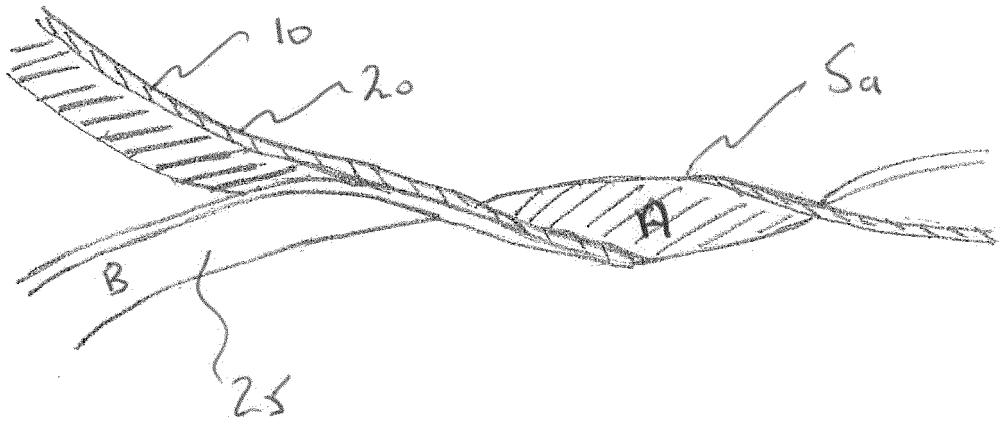
(54) IMPROVEMENTS IN OR RELATING TO POLYMER MATERIALS

(57) There is provided an elongate element (5; 5a to 5d), such as a composite and/or twisted elongate element or braid, comprising a plurality of elongate elements (10) twisted/braided together and which comprise at least one first elongate elements (20) and at least one second elongate element (25), the or each first elongate element (20) comprises a first polymer material A and the or each second elongate element comprises a second polymeric material B, a melting point (MP_A) of material A is lower than the melting point (MP_B) of material B. In a consolidated material (100) comprising at least one elongate (5; 5a to 5d), material A acts as a matrix binder/adhesive agent, and material B acts as a strengthening/integrity providing agent.



Drawing 1. Two yarns twisted together

Figure 1

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Description

FIELD OF INVENTION

[0001] This invention relates to a tape or yarn, such as a polymeric/thermoplastic/polyolefin tape or yarn, to a fabric or material formed from said tape or yarn, to an article, item or product made from said fabric or material, such as a thermoformed article, and to a method of making or forming same.

[0002] The invention particularly, though not exclusively, relates to a thermoplastic tape or yarn, to a thermoplastic material or fabric and a method of producing same. The material or fabric, e.g. composite material or fabric, may be suitable for a variety of applications. For example, composite materials or fabrics of the present invention may be comprised in articles used for high impact, anti-ballistic and/or defensive purposes. Composite materials or fabrics of the present invention may be comprised in articles to afford high-impact resistance properties.

[0003] Embodiments of the present invention relate to composite elongate elements, such as tapes or yarns, which may be used to produce a fabric or material incorporating similar or dissimilar materials in the warp and weft, such fabric being suitable for consolidating into single layer or multilayer shells or structures, e.g. under the action of heat and pressure without the need for additional resin or adhesive.

BACKGROUND TO INVENTION

[0004] Self-reinforcing polypropylene (srPP) fabric is known. Such is marketed by the present Applicant under the brand names ARMORDON ® or TORODON ®. Similar materials are available from other companies, e.g. CURV ® from Propex and PURE ® from DIT.

[0005] WO 91/11324 (DON & LOW) discloses a thermoplastic composite material or tape comprising a molecularly-oriented thermoplastic polymer base having at least one thermoplastic surface polymeric layer compatibly bonded to said polymer base by molecular interspersion between the contiguous surfaces of the adjoining base and surface layers, and said surface polymeric layer having a softening temperature lower than that of the polymer base.

[0006] GB 2 492 644 (DON & LOW) discloses a fabric or material comprising: at least first elongate elements and second elongate elements that are mutually interspersed; wherein the first elongate elements comprise a polymer base and at least one polymeric surface layer, wherein the at least one polymeric surface layer has a softening temperature lower than that of the polymer base; and wherein at least a surface of the second elongate elements comprises an ultra high molecular weight polyalkylene (UHMWPA), wherein the ultra high molecular weight polyalkylene is a material dissimilar to the polymeric surface layer, and the first elongate elements are fusible together with the second elongate elements at least at intersections.

[0007] By "molecular interspersion" is meant the intimate molecular compatibility of molecules of the surface layer and the adjacent polymer and vice versa, so that there is intermingling or fusion at their contiguous boundaries. It is believed that such molecular interspersion effectively forms an amorphous sheath which protects the polymer base against fracture during drawing, thus providing mutual mechanical reinforcement.

[0008] Mutual mechanical reinforcement involves the surface material being capable of high elongation when drawn in the solid state (or even being drawn at a temperature above its softening point, i.e. in the molten state). With a polymer layer of high modulus, and crystalline or oriented material sandwiched between amorphous high elongation surface layers, propagation of transverse fractures is inhibited allowing the total composite to be highly drawn.

[0009] A problem exists in the prior art. Single ribbon tapes of co-extruded polymer are used as warp and weft to weave fabrics. These fabrics are then layered up and hot pressed to make shaped articles. When those articles are subjected to shock loads then an article may fail due to delamination between consolidated fabric layers.

[0010] Coextruded yarns of thermoplastic polymers of at least A-B construction, where A has a melting temperature at least 10°C below that of B can be formed into fabrics eg. woven fabrics, which can, in turn, be formed into three dimensional shaped articles under the influence of heat and pressure without the need for additional adhesives or films. However, these yarns can be limited in their ratio of A to (A+B) to between 1 to 30% or less, more typically 1 to 15% or less. This can limit the strength of bonding of the tape or yarn both internally to itself and also externally to other materials. A fabric can be made from said tapes or yarns, e.g. by weaving, which is capable of being formed into 2 or 3 dimensional items under the action of heat and pressure both by itself and in conjunction with dissimilar materials. The bond strength of such fabric can be limited.

[0011] It is an object of at least one embodiment of at least one aspect of the present invention to obviate or at least mitigate one or more problems or disadvantages in the prior art.

[0012] It is an object of at last one embodiment of at least one aspect of the present invention to provide a fabric or material that may be formed without the use of, for example, a resin matric material, a film, or an adhesive. The fabric or material may, therefore, be self-adhering or self-supporting.

[0013] It is an object of at least one embodiment of at least one aspect of the present invention to provide a single

layer fabric or material which has sufficient impact resistance for use in a formed article, e.g. a suitcase shell.

[0014] It is an object of at least one embodiment of at least one aspect of the present invention to provide a laminated fabric or material which has sufficient impact resistance for use in a formed article, e.g. a suitcase shell, and which has a reduced number of layers compared to the prior art.

SUMMARY OF INVENTION

[0015] According to a first aspect of the present invention there is provided an elongate element or braid, such as a composite and/or twisted elongate element or braid, comprising a plurality of elongate elements twisted or braided together and which comprise at least one first elongate element and at least one second elongate element, wherein the or each first elongate element comprises or consists of a first polymeric material A and the or each second elongate element comprises or consists of a second polymeric material B.

[0016] The Inventors believe that (composite and/or non-coextruded twisted) elongate elements according to the present invention may provide benefit/advantage over prior elongate elements comprising coextruded elongate elements, e.g. of the construction A-B or A-B-A, where B comprises a polymeric base or substrate and A comprises at least one polymeric surface layer or opposing polymeric surface layers.

[0017] Herein, 'composite elongate element or braid' is meant to comprise or include a plurality of elongate elements, yarns, tapes, strands, plies, or fibres that are twisted or braided together.

[0018] It has been found that twisting or braiding together of the plurality of elongate elements (e.g. along their length) may provide advantage over the prior art, e.g. weaving together of single yarns. An advantage may be beneficial increased distribution of the first polymeric material throughout a matrix of a material or fabric, e.g. a woven material.

[0019] In the present invention, the first polymeric material may comprise a first polyolefin.

[0020] The second polymeric material may comprise a second polyolefin.

[0021] The first polymeric material may act as a matrix binder or adhesive agent within the material or fabric. The second polymeric material may act as a strengthening or integrity providing agent within the material or fabric.

[0022] Each of the plurality of elongate elements and/or the composite elongate elements may have tensile strength, but may be too flexible to provide compressive strength. The/each of the plurality of elongate elements and/or composite elongate elements may be coilable or reelable. The composite elongate element(s) may be capable of being woven.

[0023] The elongate elements may be twisted or 'laid' together.

[0024] Preferably the first polymeric/polyolefinic material and the second polymeric/polyolefinic material may be dissimilar, e.g. beneficially dissimilar polymers/polyolefins.

[0025] Preferably a melting point or softening point MP_A of the first polymeric material is lower than a melting point or softening point MP_B of the second polymeric material. The first and second polymeric materials may be thermally compatible and/or capable of being autogenously bonded.

[0026] The melting point or softening point MP_A of the first polymeric material may be at least 10°C less than the melting point or softening point MP_B of the second polymeric material.

[0027] The first elongate element(s) may (substantially) solely consist of the first polymeric material, e.g. a first homopolymer.

[0028] The second elongate element(s) may (substantially) solely consist of the second polymeric material, e.g. a second homopolymer.

[0029] The first elongate element(s) may comprise a single and/or homogeneous layer.

[0030] The second elongate element(s) may comprise a single and/or homogeneous layer.

[0031] In one preferred implementation, the second polymeric material may comprise or substantially comprise polypropylene, e.g. polypropylene homopolymer.

[0032] In said preferred implementation, the first polymeric material may comprise or substantially comprise polyethylene, e.g. polyethylene homopolymer.

[0033] The elongate element or braid may comprise one or more first elongate elements twisted (together) with one or more second elongate elements.

[0034] In a first embodiment the elongate element or braid may comprise a first elongate member twisted (together) with a second elongate member.

[0035] In a second embodiment the elongate element or braid may comprise one first elongate member twisted (together) with two second elongate members.

[0036] In a third embodiment the elongate element or braid may comprise one first elongate member twisted (together) with three second elongate members.

[0037] In a fourth embodiment the elongate element or braid may comprise one or more first elongate elements twisted (together) with one or more second elongate elements so as to form a composite and/or twisted elongate element or braid, and two or more of said composite and/or twisted elongate elements twisted (together). In such arrangement there may be provided a first twist between the first and second elongate elements. In such arrangement there may be provided

a second twist between the two or more composite and/or twisted elongate elements.

[0038] In any of the above embodiments the first and second elongate members may have a similar or substantially the same tex (mass in grams per 1,000 metres), e.g. 70 to 200 grams/1,000 metres, or 100 to 130 grams/1,000 metres). There may be provided 20 to 100, e.g. 20 to 60, e.g. 40 to 60 twists/turns per metre (tpm), and preferably around 40 tpm, along a length of the (composite) elongate element and/or each of the plurality of elongate elements.

[0039] In one embodiment of the present invention the plurality of elongate elements may comprise two elongate elements. In another embodiment of the present invention the plurality of elongate elements may comprise three elongate elements. Alternatively, the plurality of elongate elements may comprise more than three elongate elements.

[0040] The plurality of elongate elements may be twisted together in a left-handed or S-twist or in a right-handed or Z-twist (according to ISO 2).

[0041] In one implementation the at least one elongate element may be substantially planar, e.g. comprises a tape, prior to twisting or braiding.

[0042] In one implementation each of the plurality of (e.g. first and/or second) elongate elements may be substantially planar, e.g. comprise tapes, prior to twisting or braiding.

[0043] Beneficially, surfaces of adjacent elongate elements may contact or touch one another.

[0044] At least one/each of the plurality of elongate elements may be an extruded yarn or tape, for example, made by an extrusion process.

[0045] Advantageously the at least one second elongate element or yarn may comprise a self-reinforcing polymeric material such as self-reinforcing polypropylene (srPP). Preferably the at least one (second) elongate element may comprise a thermoplastic(s).

[0046] The/each at least one second elongate element may comprise a molecularly-oriented (thermoplastic) polymeric material. Polymeric molecular orientation may be or substantially be along a longitudinal direction of the/each at least one (second) elongate element.

[0047] The/each at least one second elongate element may be selected from polypropylene, polyesters, polyethyleneterephthalate, polyamides, Nylon (e.g. Nylon 6 or 6.6), or a polyethylene, e.g. having a density in the range 0.940 to 0.970, or linear low density polyethylene.

[0048] The second polymeric material may comprise a molecularly-oriented polyolefin polymer, such as a polypropylene polymer.

[0049] The first polymeric material may comprise a thermoplastic polymer or polyolefin or co-polymer.

[0050] The first polymeric material may comprise ethylene-propylene co-polymer, polybutylene, polybutene-1 or a co-polymer comprising two or more of butylene, ethylene and propylene, co-polyesters and co-polyamides.

[0051] The second polymeric material may comprise polypropylene and/or the first polymeric material may comprise an ethylene-propylene co-polymer, a polybutylene such as polybutene-1 or a co-polymer comprising two or more of butylene, ethylene and propylene.

[0052] The second polymeric material may comprise polyester and/or the first polymeric material may comprise a co-polyester, or the second polymeric material may be a polyamide and the first polymeric material may comprise a co-polyamide.

[0053] The first polymeric material may be thermally compatible/bondable/bonded and/or autogenously bondable/bonded with the second polymeric material. The second polymeric material may have a softening point of 10°C or more higher than the softening point of the first polymeric material.

[0054] According to a second aspect of the present invention there is provided a material or fabric, such as a thermoplastic composite material, comprising at least one elongate element, such as at least one composite elongate element or braid according to the first aspect of the present invention.

[0055] The material or fabric may comprise a plurality of (composite) elongate elements according to the first aspect of the present invention.

[0056] The material or fabric may advantageously comprise a single layer of material or fabric. The material or fabric, e.g. advantageously single layer of material or fabric, may be consolidated or consolidatable, e.g. by application of heat and/or pressure. The material or fabric of the present invention has been found to possibly provide advantages over the prior art, e.g. it has been found that since a single layer of the material or fabric may be heavier than a single layer of single yarn weave of the prior art, whereas in the prior art single layers have been laminated together to provide a suitable material for forming of a product, a single layer of fabric of the present invention suffices. This may avoid the need for lamination, so simplifying the manufacturing process and/or obviating and/or mitigating the problem of delamination.

[0057] The material or fabric may also comprise a plurality of further elongate elements, e.g. twisted elongate elements, which may be polymeric. The plurality of further elongate elements may beneficially be the same as the plurality of composite elongate elements.

[0058] The plurality of composite elongate elements and plurality of further elongate elements may be mutually interspersed.

[0059] At least some of the further elongate elements may comprise a material or materials similar or dissimilar to the

first polymeric material.

[0060] Adjacent, e.g. side-by-side, overlaid, cross-laid or intersecting, elongate elements may be fusible together at least at intersections.

[0061] Fusing may comprise heating the fabric above the melting temperature of the first polymeric material A, e.g. at a temperature between MP_A and MP_B. Fusing may comprise cooling the fabric to allow the surface layer to solidify. Fusing the elements may comprise subjecting the fabric to pressure. Fusing may be achieved by single closure press with flat or contoured plates, continuous belt press, induction heated press or via vacuum bagging and autoclaving.

[0062] The material or fabric may comprise a woven material or fabric.

[0063] The material or fabric may comprise at least one mat of mutually intersecting elongate elements fusible together at least at their intersections.

[0064] Preferably the thermoplastic material or fabric may comprise a consolidated mat or sheet, wherein the plurality of (composite) elongate elements may have been consolidated together, e.g. by application of heat and/or pressure.

[0065] Preferably the fabric or material may be formed without the use of, for example, a resin matrix material, a film or an adhesive.

[0066] The elongate elements and/or further elongate elements may be selected from tapes, threads, fibres, filaments, strands, or the like.

[0067] The further elongate elements may comprise a single layer and/or homogenous layer.

[0068] The further elongate elements may comprise a material or material similar or dissimilar to the first polymeric material.

[0069] The elongate elements or members and the further elongate members may be formed as tapes.

[0070] The elongate elements and/or further elongate elements may be woven, knitted, stitched, or may be laid out to form a random fibrous web or may be randomly interspersed to form the material.

[0071] Beneficially, the elongate elements and/or further elongate elements may be woven together to form a fabric.

[0072] The composite elongate elements and further elongate elements may be woven together to form the fabric or material. The warp may be formed of composite or further elongate elements and the weft may be formed of the other. The warp may be formed of composite elongate elements and the weft may be formed of further elongate elements. Alternatively, the warp may be formed of further elongate elements and the weft may be formed of composite elongate elements.

[0073] Alternatively, the composite and further elongate elements may be woven together to form the fabric or material, and the warp and/or the weft may comprise a mixture of composite and further elongate elements. The mixture of composite and further elongate elements may be a random arrangement of composite and further elongate elements. Alternatively, the mixture of composite and further elongate elements may be a regular alternation of composite and elongate elements.

[0074] Alternatively warp and weft may comprise, e.g. solely comprise, the composite elongate elements.

[0075] The further elongate elements may comprise one or more of: polyesters, polyamides, aramids, thermoplastic polymers, molecularly-oriented thermoplastic polymers, ultra high molecular weight polyalkylenes (UHMWPA), such as ultra high molecular weight polyethylene (UHMWPE) or ultra high molecular weight polypropylene (UHMWPP), multifilament nucleated polypropylenes, and/or carbon fibres.

[0076] The further elongate elements may be formed of hybrid yarns.

[0077] The hybrid yarns may be formed of at least two different materials or fibres comprising polyesters, polyamides, aramids, thermoplastic polymers, molecularly-oriented thermoplastic polymers, ultra high molecular weight polyalkylenes (UHMWPA), such as ultra high molecular weight polyethylene (UHMWPE) or ultra high molecular weight polypropylene (UHMWPP), multifilament nucleated polypropylenes, and/or carbon fibres.

[0078] The further elongate elements may be formed of hybrid yarns selected from hybrid yarns comprising aramids and UHMWPE or hybrid yarns comprising polypropylene.

[0079] The further elongate elements may comprise or consist of ultra high molecular weight polyalkylenes selected from UHMWPE or UHMWPP.

[0080] According to a third aspect of the present invention there is provided a laminated material, such as a rigid and/or self-supporting laminated material, comprising a plurality of layers, wherein at least one of said layers comprises a material or fabric according to the second aspect of the present invention.

[0081] In one implementation the laminated material comprises two layers, e.g. only two layers, or three layers, e.g. only three layers.

[0082] Preferably each layer comprises a material or fabric according to the second aspect of the present invention.

[0083] According to a fourth aspect of the present invention there is provided an article, such as a formed and/or three-dimensional and/or rigid and/or self-supporting article, beneficially formed from a (single layer of) material or fabric of the second aspect of the present invention, or alternatively formed from a laminated material of the third aspect of the present invention.

[0084] The article may be formed by a moulding technique, e.g. press-moulding.

[0085] The article may be capable of withstanding relatively high impact, i.e. the article may have high impact resistance properties.

[0086] The article may comprise a luggage shell, e.g. a shell for a suitcase, or at least part of a container.

[0087] The article may comprise or be selected from: an armour product, e.g. body armour, an automotive (vehicle) component, a sportswear product.

[0088] The article may be adapted for antiballistic purposes and/or comprises bulletproof vests, body armour, panels suitable for the protection of vehicles, such as military and/or commercial vehicles, bin liners, blast basket or blast blankets to contain fragmentation debris from the detonation of explosive devices.

[0089] The article may find use as carpet backing which may be used in automotive or aerospace application, or which may comprise panels suitable for use on automotive vehicles.

[0090] The article may comprise a toe-cap(s) for protective footwear, connecting straps of handles of intermediate bulk containers or the containers themselves, tarpaulins, packaging, luggage, protective cases, pipes.

[0091] According to a fifth aspect of the present invention there is provided a method of forming a composite elongate element or braid, the method comprising:

providing at least one first elongate element or yarn and at least one second elongate element or yarn;
twisting or braiding said at least one first and at least one second elongate elements or yarns together; wherein the first elongate element(s) or yarn(s) comprises or consists of a first polymeric material A and the second elongate element(s) or yarn(s) comprises or consists of a second polymeric material B.

[0092] According to a sixth aspect of the present invention there is provided a method of forming a fabric or material, such as a thermoplastic (composite) material, the method comprising:

providing a plurality of (composite) elongate elements according to the first aspect of the present invention;
forming said plurality of (composite) elongate elements into said fabric or material.

[0093] Said fabric or material may comprise a sheet or mat.

[0094] Said step of providing may also comprise providing a plurality of further elongate elements, which may be polymeric.

[0095] Said step of forming may comprise weaving.

[0096] In such case, the plurality of (composite) elongate elements may comprise warp yarns. Alternatively or additionally, the plurality of (composite) elongate elements may comprise weft yarns.

[0097] The method may further comprise the (subsequent) step of consolidating the fabric or material, e.g. single layer fabric or material, by application of heat and/or pressure.

[0098] According to a seventh aspect of the present invention there is provided a method of forming an article, such as a three-dimensional and/or rigid and/or self-supporting article, comprising the steps of:

providing a fabric or material, such as a thermoplastic (composite) material, according to the sixth aspect of the present invention;
forming the fabric or material into the article.

BRIEF DESCRIPTION OF DRAWINGS

[0099] Embodiments of the present invention will now be described by way of example only, with reference to the accompanying drawings, which are:

Figure 1	a schematic representation of a side view of a first multi-fibre (two-fibre) yarn according to a first embodiment of the present invention;
Figure 2	a schematic representation of a side view of a second multi-fibre (three-fibre) yarn, according to a second embodiment of the present invention;
Figure 3	a schematic representation of a side view of a third multi-fibre (four-fibre) yarn according to a third embodiment of the present invention;
Figure 4	a schematic representation of a side view of a fourth multi-fibre yarn according to a fourth embodiment of the present invention;
Figure 5	a schematic view of a woven fabric according to an embodiment of the present invention prior to consolidation;
Figure 6	a schematic view of a woven fabric according to an embodiment of the present invention comprising a single layer of the woven fabric of Figure 5 after consolidation;

Figures 7(a) and (b) schematic views of a laminated material according to an embodiment of the present invention comprising a plurality of layers (two layers) of the woven fabric of Figure 5 prior to lamination and after lamination;

Figure 8 a schematic view of a laminated material according to an embodiment of the present comprising a plurality of layers (three layers) of the woven fabric of Figure 5; and

Figures 9 to 12 schematic views of formed products beneficially made from a single layer of the woven fabric of Figure 6, or alternatively, from the laminated material of Figures 7(b) or Figure 8.

DETAILED DESCRIPTION OF DRAWINGS

[0100] Referring to Figures 1 to 4, there are shown first to fourth embodiments of an elongate element or braid 5; 5a to 5d, such as a composite and/or twisted elongate element or braid, comprising a plurality of elongate elements 10 twisted or braided together and which comprise at least one first elongate element 20 and at least one second elongate element 25, wherein the or each first elongate element 20 comprises or consists of a first polymeric material A and the or each second elongate element 25 comprises or consists of a second polymeric material B.

[0101] The Inventors believe that (composite twisted) elongate elements according to the present invention provide benefit/advantage over prior art elongate elements comprising coextruded elongate elements, e.g. of the construction A-B or A-B-A, where B comprises a polymeric base or substrate, and A comprises at least one polymeric surface layer or opposing polymeric surface layers.

[0102] Herein, 'composite elongate element or braid' is meant to comprise or include a plurality of elongate elements, yarns, tapes, strands, plies, or fibres that are twisted or braided together.

[0103] It has been found that twisting or braiding together of the plurality of elongate elements (e.g. along their length) provides advantage over the prior art, e.g. weaving together of single yarns. An advantage is believed to be beneficial increased distribution of the first polymeric material throughout a matrix of a material or fabric, e.g. a woven material.

[0104] In the present invention, the first polymeric material A comprises a first polyolefin. The second polymeric material B comprises a second polyolefin.

[0105] The first polymeric material A acts as a matrix binder or adhesive agent within the material or fabric. The second polymeric material B acts as a strengthening or integrity providing agent within the material or fabric.

[0106] Each of the plurality of elongate elements 10 and/or the composite elongate elements 5; 5a to 5d have tensile strength, but are too flexible to provide compressive strength. The/each of the plurality of elongate elements 10 and/or composite elongate elements 5; 5a to 5d are coilable or reelable. The composite elongate element(s) 5; 5a to 5d are capable of being woven. The elongate elements 10; 5; 5a to 5d are twisted or 'laid' together.

[0107] The first polymeric/polyolefinic material and the second polymeric/polyolefinic material are dissimilar, i.e. dissimilar polymers/polyolefins. A melting point or softening point MP_A of the first polymeric material is lower than a melting point or softening point MP_B of the second polymeric material. The first and second polymeric materials are thermally compatible, and/or capable of being autogenously bonded. The melting point MP_A of the first polymeric material is typically at least 10°C less than the melting point MP_B of the second polymeric material.

[0108] The first elongate element(s) 20 (substantially) solely consist of the first polymeric material A, e.g. a first homopolymer. The second elongate element(s) 25 (substantially) solely consist of the second polymeric material B, e.g. a second homopolymer. The first elongate element(s) 20 comprise a single and/or homogeneous layer. The second elongate element(s) 25 comprise a single and/or homogeneous layer.

[0109] In one preferred implementation, the second polymeric material comprises or substantially comprises polypropylene, e.g. polypropylene homopolymer. In said preferred implementation, the second polymeric material comprises or substantially comprises polyethylene, e.g. polyethylene homopolymer. As can be seen from Figures 1 to 4, the elongate element or braid 5; 5a to 5d comprises one or more first elongate elements 20 twisted (together) with one or more second elongate elements 25.

[0110] In said preferred implementation, the second elongate element is: extruded, made from polypropylene, highly drawn, has molecularly aligned polymer chains, and/or has a melting point (MP_B) of 165°C or higher. Also, the second elongate element is: extruded and/or made from polyethylene. The first elongate element need not be highly drawn to achieve molecular alignment. This is because the first elongate element melts away, in use, to form a matrix material, and if there is not molecular alignment, material shrinkage can be avoided. The first elongate element is sacrificially melted in the elongate element/braid or twisted tape or fabric or article made therefrom. The polyethylene has a melting point MP_A of around 134°C.

[0111] In a first embodiment (see Figure 1) the elongate element or braid 5a comprises a first elongate member 20 twisted (together) with a second elongate member 25. In said first embodiment, first elongate member 20 can be twisted together with a second elongate member 25, e.g. of the same or similar tex (mass in grams of 1,000 metres). The twist level is typically between 20 and 60 turns per metre, preferably around 40 tpm. The resultant twisted yarn can be used to construct a fabric, e.g. a woven fabric. Said woven fabric made from said tapes can then be formed into a three

dimensionally formed article by the action of heat and pressure in a mould, said article then being cooled in the mould prior to release. Thus forming can be of a single layer of fabric or of multiple layers of fabric. The resultant article can then display superior lamination strength versus a similar fabric formed only from conventionally coextruded A-B or A-B-A tapes or yarns with a lower ratio of A to (A+B), e.g. 15% versus 50% for the present invention.

[0112] In a second embodiment (see Figure 2) the elongate element or braid 5b comprises one first elongate member 20 twisted (together) with two second elongate members 25. In said second embodiment two tapes or yarns of type B are twisted with a single tape or yarn of type A of similar tex to yield a twisted tape equivalent to 33.33% cap layer (ratio of A to (A+B)).

[0113] In a third embodiment the elongate element or braid 5c comprises one first elongate member 20 twisted (together) with three second elongate members 25. In said third embodiment three tapes or yarns of type B are twisted with a ratio single tape or yarn of type A of very similar tex to yield a twisted tape equivalent to 25% cap layer (ratio of A to (A+B)), which is around twice that which can be achieved with conventionally coextruded A-B or A-B-A tapes or yarns.

[0114] In a fourth embodiment the elongate element or braid 5d comprises one or more first elongate elements A twisted (together) with one or more second elongate elements B so as to form a composite and/or twisted elongate element or braid 5a, and two or more of said composite and/or twisted elongate elements twisted (together). In such arrangement there is provided a first twist between the first and second elongate elements 20, 25. In such arrangement there is also provided a second twist between the two or more composite and/or twisted elongate elements 5a. In said fourth embodiment one tape or yarn of type A is twisted with one tape or yarn of type B. Then, two of said twisted A-B tapes or yarns are further twisted together with each other to yield a composite tape or yarn of two B and two A type tapes or yarns. The distribution of 'cap' layer A can thus be improved versus a typical side-by-side coextruded tape or yarn of A-B or A-B-A construction. Fabrics woven from said tapes or yarns, and articles processed from said fabrics may demonstrate superior internal bond strength or lamination strength due to the improved distribution of lower melt layer A.

[0115] In any of the above embodiments the first and second elongate members 20, 25 advantageously have a similar or substantially the same tex (mass in grams per 1,000 metres), e.g. 70 to 200 grams/1,000 metres, or 100 to 130 grams/1,000 metres). There is also advantageously provided 20 to 100, e.g. 20 to 60, e.g. 40 to 60, twists/turns per metre (tpm), and preferably around 40 tpm, along a length of the (composite) elongate element 5a - 5d and/or each of the plurality of elongate elements 15, 20.

[0116] It will be appreciated that, while in the first embodiment of the present invention, the plurality of elongate elements comprise two elongate elements, and n the second embodiment of the present invention the plurality of elongate elements comprise three elongate elements, in an alternative embodiment the plurality of elongate elements 10 can comprise more than three elongate elements 20, 25.

[0117] The plurality of elongate elements 20, 25; 5a to 5d can be twisted together in a left-handed or S-twist or in a right-handed or Z-twist (according to ISO 2). In one implementation at least one/each of the plurality of elongate elements is/are substantially planar, e.g. comprises a tape, prior to twisting or braiding. Beneficially, surfaces of adjacent elongate elements 20, 25 contact or touch one another. The/each elongate element 20, 25 is an extruded yarn or tape, for example, made by an extrusion process.

[0118] Advantageously the at least one second elongate element or yarn 25 comprises a self-reinforcing polymeric material such as self-reinforcing polypropylene (srPP). The/each elongate element 20, 25 comprises a thermoplastic(s). The/each at least one second elongate element 25 comprises a molecularly-oriented (thermoplastic) polymeric material.

[0119] The/each at least one second elongate element 25 can be selected from polypropylene, polyesters, polyethyleneterephthalate, polyamides, Nylon (e.g. Nylon 6 or 6.6), or a polyethylene, e.g. having a density in the range 0.940 to 0.970, or linear low density polyethylene. The second polymeric material B typically comprises a molecularly-oriented polyolefin polymer, such as a polypropylene polymer. The first polymeric material A comprises a thermoplastic polymer or polyolefin or co-polymer. The first polymeric material A can comprise ethylene-propylene co-polymer, polybutylene, polybutene-1 or a co-polymer comprising two or more of butylene, ethylene and propylene, co-polyesters and co-polyamides.

[0120] The second polymeric material B can be polypropylene and/or the first polymeric material A can comprise an ethylene-propylene co-polymer, a polybutylene such as polybutene-1 or a co-polymer comprising two or more of butylene, ethylene and propylene.

[0121] The second polymeric material B can be polyester and/or the first polymeric material A can comprise a co-polyester, or the second polymeric material B can be a polyamide and the first polymeric material can comprise a co-polyamide.

[0122] The first polymeric material A can be thermally compatible and/or autogenously bondable/bonded to/with the second polymeric material B. The second polymeric material B can have a softening point of 10°C or more higher than the softening point of the first polymeric material A.

[0123] Referring now to Figure 5, there is shown a material or fabric 100, such as a thermoplastic composite material according to an embodiment of the present invention, comprising at least one elongate element 5a to 5d of Figures 1 to 4.

[0124] The material or fabric 100 comprises a plurality of (composite) elongate elements 5; 5a to 5d.

[0125] The material or fabric 100 advantageously comprise a single layer of material or fabric 100. The material or fabric 100, e.g. advantageously single layer of material or fabric, can be consolidated or is consolidatable, e.g. by application of heat and/or pressure. The material or fabric 100 has been found to possibly provide advantages over the prior art, e.g. it has been found that since a single layer of the material or fabric 100 can be heavier than a single layer of single yarn weave of the prior art, whereas in the prior art single layers have been laminated together to provide a suitable material for forming of a product, a single layer of material or fabric 100 of the present invention suffices. This can avoid the need for lamination, so simplifying the manufacturing process and/or obviating and/or mitigating the problem of delamination.

[0126] The material or fabric 100 can also comprise a plurality of further elongate elements 105, e.g. twisted elongate elements, which are polymeric. The plurality of further elongate elements 100 can beneficially be the same as the plurality of composite elongate elements 5a to 5d.

[0127] The plurality of composite elongate elements 5a to 5d and plurality of further elongate elements 105 can be mutually interspersed. At least some of the further elongate elements 105 can comprise a material or materials similar or dissimilar to the first polymeric material.

[0128] Adjacent, e.g. side-by-side, overlaid, cross-laid or intersecting, elongate elements 5a to 5d can be fusible together at least at intersections. Fusing can comprise heating the fabric above the melting temperature of the first polymeric material A, e.g. to a temperature between MP_A and MP_B. Fusing can comprise cooling the fabric to allow the surface layer to solidify. Fusing the elements can comprise subjecting the fabric to pressure. Fusing can be achieved by single closure press with flat or contoured plates, continuous belt press, induction heated press or via vacuum bagging and autoclaving.

[0129] Figure 6 shows the fabric 100 after consolidation via a combination of heat and/or pressure. As seen from Figure 5, the fabric 100 comprises a woven fabric. The fabric 100 comprises at least one mat of mutually intersecting elongate elements 5a to 5d, 105 fusible together at least at their intersections.

[0130] The further elongate elements 105 can comprise a single layer or homogenous layer. The further elongate elements 105 can comprise a material or materials similar or dissimilar to the first polymeric material A. The elongate elements 5a to 5d and the further elongate elements 105 are formed as tapes. The elongate elements 20, 25; 5a to 5d comprise one or two surface layers or two opposing surface layers.

[0131] The material or fabric 100 typically comprises a woven material or fabric. The material or fabric 100 can comprise at least one mat of mutually intersecting elongate elements fusible together at least at their intersections. The thermoplastic material or fabric 100 comprise a consolidated mat or sheet, wherein the plurality of (composite) elongate elements 5a to 5b have been consolidated together, e.g. by application of heat and/or pressure. The fabric or material can be formed without the use of, for example, a resin matrix material, a film or an adhesive. The elongate elements 20, 25; 5a to 5d and/or further elongate elements 105 can selected from tapes, threads, fibres, filaments, strands, or the like. The further elongate elements can comprise a single layer and/or homogenous layer. The further elongate elements can comprise a material or material similar or dissimilar and/or thermally compatible and/or autogenously bondable with the first polymeric material.

[0132] The elongate elements or members 20, 25; 5a to 5d and the further elongate members 105 can be formed as tapes. The elongate elements 5a to 5d and/or further elongate elements can be woven, knitted, stitched, or can be laid out to form a random fibrous web or may be randomly interspersed to form the material. Beneficially, the elongate elements 5a to 5d and/or further elongate elements 105 can be woven together to form a fabric.

[0133] The composite elongate elements 5a to 5d and further elongate elements 105 can be woven together to form the fabric or material 100. The warp can be formed of composite or further elongate elements 5a to 5d and the weft may be formed of the other. The warp can be formed of composite elongate elements 5a to 5d and the weft may be formed of further elongate elements 105. Alternatively, the warp can be formed of further elongate elements 105 and the weft may be formed of composite elongate elements 5a to 5d.

[0134] As mentioned above, the further elongate elements 105 can be the same as (i.e. can be identical to) the composite elongate elements 5a to 5d.

[0135] Alternatively, the composite and further elongate elements can be woven together to form the fabric or material, and the warp and/or the weft may comprise a mixture of composite and further elongate elements. The mixture of composite and further elongate elements can be a random arrangement of composite and further elongate elements. Alternatively, the mixture of composite and further elongate elements can be a regular alternation of composite and elongate elements.

[0136] Alternatively warp and weft can comprise, e.g. solely comprise, the composite elongate elements 5a to 5d.

[0137] The further elongate elements 105 can comprise one or more of: polyesters, polyamides, aramids, thermoplastic polymers, molecularly-oriented thermoplastic polymers, ultra high molecular weight polyalkylenes (UHMWPA), such as ultra high molecular weight polyethylene (UHMWPE) or ultra high molecular weight polypropylene (UHMWPP), multifilament nucleated polypropylenes, and/or carbon fibres.

[0138] The further elongate elements can be formed of hybrid yarns. The hybrid yarns can be formed of at least two different materials or fibres comprising polyesters, polyamides, aramids, thermoplastic polymers, molecularly-oriented thermoplastic polymers, ultra high molecular weight polyalkylenes (UHMWPA), such as ultra high molecular weight polyethylene (UHMWPE) or ultra high molecular weight polypropylene (UHMWPP), multifilament nucleated polypropylenes, and/or carbon fibres.

[0139] The further elongate elements 105 can be formed of hybrid yarns selected from hybrid yarns comprising aramids and UHMWPE or hybrid yarns comprising polypropylene.

[0140] The further elongate elements 105 can comprise or consist of ultra high molecular weight polyalkylenes selected from UHMWPE or UHMWPP.

[0141] Referring now to Figures 7(a) and (b), there is shown two layers of fabric 100 prior to lamination and after thermal lamination, respectively. Lamination of the two layers of fabric 100 forms a laminated material 200.

[0142] The laminated material 200 (which is rigid or nondrapable at normal room/ambient temperature) comprises a plurality of layers 205, wherein at least one of said layers 205 comprise the fabric 100. In one implementation the laminated material 200 comprises two layers 205, e.g. only two layers, or alternatively three layers, e.g. only three layers (see Figure 8). Advantageously, each layer 205 comprises the fabric 100.

[0143] Referring now to Figures 9 to 12, there are shown articles, i.e. three-dimensional (rigid or self-supporting) articles formed from fabric 100, or alternatively formed from the laminated material 200.

[0144] The articles 400a to 400d are typically formed by a moulding technique, e.g. press-moulding. The articles 400a to 400d are capable of withstanding relatively high impact, i.e. the articles 400a to 400d have relatively high impact resistance properties.

[0145] Referring to Figure 9, the article 400a comprises a luggage shell, e.g. a shell for a suitcase. Alternatively, the article can comprise or be selected from: a container, an armour product, e.g. body armour, automotive (vehicle) component, sportswear product. The article can be adapted for high impact and/or antiballistic purposes, and/or comprises bulletproof vests, body armour, panels suitable for the protection of military and commercial vehicles, bin liners, blast basket or blast blankets to contain fragmentation debris from the detonation of explosive devices. The article may find use as carpet backing which may be used in automotive or aerospace application or which comprises panels suitable for use on automotive vehicles.

[0146] Referring to Figures 10 and 11, the article 400b comprises a toe-cap(s) for protective footwear. Alternatively, the article can comprise connecting straps of handles of intermediate bulk containers or the containers themselves, tarpaulins, packaging, luggage, protective cases, pipes. Figure 12 shows an article 400d comprising an automotive component (e.g. door trim) prior to finishing/trimming.

[0147] The present invention provides a method of forming a composite elongate element or braid 5, the method comprising:

providing at least one first elongate element or yarns 20 and at least one second elongate element or yarn 25;
twisting or braiding said at least one first and at least one second elongate elements or yarns 20, 25 together; wherein the first elongate element(s) or yarn(s) 20 comprises or consists of a first polymeric material, and the second elongate element(s) or yarn(s) comprise or consist of a second polymeric material. The first polymeric material A has a softening temperature lower than that of the second polymeric material B.

[0148] The present invention provides a method of forming a fabric or material 100, such as a thermoplastic (composite) material, the method comprising:

providing a plurality of composite elongate elements 5a to 5d;
forming said plurality of composite elongate elements 5a to 5d into said fabric or material 100.

[0149] Said fabric 100 typically comprises a sheet or mat. Said step of providing can also comprise providing a plurality of further elongate elements 105. Said step of forming comprises weaving. In such case, the plurality of composite elongate elements 5a to 5d can comprise warp/weft yarns. Alternatively or additionally, the plurality of composite elongate elements can comprise weft/warp yarns. The method further comprises the (subsequent) step of consolidating the fabric 100 by application of heat and/or pressure.

[0150] The present invention provides a method of forming an article 400, such as a three-dimensional article, comprising the steps of:

providing at least one layer of a fabric 100 or material 200, such as a thermoplastic (composite) material;
forming the fabric 100 or material 200 into the article 400.

[0151] It will be appreciated that the embodiments of the present invention hereinbefore described are given by way

of example only, and are not meant to be limiting to the scope of the invention in any way. It will, for example, be appreciated that the typically heavier fabrics produced by compound weaving of twisted tapes as warp and/or weft avoid the need for multi-layering of fabric. The resultant thermoformed articles are, therefore, less likely to be subject to failure by delamination. The material can be failure averted and utility of the thermoformed parts enhanced.

[0152] The present invention seeks to provide a solution to one or more issues in the prior art by permitting the ratio of cap layer to be increased beyond that which can presently be realised by coextrusion. The ratio of cap layer may, for example, be effectively tuned to any particular value between 1 and 50% or, indeed, higher. By twisting together at least one second polyolefin tape or yarn with at least one first polyolefin tape or yarn of a different polyolefinic nature, and with a melting point at least 10°C below that of the second tape or yarn, a means is provided for tuning the cap layer ratio anywhere between 1 and 50% or even higher. Any ratio can be achieved by controlling the number of each type of tape or yarn incorporated into the twisting operation and by controlling the relative weight or tex of the at least one B with the at least one A tape or yarn.

[0153] The solution provides benefits by enhancing the bonding capacity of the twisted tapes or yarns to themselves, or for fabric constructed from said tapes or yarns to bind to itself or to other materials without the need for additional adhesives or films. Articles made from said tapes or yarns or fabrics, whether bonded to themselves or also to other materials, can be made with a tuneable spectrum of properties, e.g. stiffness, delamination strength, impact strength, etc. All of this can be achieved without the need for additional adhesive or film. The breadth of product performance may thus be widened, which may provide a wider range of applications to be served than is possible with current coextruded tape or yarn technology.

Claims

1. An elongate element or braid, such as a composite and/or twisted elongate element or braid, comprising a plurality of elongate elements twisted or braided together and which comprise at least one first elongate element and at least one second elongate element, wherein the or each first elongate element comprises or consists of a first polymeric material (A) and the or each second elongate element comprises or consists of a second polymeric material (B).

2. An elongate element or braid as claimed in claim 1, wherein:

   the first polymeric material comprises a first polyolefin and the second polymeric material comprises a second polyolefin; and/or
   the first polymeric/polyolefinic material and the second polymeric/polyolefinic material are dissimilar; and/or
   a melting point or softening point (MP_A) of the first polymeric material is lower than a melting point or softening point (MP_B) of the second polymeric material, and/or
   the first and second polymeric materials is thermally compatible/bondable/bonded; and/or capable of being autogenously bonded; and/or
   the melting point (MP_A) of the first polymeric material is at least 10°C less than the melting point (MP_B) of the second polymeric material.

3. An elongate element or braid as claimed in any preceding claim, wherein:

   the first elongate element(s) solely consist(s) of the first polymeric material, and/or
   the second elongate element(s) solely consists of the second polymeric material; and/or
   the first elongate element(s) comprise a single and/or homogeneous layer; and/or
   the second elongate element(s) comprise a single and/or homogeneous layer; and/or
   the second polymeric material comprises or substantially comprises polypropylene; and/or
   the first polymeric material comprises or substantially comprises polyethylene.

4. An elongate element or braid as claimed in any of claims 1 to 3, wherein the elongate element or braid comprises a first elongate member twisted (together) with a second elongate member, or the elongate element or braid comprises one first elongate member twisted (together) with two second elongate members or the elongate element or braid comprises one first elongate member twisted (together) with three second elongate members, or the elongate element or braid comprises one or more first elongate elements twisted (together) with one or more second elongate elements so as to form a composite and/or twisted elongate element or braid, and two or more of said composite and/or twisted elongate elements twisted (together), such that there is provided a first twist between the first and second elongate elements, and a second twist between the two or more composite and/or twisted elongate elements.

5. An elongate element or braid as claimed in any preceding claim, wherein the first and second elongate members have a similar or substantially the same tex (mass in grams per 1,000 metres), optionally selected from: 70 to 200 grams/1,000 meters, or 100 to 130 grams/1,000 metres; and/or there are provided 20 to 100, 20 to 60, or 40 to 60 twists/turns per metre (tpm), such as around 40 tpm, along a length of the (composite) elongate element and/or each of the plurality of elongate elements.

6. An elongate element or braid as claimed in any preceding claim, wherein each of said plurality of elongate elements are substantially planar, for example, comprises a tape, prior to twisting or braiding, and optionally in surfaces of adjacent elongate elements contact or touch one another.

7. An elongate element or braid as claimed in any preceding claim, wherein each of the plurality of elongate element is an extruded yarn or tape, for example, made by an extrusion process; and/or the at least one second elongate element or yarn comprises a self-reinforcing polymeric material such as self-reinforcing polypropylene (srPP); and/or the/each at least one second elongate element comprises a molecularly-oriented (thermoplastic) polymeric material.

8. An elongate element or braid as claimed in any preceding claim, wherein:

the/each at least one second elongate element is selected from polypropylene, polyesters, polyethyleneterephthalate, polyamides, Nylon (e.g. Nylon 6 or 6.6), or a polyethylene, for example, having a density in the range 0.940 to 0.970, or linear low density polyethylene; and/or
the first polymeric material comprises a thermoplastic polymer or polyolefin or co-polymer; and/or
the first polymeric material comprises ethylene-propylene co-polymer, polybutylene, polybutene-1 or a co-polymer comprising two or more of butylene, ethylene and propylene, co-polyesters and co-polyamides.

9. An elongate element or braid as claimed in any preceding claim, wherein:

the second polymeric material is polypropylene and/or the first polymeric material comprises an ethylene-propylene co-polymer, a polybutylene such as polybutene-1 or a co-polymer comprising two or more of butylene, ethylene and propylene; and/or
the second polymeric material is polyester and/or the first polymeric material comprises a co-polyester, or the second polymeric material is a polyamide and the first polymeric material comprises a co-polyamide.

10. A material or fabric, such as a thermoplastic composite material, comprising at least one elongate element, such as at least one composite elongate element or braid according to any of claims 1 to 9, wherein optionally the material or fabric has been consolidated such as by the application of heat and/or pressure.

11. A material or fabric as claimed in claim 10, wherein the material or fabric comprises a single layer of material or fabric; and/or
the material or fabric comprises a woven material or fabric; and/or
the first polymeric material acts as a matrix binder or adhesive agent within the material or fabric, and the second polymeric material acts as a strengthening or integrity providing agent within the material or fabric.

12. A laminated material, such as a rigid and/or self-supporting laminated material, comprising a plurality of layers, wherein at least one of said layers comprises a material or fabric according to either of claims 10 or 11.

13. An article, such as a three-dimensional and/or self-supporting article, formed from a (single layer of) material or fabric of either of claims 10 or 11, or alternatively formed from a laminated material of claim 21.

14. A method of forming a composite elongate element or braid, the method comprising:

providing at least one first elongate element(s) or yarn(s) and at least one second elongate element(s) or yarn(s); twisting or braiding said at least one first and at least one second elongate element(s) or yarn(s) together; wherein the first elongate element or yarn comprises or consists of a first polymeric material and the second elongate element(s) or yarn(s) comprises or consists of a second polymeric material.

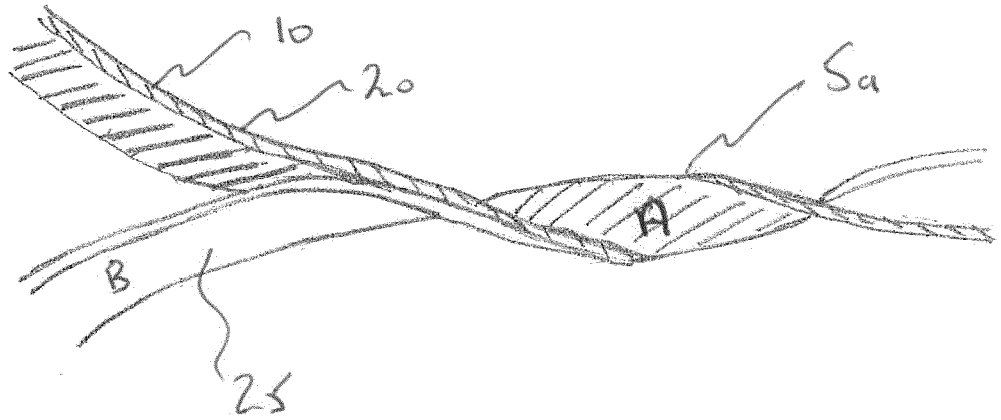
15. A method of forming a fabric or material, such as a thermoplastic/composite material, the method comprising:

providing a plurality of (composite) elongate elements according to any of claims 1 to 10;

forming said plurality of (composite) elongate elements into said fabric or material.

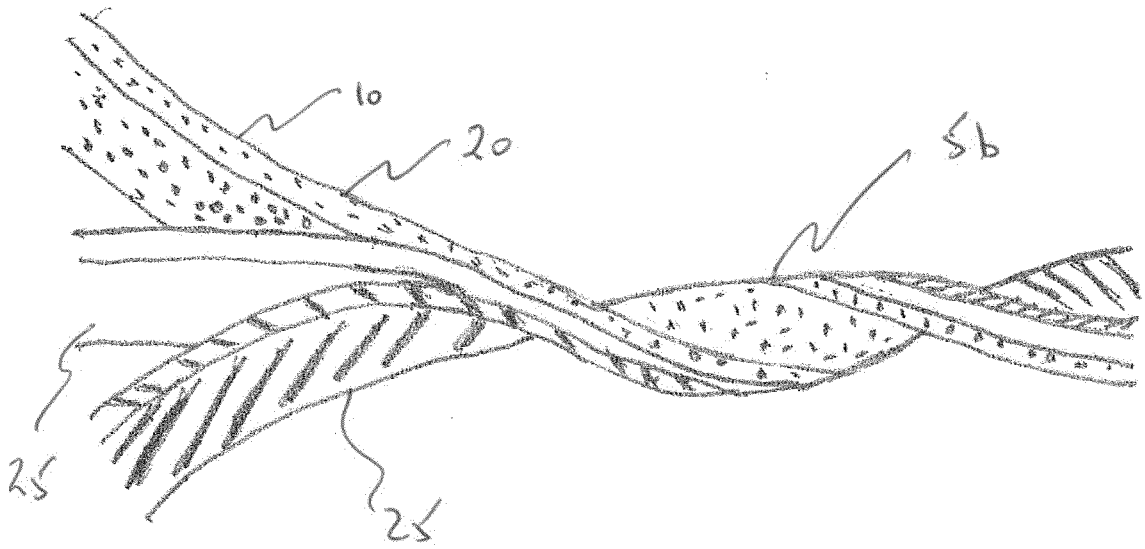
16. A method of forming an article, such as a three-dimensional and/or rigid and/or self-supporting article, comprising the steps of:

providing a fabric or material, such as a thermoplastic (composite) material, according to either of claims 10 or 11 or a laminated material according to claim 12;
forming the fabric or material into the article.



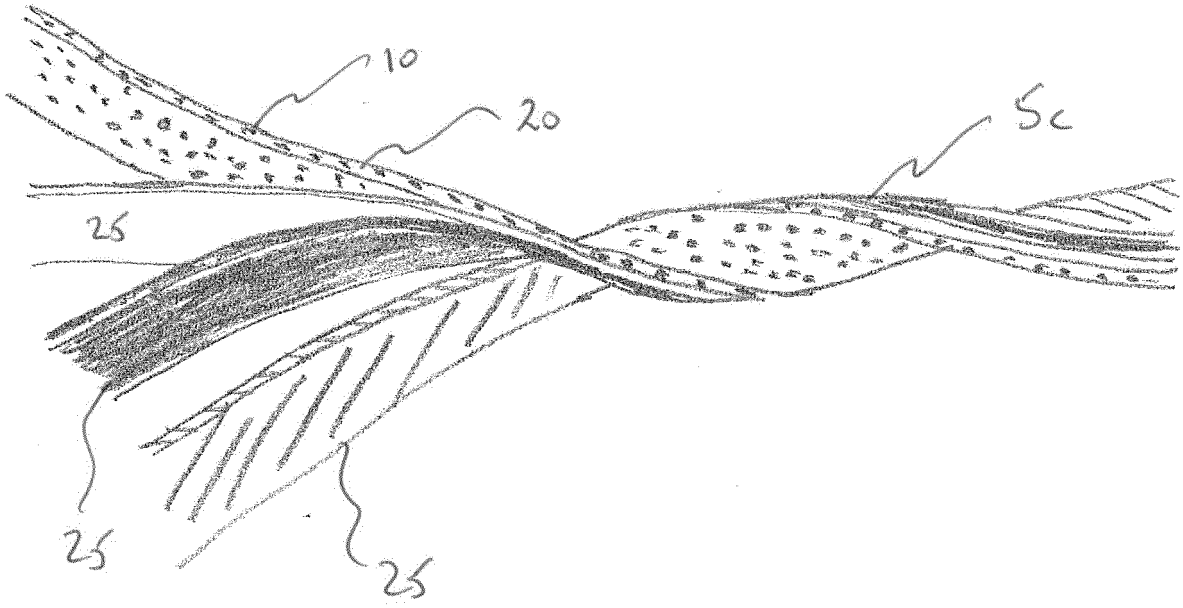
Drawing 1. Two yarns twisted together

Figure 1



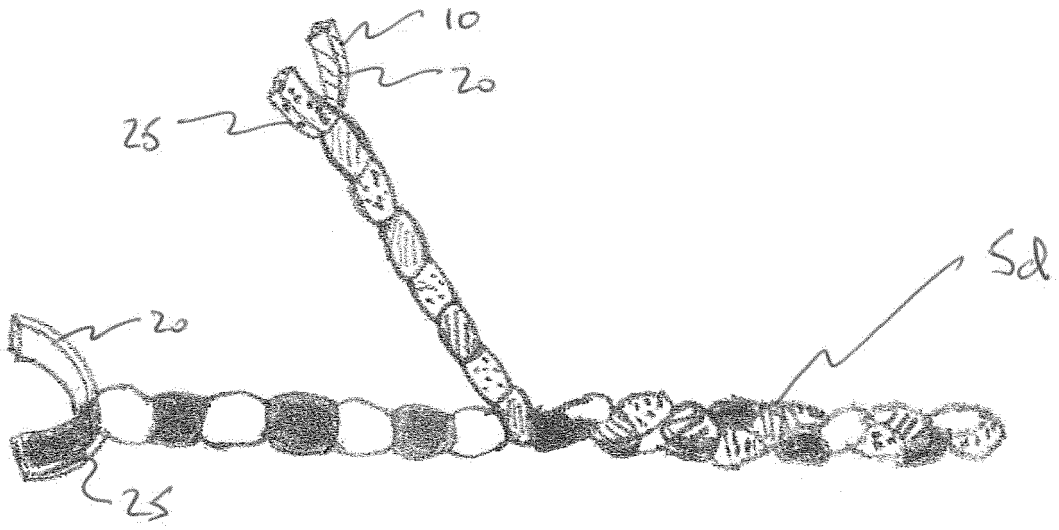
Drawing 2. Three yarns twisted together

Figure 2



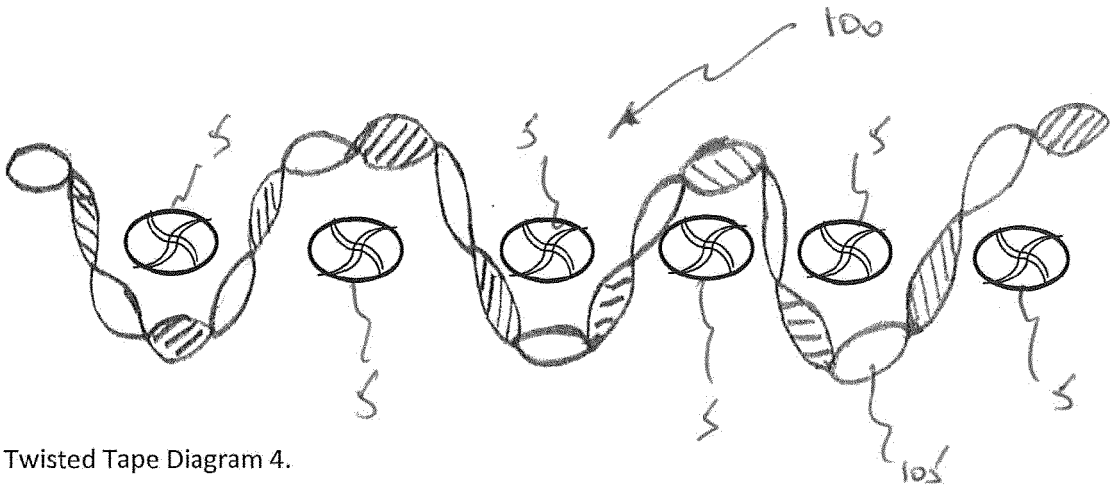
Drawing 3. Four yarns twisted together

Figure 3



Drawing 4. Embodiment 3. Two pairs of pre-twisted tapes (of 2 yarns each) which are then further twisted together.

Figure 4



Twisted Tape Diagram 4.

Continuous twisted ribbon represents twisted warp and circles represent twisted weft woven into a fabric

Figure 5

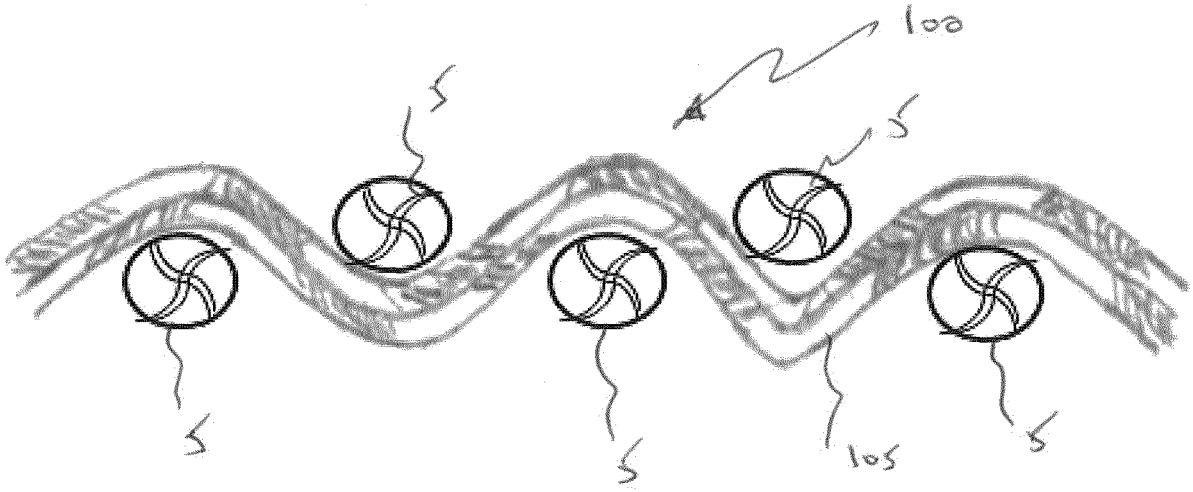


Figure 6

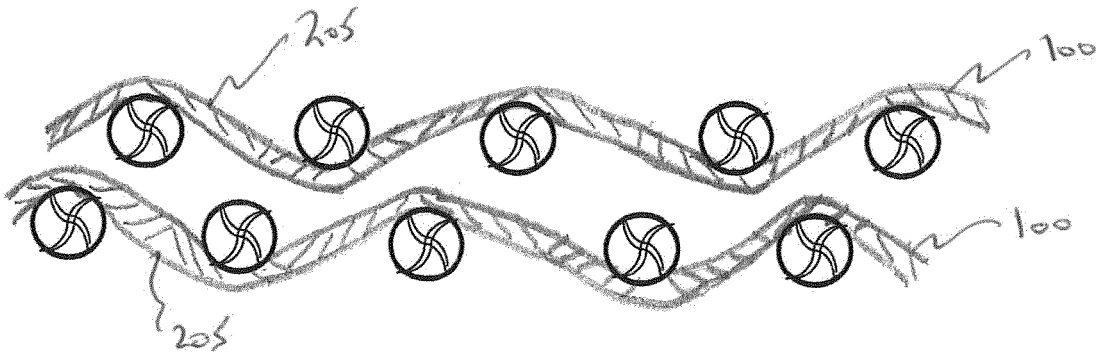
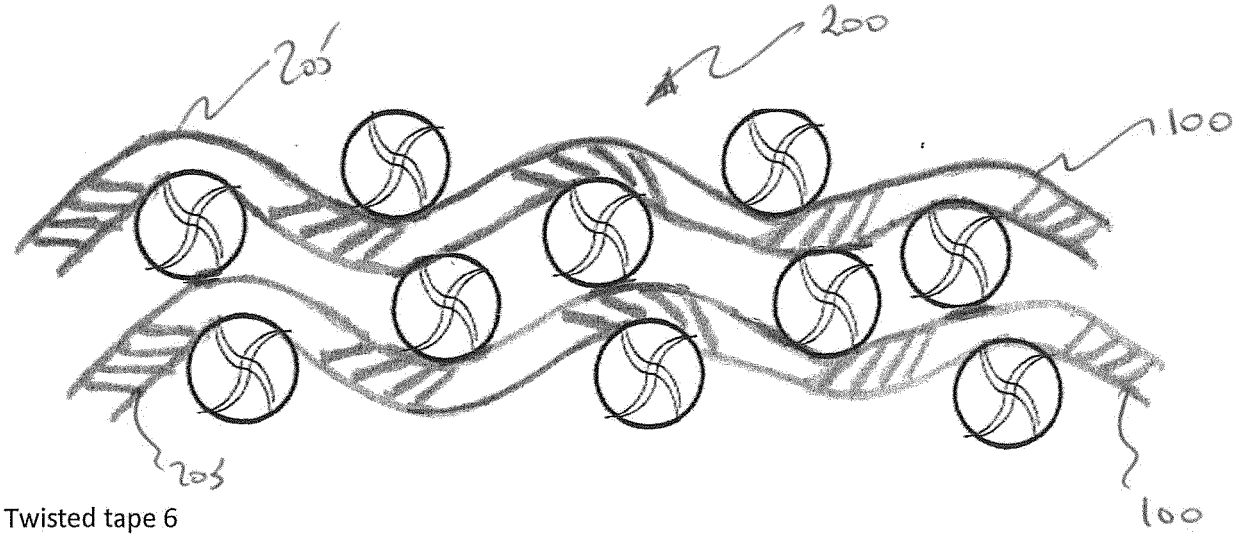


Diagram of two layers of fabric prior to being thermally consolidated.

Figure 7(a)



Twisted tape 6

Consolidated panel thermoformed from two layers of fabric formed from twisted yarns (warp and weft) of co-extruded PP tapes. Diagram shows contact between layers as being due to warp to weft contact only, but in practice weft to weft and warp to warp contacts are also present.

Figure 7(b)

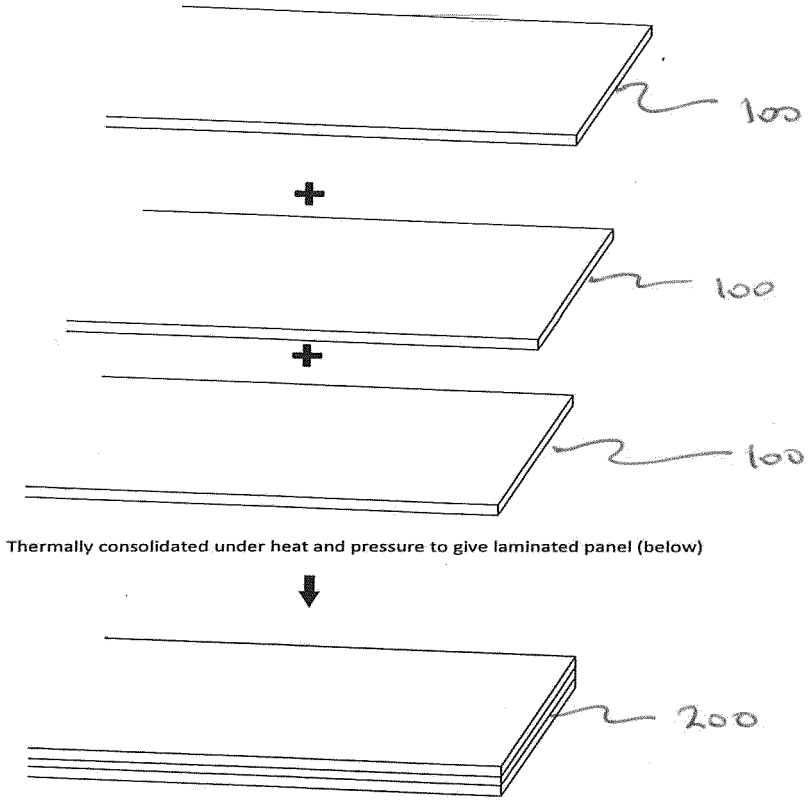

100
100
100
Thermally consolidated under heat and pressure to give laminated panel (below)
200

Figure 8

Figure 9

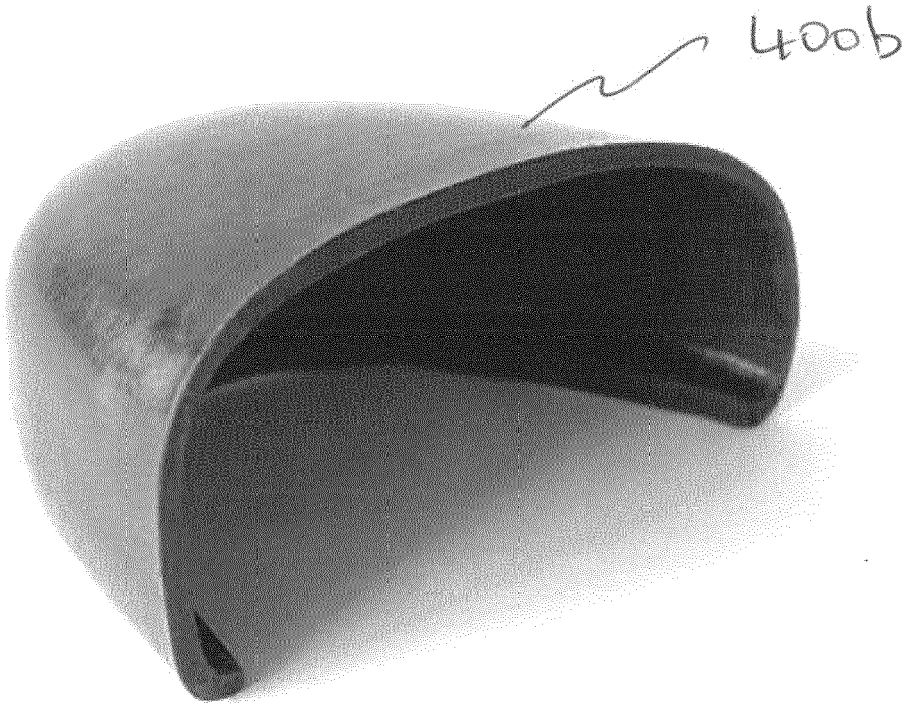


Figure 10

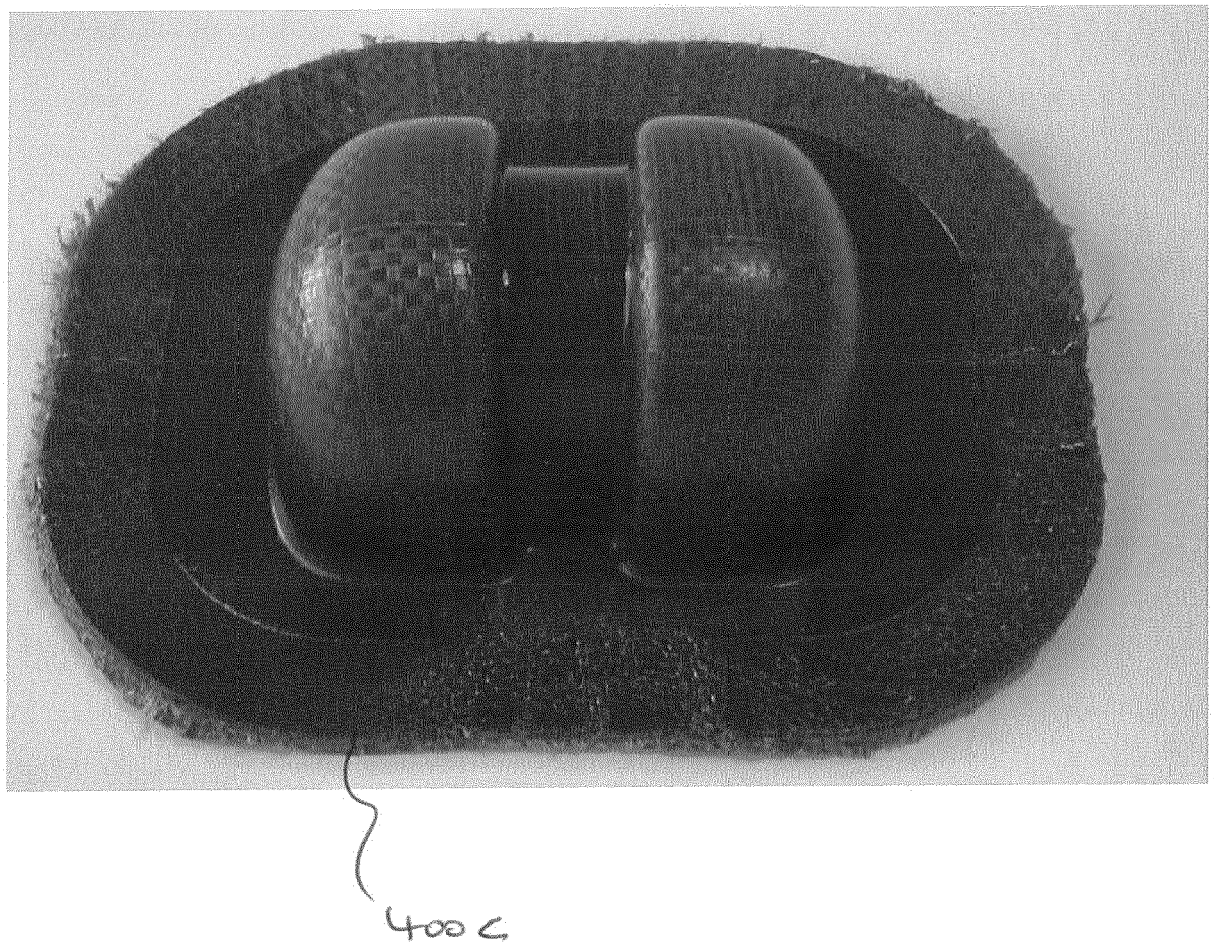


Figure 11

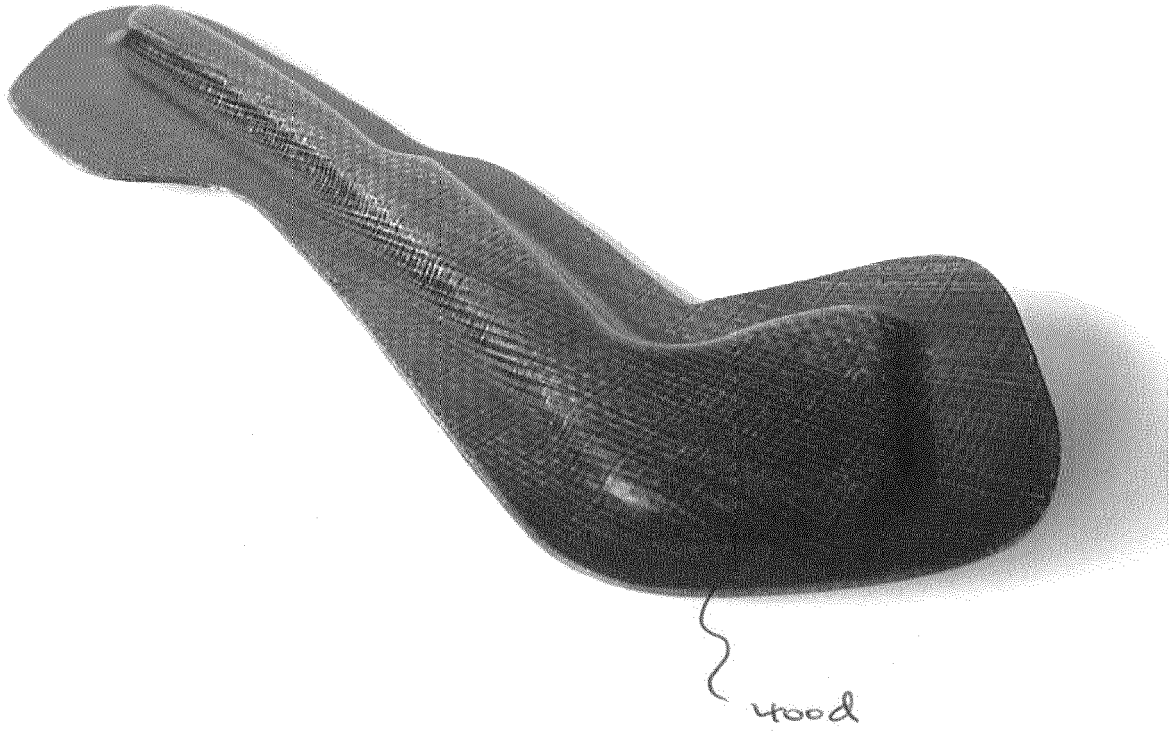


Figure 12

REFERENCES CITED IN THE DESCRIPTION

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