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(54) **IMPROVEMENTS IN OR RELATING TO ARTIFICAL SURFACES**

(57) There is disclosed a material or yarn (5) for an artificial surface (10), such as a sports surface, for example, a hockey surface. The yarn (5) comprises a synthetic turf or grass yarn comprising a polyolefin material and at least one additive comprising a siloxane additive. The at least one additive comprises or forms a layer on the material or yarn (5) or on the polyolefin material, such as an outer layer on the yarn (5) or on the polyolefin material. The artificial surface (10) comprises a synthetic turf or grass surface or system, wherein the artificial surface (10) has a rotational resistance of 25Nm to 45Nm when dry or unwatered or unwetted.

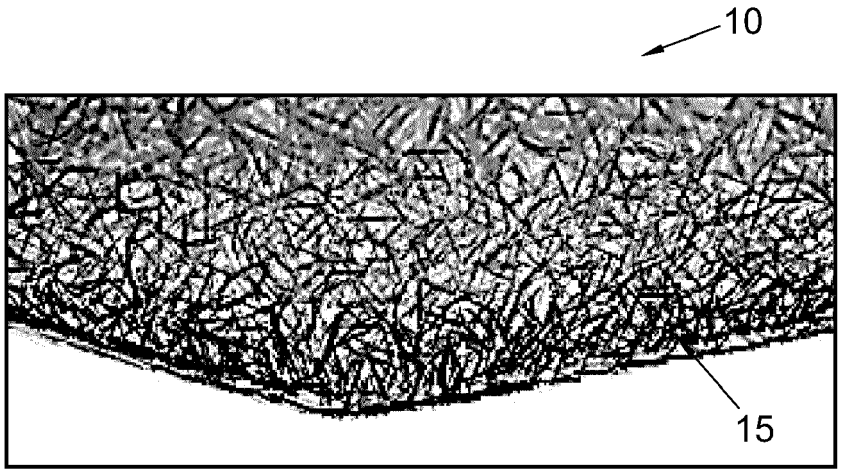

FIG. 5

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Description

FIELD OF INVENTION

[0001] The present invention relates to a material or yarn for an artificial surface, such as a sports surface, and particularly, though not exclusively, a hockey (field) surface. The invention also relates to a method of manufacturing a material or yarn for an artificial surface, an artificial surface, and a sports field, pitch or court.

BACKGROUND TO INVENTION

[0002] Tufted artificial grass surfaces, 'carpets' or systems are known. Polyolefin 'face' yarns can be tufted into a primary backing layer.

[0003] One or more implementations of this invention relate to a texturized polyolefin monofilament artificial grass yarn developed for waterless hockey fields, e.g., Federation Internationale de Hockey (FIH) approved synthetic grass field hockey systems for elite level field hockey (also commonly called hockey). Waterless systems are desirable as current available synthetic grass systems all require water flooding to some degree to enable the synthetic surface to achieve the performance required for elite level play.

[0004] Presently dry synthetic grass surfaces, i.e., with no water flooding, are undesirable at elite level hockey due to:

(a) poor surface interaction between the hockey ball and the surface,
(b) poor surface interaction between the hockey stick and the surface, and
(c) poor interactions between the player and the surface.

[0005] All of these factors can conspire, either individually or in combination, for the utilisation of water flooding to counteract these effects.

[0006] While it is presently mandatory that FIH tournaments are hosted on synthetic turf with water flooding, this method of achieving the performance required at elite level is wasteful of water.

[0007] As such, producing a synthetic grass yarn suitable for a waterless hockey system is extremely desirable in the current ecological climate to save water.

[0008] Historically hockey developed on natural grass turf. On natural grass, the style of play is much slower, typically "stop, hit & run". In the early 1970s, "synthetic grass" fields began to be used for hockey, based on polyamide/nylon material. Such was beneficial for hockey, providing a fast, flat playing surface which was no longer subject to bumps and divots of a natural grass field. This in turn gave better ball control, mitigating against a ball shooting off in an undesirable direction. Sand was spread between fibres to create enough firmness, traction and stability for the players. It was these key characteristics that resulted with the first Olympic Games on a synthetic surface being held at Montreal in 1976.

[0009] In the early 1970s, when synthetic turf began to be used, synthetic turf pitches changed many aspects of field hockey, including gaining speed. This has given rise to a more technical style of play and new tactics and techniques such as the Indian dribble developed, followed by new rules to take such into account. The move to synthetic surfaces has made field hockey become a better, more exciting game for the players and the spectators with increased popularity.

[0010] Currently there are four (4) main types of synthetic turf hockey surface:

(a) Global Elite (wet surface): water flooded surfaces that are primarily used for FIH World Level International Competitions.
(b) Global (wet surface): water flooded surfaces that are primarily used for lower level international and top-level national competitions.
(c) National (dry surface): normally sand dressed or sand filled surfaces designed primarily for hockey. This category of surface is normally used for lower level national, regional and club play.
(d) Multi-Sport (dry surface): surfaces designed for a number of sports and on which basic community and development level hockey can be played.

[0011] While hockey is still played on traditional grass fields at some local levels and lesser national divisions, grass fields have been replaced by synthetic surfaces almost everywhere in the Western world.

[0012] In recent years, there has been a large increase in the number of water-flooded synthetic turfs (i.e., Global category fields). Such have significant performance advantages over the other categories, e.g.:

(a) Creating a fast game with the ball moving across the surface quickly.
(b) Allowing a player to get under the ball, due to the absence of sand, as the blades of grass are free moving.

(c) Provision of consistency of ball roll, with no unexpected deviations, making for easier control and allowing for increase in skill levels.
(d) Enabling specific stick techniques important to the fast nature of the game, such as the drag flick.
(e) Can scuff the surface with the stick and have reduced impact, making the player more comfortable.
(f) The water helps the ball to slow more consistently when passing/rolling.
(g) The water acts as a damper and prevents the ball bouncing and keeps it on the surface.
(h) The water acts as a lubricant between the stick and ball, and the stick and turf.
(i) Enables players to slide.
(j) Enables consistent performance characteristics irrespective of dry weather or rain.

[0013] Under the current rules of the game, it is mandatory that all FIH tournaments are hosted on wet synthetic turf fields.

[0014] Previously, watering of synthetic hockey surfaces - which is generally performed by water cannon - was at a rate of 3 litres/m^2. Due to the negative ecological effects this has now been reduced to no less than 1litre/m^2.

[0015] The present Inventors have identified and sought to address a desire in the art to reduce the amount of water used in watering of synthetic hockey pitches, and preferably to move away from water flooded systems. Reasons for this are that water flooded synthetic turfs present many challenges:

(a) They are wasteful of water. A minimum of 12,000 litres/game to a maximum of 36,000 litres/game of water is typically applied to the surface.
(b) Availability of a sufficient quantity of potable water during short time periods, such as half time - ideally optimal irrigation should be able to be completed in less than 10 minutes.
(c) Uniform wetness over the entire field of play, including the run-offs.
(d) Adequate drainage is required to maintain the water levels close to the surface which is required during game play.
(e) To avoid drainage issues, the pitch requires a crown gradient, but if there is too much of a gradient it can also cause the pitch to dry unevenly causing ball roll to be unpredictable.
(f) If the water is not reused, then there is a requirement to dispose of the water.
(g) Ambient conditions dictate the volume and the regularity required for pitch irrigation.
(h) This all adds significant cost to the pitch, both initially, as well as annual costs going forward.
(i) If the water storage or recycling is not carefully managed, then this can raise the risk of water borne bacterial infections to the players and/or the spectators from diseases such as Legionnaires Disease.
(j) Another common issue with water pitches is the formation of algae on the surface, which is not only unsightly, but can be a health and safety issue for the players and cause long term damage to the synthetic surface.
(k) The pitch is usually irrigated by pop-up sprinklers or water cannons - both these systems have to be carefully managed to prevent disruption to the game and spectators during the irrigation process. Players have to manoeuvre around the water sprinklers, and spectators may have to move to avoid being sprinkled, depending on wind direction.
(l) Player comfort; the players are completely saturated by the end a game, which can be uncomfortable, cause skin chaffing and wet feet, and can also lead to increased humidity in hot climates as the water evaporates, potentially resulting in fatigue.

[0016] It may be an object of at least one embodiment of at least one aspect of the present invention to obviate or mitigate one or more disadvantages or problems in the prior art.

[0017] It may be an object of at least one embodiment of at least one aspect of the present invention to provide an improved artificial surface, such as a sports (playing) surface, such as a hockey surface.

SUMMARY OF INVENTION

[0018] According to the present invention there is provided a material or yarn for an artificial surface, such as a sports surface, for example, a hockey surface, a method of manufacturing a material or yarn for an artificial surface, an artificial surface, and a sports field, pitch or court according to the appended claims.

FIRST INVENTION

[0019] According to a first aspect of the present invention there is provided a material or yarn for an artificial surface, such as a sports surface, and advantageously for a hockey surface.

[0020] The material or yarn may comprise a synthetic turf or grass yarn.

[0021] The material or yarn may substantially comprise a polyolefin or polymer(ic) (base) material.

[0022] In this embodiment, the polyolefin or polymer material may comprise polyethylene, or alternatively comprises

nylon.

[0023] The material or yarn may comprise at least one additive, for example, at least one slip additive, preferably a permanent slip additive. A slip additive may be an additive that can be added to polyolefin or polymer materials to control/lower friction. A slip additive may be added directly into a polyolefin or polymer material during an extrusion process and may migrate to a surface as the polyolefin or polymer material cools, thereby allowing a (solid) lubricating layer to form.

[0024] The at least one additive may comprise a further polyolefin or polymer.

[0025] The at least one additive may comprise or include a siloxane additive, a siloxane-based additive, and/or an additive that comprises a siloxane functional group.

[0026] The at least one additive may comprise or include an organosilicon, a silicone polymer or a silicone compound.

[0027] The at least one additive may comprise or include a cyclic siloxane.

[0028] The at least one additive may comprise or include a dimethylsiloxane or a cyclic dimethylsiloxane.

[0029] Preferably, the at least one additive may (at least or substantially) comprise or include Octamethylcyclotetrasiloxane (D4) (CAS No 556-67-2; EC No 209-136-7).

[0030] Alternatively or additionally, the at least one additive may comprise or include at least one of, or be selected from one or more of: Hexamethylcyclotrisilaxane (D3), Decamethylcyclopentasiloxane (D5), Dodecamethylcyclohexasiloxane (D6), Hexamethyldisiloxane (HMDS).

[0031] The siloxane additive may comprise an ultra-high molecular weight (UHMW) siloxane polymer. The siloxane additive may comprise an ultra-high molecular weight (UHMW) siloxane polymer, which may be dispersed in the/a polyolefin or polymer material, e.g., a low-density polyolefin material, e.g., polyethylene (LDPE).

[0032] The at least one additive, e.g., (permanent) slip additive, may act to reduce the coefficient of (dynamic) friction μ of the material or yarn. The coefficient of (dynamic) friction may be defined as the force between two objects when the two objects are moving relatively against one another.

[0033] Embodiments of the present invention may provide a material or yarn having an altered or engineered surface tension which may provide the material or yarn with an increased lubrication or lubrication feel, thus obviating the need to water the artificial surface.

[0034] The material or yarn may comprise a monofilament.

[0035] The polyolefin material may comprise 80% to 90% of the material or yarn.

[0036] The at least one additive may comprise 0.1% to 10% of the material or yarn, preferably 0.5% to 10%, and most preferably 1% to 6%, e.g., 4% to 6% or 2%.

[0037] The material or yarn may comprise at least one further additive. The at least one further additive may be selected from one or more of: a colour pigment(s), an ultraviolet light stabiliser and an anti-oxidant.

[0038] The at least one additive may comprise a layer on the material or yarn or on the polyolefin material (or polyolefin material or yarn core), preferably an outer layer on the material or yarn or on the polyolefin material. The layer may be formed due to migration of the at least one additive during manufacture of the material or yarn, e.g., during a cooling process. The at least one additive may not be chemically linked to/with the polyolefin or polymer (base) material. The at least one additive may be retained in the polyolefin or polymer material due to a high molecular weight (and resultant impaired mobility) of molecules of the at least one additive.

[0039] The provision of the at least on additive may beneficially selectively control/lower the coefficient of friction μ of the material or yarn, e.g., an outer surface of the material or yarn. In this way slip or surface friction of the material or yarn can be selectively controlled.

[0040] The material or yarn may be texturized or crimped.

[0041] According to a second aspect of the present invention there is provided a method of manufacturing a material or yarn for an artificial surface according to the first aspect of the present invention, the method comprising:

providing a raw material;
providing at least one additive;
extruding the raw material and the at least one additive so as to form the material or yarn.

[0042] The at least one additive may comprise or be provided in pelletised form, e.g., as a masterbatch.

[0043] The at least one additive may comprise a slip additive.

[0044] The at least one additive may comprise a siloxane additive.

[0045] The siloxane additive may comprise an ultra-high molecular weight (UHMW) siloxane polymer, which may be dispersed in a low-density polyethylene (LDPE).

[0046] The at least one additive may form or comprise a layer on the material or yarn or on the polyolefin material (or polyolefin material or yarn core), preferably an outer layer on the material or yarn or on the polyolefin material.

[0047] The layer may be formed due to migration of the at least one additive during manufacture of the material or yarn, e.g., during a cooling process, e.g., subsequent to extrusion.

[0048] The method may comprise the subsequent step of:
texturizing the material or yarn.
[0049] Texturizing the material or yarn may comprise crimping the material or yarn.
[0050] According to a third aspect of the present invention there is provided an artificial surface comprising at least one, and preferably a plurality, of materials or yarns according to the first aspect of the present invention.
[0051] The artificial surface may comprise an artificial surface according to the sixth aspect of the present invention.
[0052] The artificial surface may comprise a sports (playing) surface, preferably a hockey field.
[0053] The artificial surface may be capable of providing a rotational resistance of between 25Nm and 45 Nm when dry or unwatered or unwetted. The artificial surface may preferably have a rotational resistance of 25 Nm to 33Nm, and most preferably 28Nm to 32Nm. The rotational resistance may be measured with a dimpled foot.
[0054] The rotational resistance may be measured in accordance with EN 15301-1.
[0055] The artificial surface may be capable of providing a ball rebound of 100mm to 400mm when dry or unwatered or unwetted. The artificial surface may preferably have a ball rebound of 320mm to 380mm, preferably 320mm to 365mm, or around 364mm.
[0056] The ball rebound may be measured in accordance with EN 1225.
[0057] The artificial surface may comprise a synthetic turf or grass surface or system.
[0058] According to a fourth aspect of the present invention there is provided a sports field, pitch or court, or a play/playing area, comprising an artificial surface according to the third aspect of the present invention.
[0059] Preferably the sports field, pitch or court comprises a hockey field.
[0060] According to a fifth aspect of the present invention there is provided a method of manufacturing an artificial surface, the method comprising:

providing a material or yarn for an artificial surface according to the first aspect of the present invention;
tufting the material or yarn to a (primary) backing or substrate.

[0061] The material or yarn may be provided according to the method of the second aspect of the present invention.
[0062] The (primary) backing or substrate may comprise a woven product. The woven product may comprise or be adapted to be used as a backing, such as a primary backing or as a substrate layer, for example, for a surface, ground or floor covering such as artificial or synthetic grass or turf. The woven product may comprise at least a first woven layer. The woven product may comprise at least a second woven layer. The first and second woven layers may be attached together or may be interwoven. The woven product may, therefore comprise interwoven areas or interweaves.
[0063] The first woven layer may comprise a plurality of warp tapes or threads and a plurality of weft tapes or threads, the warp tapes or threads and the weft tapes or threads of the first woven layer being substantially perpendicular to one another.
[0064] The second woven layer may comprise a plurality of warp tapes or threads and a plurality of weft tapes or threads, the warp tapes or threads and the weft tapes or threads of the second woven layer being substantially perpendicular to one another;
[0065] The warp tapes or threads of the first and second woven layers may be substantially parallel to one another.
[0066] The weft tapes or threads of the first and second woven layers may be substantially parallel to one another.
[0067] Each interwoven area or interweave may comprise one or more of:

a weft tape(s) or thread(s) of the first woven layer and a transversely coincident weft tape(s) or thread(s) of the second woven layer which are passed over both a warp tape(s) or thread(s) of the first woven layer and a longitudinally coincident warp tape(s) or thread(s) of the second woven layer; and/or
an adjacent weft tape(s) or thread(s) of the first woven layer and an adjacent and transversely coincident weft tape(s) or thread(s) of the second woven layer which are passed under both said warp tape(s) or thread(s) of the first woven layer and said longitudinally coincident warp tape(s) or thread(s) of the second layer.

[0068] The features of the invention as defined in the first to fifth aspects given hereinabove may be provided in combination with the features of the invention as defined in the sixth to tenth aspects given hereinbelow.

SECOND INVENTION

[0069] According to a sixth aspect of the present invention there is provided an artificial surface.
[0070] The artificial surface may comprise a sports (playing) surface, and preferably hockey field. The artificial surface may be "waterless", i.e., not require application of water to provide predetermined performance characteristics, such as rotational resistance and/or ball rebound.
[0071] The artificial surface may comprise a synthetic turf or grass surface or system.

[0072] The artificial surface may have a rotational resistance of 25Nm to 45Nm when dry or unwatered or unwetted. The artificial surface may preferably have a rotational resistance of 25 Nm to 33Nm, and most preferably 28Nm to 32Nm.

[0073] The rotational resistance may be measured with a dimpled foot. The rotational resistance may be measured in accordance with BS EN 15301-1 (Surfaces for sports areas. Determination of rotational resistance). The BS EN15301-1:2007 test is a means to measure traction on a sports surface. Equipment consists of a dimpled foot and a torque wrench. The dimpled foot is dropped from a given height on to the sports surface, the foot is then turned on the surface using the torque wrench through at least 45° and a maximum torque value on the wrench is recorded. Multiple locations are typically tested. For a hockey system, the rotational resistance regardless of condition (wet or dry) should (preferably) be in the range 25Nm to 45Nm.

[0074] The artificial surface may be capable of providing a ball rebound of 100mm to 400mm when dry or unwatered or unwetted. The artificial surface may have a ball rebound of 320mm to 380mm, preferably 320mm to 365mm or around 364mm.

[0075] The ball rebound may be measured in accordance with BS EN 12235 (Surfaces for sports areas. Determination of vertical ball behaviour). The BS EN 12235:2013 test measures ball rebound properties on a sports surface. Equipment holds a ball via a magnetic plate at a given height, and a sensitive microphone records the first and second bounce. Using software, the height of the first and second bounce can be calculated. Multiple locations are typically tested. For a Global system, the ball rebound regardless of condition (wet or dry) should (preferably) be in the range of 100 to 400mm.

[0076] The artificial surface may have a standard acceleration due to gravity value (g value) of 5.5 to 8.5, and preferably of 6 to 8.3. The g value may be measured using an accelerometer.

[0077] The rotational resistance, ball rebound and/or g value may be measured with the artificial surface (substantially) dry or unwatered or unwetted.

[0078] The artificial surface may comprise at least one and preferably a plurality of materials or yarns for an artificial surface, such as a sports surface, for example, a hockey surface.

[0079] The material(s) or yarn(s) may be tufted to a (primary) backing.

[0080] According to a seventh aspect of the present invention there is provided a material or yarn for an artificial surface or when used in, such as a sports surface, for example, a hockey surface, according to the sixth aspect of the present invention.

[0081] The material or yarn may comprise a material or yarn according to the first aspect of the present invention.

[0082] The material or yarn may comprise a synthetic turf or grass yarn.

[0083] The material or yarn may substantially comprise a polyolefin or polymer material.

[0084] The polyolefin material may preferably comprise polyethylene, or alternatively may comprise nylon.

[0085] The material or yarn may comprise at least one additive, for example, at least one slip additive, preferably a permanent slip additive.

[0086] The at least one additive may comprise or include a siloxane-based additive.

[0087] According to an eighth aspect of the present invention there is provided a method of manufacturing a material or yarn for an artificial surface according to the sixth aspect of the present invention.

[0088] The method may comprise:

providing a raw material;
providing at least one additive;
extruding the raw material and the at least on additive so as to form the material or yarn.

[0089] The at least one additive may comprise be provided in pelletised form, e.g., as a masterbatch.

[0090] The at least one additive may comprise a slip additive.

[0091] The at least one additive may comprise a siloxane additive.

[0092] The siloxane additive may comprise an ultra-high molecular weight (UHMW) siloxane polymer, which may be dispersed in a low-density polyethylene (LDPE).

[0093] The at least one additive may form or comprise a layer on the material or yarn or on the polyolefin material (or polyolefin material or yarn core), preferably an outer layer on the material or yarn or on the polyolefin material.

[0094] The layer may be formed due to migration of the at least one additive during manufacture of the material or yarn, e.g., during a cooling process, e.g., subsequent to extrusion.

[0095] The method may comprise the subsequent step of:
texturizing the material or yarn.

[0096] Texturizing the material or yarn may comprising crimping the material or yarn.

[0097] According to a ninth aspect of the present invention there is provided a sports field, pitch or court, or a play/playing area, comprising an artificial surface according to the sixth aspect of the present invention.

[0098] Preferably the sports field or pitch comprises a hockey field.

[0099] According to a tenth aspect of the present invention there is provided a method of manufacturing an artificial

surface according to the sixth aspect of the present invention, the method comprising:

providing a material or yarn according to the seventh aspect of the present invention;
tufting the material or yarn to a primary backing or substrate.

[0100] The (primary) backing or substrate may comprise a woven product. The woven product may comprise or be adapted to be used as a backing, such as a primary backing or as a substrate layer, for example, for a surface, ground or floor covering such as artificial or synthetic grass or turf. The woven product may comprise at least a first woven layer.

[0101] The woven product may consist of the first woven layer.

[0102] Alternatively, the woven product may comprise at least a second woven layer. The first and second woven layers may be attached together or may be interwoven. The woven product may, therefore comprise interwoven areas or interweaves.

[0103] The first woven layer may comprise a plurality of warp tapes or threads and a plurality of weft tapes or threads, the warp tapes or threads and the weft tapes or threads of the first woven layer being substantially perpendicular to one another.

[0104] The second woven layer may comprise a plurality of warp tapes or threads and a plurality of weft tapes or threads, the warp tapes or threads and the weft tapes or threads of the second woven layer being substantially perpendicular to one another;

[0105] The warp tapes or threads of the first and second woven layers may be substantially parallel to one another.

[0106] The weft tapes or threads of the first and second woven layers may be substantially parallel to one another.

[0107] Each interwoven area or interweave may comprise one or more of:

a weft tape(s) or thread(s) of the first woven layer and a transversely coincident weft tape(s) or thread(s) of the second woven layer which are passed over both a warp tape(s) or thread(s) of the first woven layer and a longitudinally coincident warp tape(s) or thread(s) of the second woven layer; and/or
an adjacent weft tape(s) or thread(s) of the first woven layer and an adjacent and transversely coincident weft tape(s) or thread(s) of the second woven layer which are passed under both said warp tape(s) or thread(s) of the first woven layer and said longitudinally coincident warp tape(s) or thread(s) of the second layer.

[0108] It will be appreciated that any features of any of the aforementioned aspect of the present invention may be used either singly or in combination with any other features of any of the aforementioned aspects of the present invention.

[0109] The features of the invention as defined in the sixth to tenth aspects given hereinabove may be provided in combination with the features of the invention as defined in the first to fifth aspects given hereinabove.

BRIEF DESCRIPTION OF DRAWINGS

[0110] Embodiments of the present invention will now be described by way of example only, and with reference to the accompanying drawings, which are:

Figure 1 a schematic view of an extrusion apparatus used in the manufacture of a material or yarn for an artificial surface according to the present invention;

Figure 2(a) a schematic view of a portion of a texturising apparatus used in the manufacture of the material or yarn for an artificial surface according to the present invention;

Figure 2(b) a schematic view of the texturising apparatus of Figure 2(a) used in the manufacture of the material or yarn for an artificial surface according to the present invention;

Figure 3(a) a schematic view of a tufting process used in the manufacture of the material or yarn for an artificial surface according to the present invention;

Figure 3(b) a schematic view of the tufting apparatus used in the manufacture of the material or yarn for an artificial surface according to the present invention;

Figure 3(c) a schematic sectional side view and a schematic top view of a (primary) backing for use in an embodiment of an artificial surface according to the present invention;

Figure 3(d) a schematic sectional side view of a (primary) backing for use in an embodiment of an artificial surface according to the present invention;

Figures 4(a) a schematic diagram of a material or yarn according to an embodiment of the present invention prior to texturizing;

Figures 4(b) a schematic diagram of a material or yarn according to an embodiment of the present invention subsequent to texturizing;

Figure 5 a schematic diagram of an artificial surface comprising the material or yarn according to Figure 4(b);

Figure 6(a) a table providing technical data regarding a number of possible at least one additive candidates; and
Figure 6(b) a table providing chemical data regarding the possible at least one additive candidates of Figure 6(a).

DETAILED DESCRIPTION OF DRAWINGS

[0111] Referring to Figures 1 to 6(b), there will be described a material or yarn, generally designated 5, for an artificial surface 10, such as a sports surface, for example, a hockey surface, according to an embodiment of the present invention. There will also be described a method of manufacturing the material or yarn 5, the artificial surface 10 comprising the material or yarn 5, and a sports field, pitch or court or play/playing area, such as a hockey field, comprising the artificial surface 10.

[0112] Herein the following terms are to be generally understood as follows:

Accelerometer: an electronic sensor that measures the acceleration forces acting on an object in order to determine the object's position in space and monitor the object's movement.
Ball rebound: a test to seek to ensure consistent bounce of a (hockey) ball dropped from a fixed height.
Extrusion process: a means by which polyolefin raw materials by means of heat are melted and combined with other polyolefin additives, for instance colour additives, to form a homogenous mixture and be made into a new form.
FIH: the Federation Internationale de Hockey - the international governing body of field hockey.
Grass yarn: a synthetic fibre, a plurality of such forming a surface made to look like natural grass.
Monofilament yarn: a type of artificial grass yarn produced by extruding molten polymeric materials through a die to produce continuous strands.
Rotational resistance (or traction): a test for (artificial) turf fields to assess an amount of grip a field returns to a sport person or athlete, e.g., when a plant-and-turn or change in direction is performed.
Texturized yarn: filament(s) that have been given notably greater apparent volume or bulk than conventional yarns of similar filament count or which have been made more extensible by filament distortion through physical, chemical or heat treatment or a combination of these.
Synthetic surface: an overall system, which comprises a sub-base, drainage, potentially a shockpad, and an artificial grass surface or carpet, and often an infill material which sits between the grass yarn to keep such in place and assist in specific performance requirements.

[0113] Referring to Figures 4(a) and (b), according to an embodiment of the present invention, there is provided a material or yarn 5 for an artificial surface 10, such as a sports surface, and particularly advantageously for a hockey surface or field.

[0114] The material or yarn 5 comprises a synthetic turf or grass yarn. The material or yarn 5 substantially comprise a polyolefin (base) material. In this embodiment, the polyolefin material comprises polyethylene, or alternatively comprises nylon.

[0115] The material or yarn 5 comprise at least one additive, for example, at least one slip additive, preferably a permanent slip additive. The at least one additive comprises a further polyolefin. In this embodiment, the at least one additive comprises or includes a siloxane additive, a siloxane-based additive, and/or an additive that comprises a siloxane functional group.

[0116] The at least one additive can comprise or include an organosilicon, a silicone polymer or a silicone compound. The at least one additive can comprise or include a cyclic siloxane. The at least one additive can comprise or include a dimethylsiloxane or a cyclic dimethylsiloxane.

[0117] Advantageously, the at least one additive comprises or includes (at least) Octamethylcyclotetrasiloxane (D4) (CAS No 556-67-2; EC No 209-136-7).

[0118] Alternatively or additionally, the at least one additive comprises or includes at least one of, or is selected from one or more of: Hexamethylcyclotrisilaxane (D3), Decamethylcyclopentasiloxane (D5), Dodecamethylcyclohexasiloxane (D6), and/or Hexamethyldisiloxane (HMDS).

[0119] The siloxane additive can comprise an ultra-high molecular weight (UHMW) siloxane polymer. The siloxane additive can comprise an ultra-high molecular weight (UHMW) siloxane polymer, which may be dispersed in the/a polyolefin material, e.g., a low-density polyolefin material, e.g., polyethylene (LDPE).

[0120] The at least one additive, e.g., (permanent) slip additive, may act to reduce the coefficient of (dynamic) friction of the material or yarn. The coefficient of dynamic friction may be defined as the force between two objects when the two objects are moving relatively against one another.

[0121] Embodiments of the present invention provide a material or yarn having an altered or engineered surface tension which can provide the material or yarn with an increased lubrication or lubrication feel, thus obviating the need to water the artificial surface.

[0122] The material or yarn comprises a monofilament.

[0123] The polyolefin material comprises 80% to 90% of the material or yarn.

[0124] The at least one additive comprises 0.1% to 10% of the material or yarn, preferably 0.5% to 10%, and most preferably 1% to 6%, e.g., 4% to 6% or 2%.

[0125] The material or yarn can comprise at least one further additive. Typically, the at least one further additive can be selected from one or more of: a colour pigment(s), an ultraviolet light stabiliser and an anti-oxidant.

[0126] Beneficially, the at least one additive comprises a layer on the material or yarn or on the polyolefin material (or polyolefin material or yarn core), preferably an outer layer on the material or yarn or on the polyolefin material. The layer can be formed due to migration of the at least one additive during manufacture of the material or yarn, e.g., during a cooling process.

[0127] The material or yarn is texturized or crimped.

[0128] Referring to Figures 1 to 3, according to the present invention there is provided a method of manufacturing a material or yarn 5 for an artificial surface 10, the method comprising:

providing a raw material;
providing at least one additive;
extruding the raw material and the at least on additive so as to form the material or yarn 5.

[0129] The at least one additive is typically provided in pelletised form, e.g., as a masterbatch.

[0130] The at least one additive comprises a slip additive.

[0131] The at least one additive can comprise a siloxane additive.

[0132] The siloxane additive can comprise an ultra-high molecular weight (UHMW) siloxane polymer, which can be dispersed in a low-density polyethylene (LDPE).

[0133] Beneficially, the at least one additive forms or comprises a layer on the material or yarn 5 or on the polyolefin material (or polyolefin material or yarn core), advantageously an outer layer on the material or yarn or on the polyolefin material.

[0134] The layer can be formed due to migration of the at least one additive during manufacture of the material or yarn, e.g., during a cooling process, e.g., subsequent to extrusion.

[0135] The method can comprise the subsequent step of:
texturizing the material or yarn 5.

[0136] Texturizing the material or yarn comprises crimping the material or yarn.

[0137] Referring to Figure 5, according to the present invention there is provided an artificial surface10 comprising at least one, and beneficially a plurality, of materials or yarns 5.

[0138] The artificial surface 10 comprises a sports (playing) surface, beneficially a hockey field.

[0139] The artificial surface 10 is capable of providing a rotational resistance of between 25Nm and 45 Nm when dry or unwatered or unwetted. The artificial surface 10 has a rotational resistance of 25 Nm to 33Nm, and most preferably 28Nm to 32Nm. The rotational resistance can be measured with a dimpled foot. The rotational resistance can be measured in accordance with EN 15301-1.

[0140] The artificial surface 10 is capable of providing a ball rebound of 100mm to 400mm when dry or unwatered or unwetted. The artificial surface 10 beneficially has a ball rebound of 320mm to 380mm, preferably 320mm to 365mm, or around 364mm. The ball rebound can be measured in accordance with BS EN 12235.

[0141] The artificial surface typically comprises a synthetic turf or grass surface or system.

[0142] According to the present invention there is provided a sports field, pitch or court, or a play/playing area, comprising the artificial surface 10.

[0143] Beneficially, the sports field, pitch or court comprises a hockey field.

[0144] Referring to Figures 1 to 3 (c), according to the present invention, there is provided a method of manufacturing the artificial surface 10, the method comprising:

providing the material or yarn 5 for the artificial surface 10;
tufting the material or yarn 5 to a (primary) backing or substrate 15.

[0145] The material or yarn 5 is provided according to the method hereinbefore described.

[0146] The (primary) backing or substrate 15 comprises a woven product. The woven product comprises or is adapted to be used as a backing, such as a primary backing or as a substrate layer, for example for a surface, ground or floor covering such as artificial or synthetic grass or turf. The woven product can comprise at least a first woven layer 20 (see Figures 3(c) or 3(d).

[0147] The woven product can consist of the single first woven layer 20 (see Figure 3(c)).

[0148] Alternatively, the woven product can comprise at least a second woven layer 25 (see Figure 3(d)). The first and second woven layers 20, 25 can be attached together or can be interwoven. The woven product can, therefore,

comprise interwoven areas or interweaves.

[0149] The first woven layer 20 can comprise a plurality of warp tapes or threads 30 and a plurality of weft tapes or threads 35, the warp tapes or threads 30 and the weft tapes or threads 35 of the first woven layer being substantially perpendicular to one another.

[0150] The second woven layer 25 comprises a plurality of warp tapes or threads 40 and a plurality of weft tapes or threads 45, the warp tapes or threads 40 and the weft tapes or threads 45 of the second woven layer 25 being substantially perpendicular to one another;

The warp tapes or threads 30, 40 of the first and second woven layers 20, 25 are substantially parallel to one another.

[0151] The weft tapes or threads 35, 45 of the first and second woven layers 25, 30 are substantially parallel to one another.

[0152] Each interwoven area or interweave comprises one or more of:

a weft tape(s) or thread(s) 35 of the first woven layer 20 and a transversely coincident weft tape(s) or thread(s) 45 of the second woven layer 25 which are passed over both a warp tape(s) or thread(s) 30 of the first woven layer 25 and a longitudinally coincident warp tape(s) or thread(s) 40 of the second woven layer 30; and/or

an adjacent weft tape(s) or thread(s) 35 of the first woven layer 20 and an adjacent and transversely coincident weft tape(s) or thread(s) 45 of the second woven layer 30 which are passed under both said warp tape(s) or thread(s) 30 of the first woven layer 25 and said longitudinally coincident warp tape(s) or thread(s) 40 of the second layer 30.

[0153] According to the present invention there is provided an artificial surface 10. The artificial surface 10 comprises a sports (playing) surface, and beneficially a hockey field. The artificial surface 10 comprises a synthetic turf or grass surface or system.

[0154] The artificial surface 10 has a rotational resistance of 25Nm to 45Nm when dry or unwatered or unwetted. The artificial surface has a rotational resistance of 25 Nm to 33Nm, and most preferably 28Nm to 32Nm.

[0155] The rotational resistance can be measured with a dimpled foot. The rotational resistance can be measured in accordance with BS EN 15301-1 (Surfaces for sports areas. Determination of rotational resistance). The BS EN15301-1:2007 test is a means to measure traction on a sports surface. Equipment consists of a dimpled foot and a torque wrench. The dimpled foot is dropped from a given height on to the sports surface, the foot is then turned on the surface using the torque wrench through at least 45° and a maximum torque value on the wrench is recorded. Multiple locations are tested. For a hockey system, the rotational resistance regardless of condition (wet or dry) should lie between 25Nm and 45Nm.

[0156] The artificial surface is capable of providing a ball rebound of 100mm to 400mm when dry or unwatered or unwetted. The artificial surface can have a ball rebound of 320mm to 380mm, preferably 320mm to 365mm or around 364mm.

[0157] The ball rebound can be measured in accordance with BS EN 12235. The BS EN 12235:2013 test measures ball rebound properties on a sports surface. Equipment holds a ball via a magnetic plate at a given height, and a sensitive microphone records the first and second bounce. Using software, the height of the first and second bounce can be calculated. Multiple locations are tested. For a Global system, the ball rebound regardless of condition (wet or dry) should lie from 100 to 400mm.

[0158] The artificial surface has a standard acceleration due to gravity value (g value) of 5.5 to 8.5, and preferably of 6 to 8.3. The g value may be measured using an accelerometer.

[0159] The rotational resistance, ball rebound and/or g value may be measured with the artificial surface (substantially) dry or unwatered or unwetted.

[0160] The artificial surface 10 comprises at least one and preferably a plurality of materials or yarns 5.

[0161] The material(s) or yarn(s) 5 are tufted to (primary) backing 15.

[0162] According to the present invention there is provided a material or yarn 5 for an artificial surface 10 or when used in, such as a sports surface, for example, a hockey surface, as hereinbefore described.

[0163] The material or yarn 5 comprises the material or yarn 5 as hereinbefore described.

[0164] According to the present invention there is provided a method of manufacturing a material or yarn 5 for an artificial surface 10 as hereinbefore described.

[0165] The method can comprise:

providing a raw material;

providing at least one additive;

extruding the raw material and the at least on additive so as to form the material or yarn 5.

[0166] According to the present invention there is provided a sports field, pitch or court, or a play/playing area, comprising an artificial surface 10 as hereinbefore described.

[0167] According to the present invention there is provided a method of manufacturing an artificial surface as herein-before described, the method comprising:

providing 5 material or yarn 5;
tufting the material or yarn to a primary backing or substrate 15.

[0168] Specific embodiments and examples of the present invention will now be described in further detail.

[0169] A general solution to a problem to which the present invention is addressed, namely the problem of the need to wet known (hockey) artificial surfaces, is to seek to change the surface tension of a dry monofilament grass yarn to give the yarn a more lubricated "feel", thus replacing the need for water.

[0170] In order to remove the need for water flooding from synthetic turf system the Inventors considered what it is players like about playing on a watered surface. The following are the key drivers for the use of water on elite hockey surfaces:

(a) a faster surface;
(b) consistency of play;
(c) better ball control;
(d) smooth surface interaction between the surface and the stick and the surface and the ball.

[0171] In known systems, the water flooding acts as a lubricant, lowering the coefficient of dynamic friction on the surface while holding a ball to the surface in a predictable manner. The Inventors have found that the same or a substantially similar effect can be achieved on a dry/unwetted artificial surface using a permanent slip additive using siloxane chemistry. (Specifically, an additive containing Octamethylcyclotetrasiloxane (D4) CAS No 556-67-2; EC No 209-136-7).

[0172] In the present invention the addition of a permanent slip additive to the (base) polymer acts to reduce the coefficient of dynamic friction; which is defined as the force between two objects when object is moving or if two objects are moving against one another. During processing, the permanent slip additive migrates to the surface as the material cools, because of incompatibilities with the base polymer, allowing a solid lubricating layer to form. This layer acts to lower the dynamic friction or adhesion between contacting surfaces. The permanent slip additive is not chemically linked with the basic polymer, but is retained in the polymer due to the high molecular weight of the additive and the resultant impaired mobility.

Process

Extrusion Process

[0173] Referring to Figure 1, there is shown an extrusion apparatus, generally designated 100.

[0174] The permanent slip additive, which is non-migratory, is incorporated into the synthetic grass yarn during the extrusion process.

[0175] Synthetic grass yarns are produced via monofilament extrusion. In this process raw material of polyethylene polymer pellets (dosage 80-90%), combination masterbatch - which contains colour pigments, ultra-violet light stabilisers and antioxidants in a carrier resin (dosage 5-10%), polymer process aid (dosage 0.2-1 %) and the slip additive (dosage 0.1 -10%), form the recipe.

[0176] The ingredient materials are all dosed in precise amounts according to a recipe into an extruder. The extruder apparatus 100 has a heated barrel which contains a screw. The ingredient materials drop into the heated barrel (enters barrel in excess of 200°C) containing the screw, and the screw starts to transport the material. During transportation, the heat and the action of the screw cause the material to melt and mix together into a homogeneous mixture. At the end of the extruder apparatus 100 are a set of filters which remove any degraded or oversized material, the molten homogenous mixture is transported to a heated die 105 (heated in excess of 200°C) containing plates with holes which the material is forced out of into a water bath 110 to quickly cool the molten mixture in to continuous filament/yarn like forms - these are called monofilaments.

[0177] The holes in the plates are homogenous in size and shape, for example, diamond shape, so that each mono-filament is identical. Once the monofilaments are cooled in the water bath 110 (below 40°C), the monofilaments are transported to a drying section; here the water is removed from the monofilaments so that the filaments can start to be drawn and annealed. In a drawing section, the monofilaments are stretched using an oven (heated in excess of 80°C) in the machine direction this gives the monofilaments strength. The monofilaments are then heated (in excess of 80°C) and then annealed in their new form. In the final section the monofilaments are cooled (below 40°C) and an application of spin oil (0.1-1 % w/v) is applied via a lick roller before the monofilaments are grouped into monofilament bundles and

are collected onto spools for the next stage of the process.

Texturizing Process

[0178] Referring to Figures 2(a) and (b), there is shown a texturizing apparatus, generally designated 200.

[0179] After extruding the recipe to make a monofilament grass yarn 5, the yarn 5 is draw texturized via the stuffer box process, which gives a bulked, crimped effect to the yarn. The stuffer box method of texturizing bulks the yarn 5 by compressing the monofilament in a heated tube; this causes the monofilaments to fold or bend at a sharp angle giving a zig-zag or wavy crimp, while simultaneously set by a heating device. The amount of the effect is controlled by the speed - thereby increasing or decreasing the amount of material within the tube and temperature of the unit. The prime purpose of texturizing a monofilament grass yarn is to create a bulky structure. Texturizing the grass monofilament yarns 5 give such several desirable properties. These are; the bulked fibres have excellent surface coverage; the random structure created by texturizing means that the yarns 5 do not have any directionality once tufted into a carpet; and the random structure and the voids created by the texturizing process mean that the filaments mesh together giving an even flat surface.

[0180] Current texturizing technology gives a very consistent bulk/crimp to the yarn 5 assisting to make a flat surface. This is a measurable characteristic, and is expressed as a percentage. Such is calculated by measuring the contraction of a texturized percentage rate of the stretched out (non-texturized) yarn length. This is also helped by limiting the range in residual heat shrink values of the yarn 5, which is controlled in the extrusion process.

[0181] Referring to Figures 2(a) and (b), ribbons 210 of the material or yarn 5 are provided to the texturizing apparatus 200 which comprises: first heating godet 211, second heating godet 212, stuffer box 213, cooling godet 214, suction 215, withdrawal godet 216, air nozzle 218, standing cover 219, texturizing nozzle 221, air outlet area 223, guide groove 225 and openings 226.

Tufting Process

[0182] Referring to Figures 3(a) and (b), there is shown a tufting process and a tufting apparatus, generally designated 300. Figure 3(c) shows a backing 15 for an artificial surface 10 according to an embodiment of the present invention.

[0183] In the tufting process, the artificial surface or "carpet construction" is important; a dense construction is desirable. The construction is describable by three parameters: stitch rate - defined as the number of stitches over a given length; pile height - the length of the stitch protruding from the primary backing cloth; and tuft gauge - which is the distance between the tufting needles, commonly described in fractions of an inch. Less descriptive is the pile weight, which is the weight of the carpet per square meter which can range from 800g/m^2 to 2200g/m^2 or can range from 1200g/m^2 to over 2000g/m^2. During tufting good tension control on the yarn 5 to ensure consistency to the tufting needles and sharp blades are required to cut the pile length to the correct height, followed by consistent heat application in the coating process, so that the crimp/bulk is activated and curls down towards the backing cloth. All this should give evenness to the final synthetic grass surface, helping to eliminate irregular/inconsistent ball roll, or ball "bobbling".

[0184] Referring to Figures 4(a) and (b), there is shown a material or yarn 5 according to the present invention before and after texturizing, respectively.

[0185] Referring to Figure 5, there is shown an artificial surface 10 according to the present invention.

Supporting Evidence - Examples and Comparative Examples

[0186] To prove the efficacy of the at least one (slip) additive in the present invention, a number of tests were carried out. Initially tests were made using the FIH Hockey Turf and Field Standards. Part 2. Requirements for Hockey Turf Products. 2017 Edition. Tests performed were:

(a) rotational resistance (smooth foot);
(b) rotational resistance (dimpled foot);
(c) ball rebound.

[0187] A challenge was that the present FIH standard is based on water filled turf, so the tests are designed around this. New tests will likely have to be designed and defined to appraise the performance of a waterless system according to the present invention.

[0188] Additional testing was made outside of the scope of the FIH standards manual; investigations were made regarding player/surface/ball interaction. For such, an accelerometer was used which was attached to a player's hockey stick; all data was captured at 10,000 samples/second (10kHz) using an accelerometer capable of +/-500g. Such was also captured on high-speed camera to make an assessment of ball consistency across a surface, as well as a players'

movements.

[0189] For the test, several different addition rates of slip additive were trialled - results can be found in the supporting data hereinbelow. The data from the tests which were made indicated that the additive has an effect on the surface properties. The rotational resistance (dimpled foot), ball rebound, and skin friction (Securisport) show differences.

Supporting Data

[0190] During testing, the samples were compared against a control sample - namely, "Xcel Ultra" available from SIS Pitches - which is an FIH approved surface for wet field hockey.

(a) Rotational Resistance (smooth foot)

[0191] When looking at the results one could see very little variation between the samples. These metrics indicate that the use of the smooth foot was not effective in determining any differentiation between the samples. This highlights the need for specific waterless hockey surface testing metrics, as wet and dry surfaces are not comparable under this method.

(b) Rotational Resistance (dimpled foot) (in accordance with BS EN 15301-1) Reference is made to Table 1 below:

[0192]

Table 1

Sample	Addition Rate (PPM)	FIH Requirement	Test Condition	Average result
0.2% Addition	2000	25 - 45Nm	Dry	47.2Nm
0.5% Addition	5000		Dry	44.4Nm
1% Addition	10 000		Dry	41.6Nm
2% Addition	20 000		Dry	39.4Nm
3% Addition	30 000		Dry	33.2Nm
4% Addition	40 000		Dry	31.0Nm
5% Addition	50 000		Dry	30.8Nm
6% Addition	60 000		Dry	28.6Nm
Xcel Ultra	n/a		Wet	38.0Nm

[0193] From the data above one can see that 1% to 6% dosage levels (10,000 to 60,000 ppm) all meet the FIH requirement of 25-45Nm for rotational resistance.

[0194] 0.2% - 0.5% dosage levels (2,000 to 5,000 ppm) do not meet the FIH requirement for rotational resistance.

[0195] This shows that the use of the additive in increasing dosage levels passes the requirement set by the FIH of 25 to 45Nm.

[0196] The Xcel Ultra sample, which does not contain additive, fails the requirement for rotational resistance when dry and only meets the requirement when water is added.

[0197] The 2% dosage level (20,000ppm) gave a comparable result to the wet Xcel Ultra carpet.

(c) Ball Rebound (in accordance with BS EN 12235)

[0198] Reference is made to Table 2 below:

Table 2

Sample	Addition Rate (PPM)	FIH Requirement	Test Condition	Average result
0.2% Addition	2000	100 - 400mm	Dry	387.2mm
0.5% Addition	5000		Dry	362.6mm
1 % Addition	10 000		Dry	386.4mm
2% Addition	20 000		Dry	364.2mm
3% Addition	30 000		Dry	366.6mm
4% Addition	40 000		Dry	361.2mm
5% Addition	50 000		Dry	362.6mm
6% Addition	60 000		Dry	325.0mm
Xcel Ultra	n/a		Dry	402.4mm
Xcel Ultra	n/a		Wet 0 mins	351.6mm
Xcel Ultra	n/a		Wet 15 mins	341.0mm

[0199] From the data above, all the samples pass the FIH requirement, except the dry Xcel Ultra carpet which does not contain any additive.

[0200] The 6% dosage level (60,000ppm) of the slip additive is actually better than the wet Xcel Ultra carpet at 0 minutes wetting and after 15 minutes wetting.

[0201] Ball rebound can also be influenced by the choice of shockpad under the carpet.

[0202] These results show that the at least one additive has a dampening effect, holding a ball to the surface in the same way as water does on a wet system.

(d) Tests Outside Scope of FIH Manual

[0203] Accelerometer data is available, tests having been performed with the accelerometer and both a female hockey player and a male hockey player making long sweeps - this was considered a good way to create a measurement in an attempt to obtain a continuous vibration.

[0204] What the test was seeking to pick up was stick "chatter", water acting like a lubricant on a wet pitch, easing the passage of the stick across the surface.

[0205] Calculations of average "g" values (g being the standard acceleration due to gravity) on the surface (average of acceleration from moment of meeting the surface to connecting to the ball). Mostly, the results were the same (see Table 3):

Table 3

Addition Rate (%)	Addition Rate (PPM)	Average g Value
0.2	2000	8.3
0.5 - 1	5000 -10000	7.2
2	20 000	6
3-5	30 000 - 50 000	7.5
6	60 000	8.3

[0206] The tests did not measure on a wet surface during this initial test and did not include a Global category FIH approved surface for comparison.

[0207] It should be noted that 0.2% and 6% dosage levels (2,000 to 60,000 ppm) often gave the same result, behaving in the same way but for different reasons; both had a "sticky" property to the player. 0.2% dosage level (2,000 ppm) because such behaves like a dry surface (limited additive), and 6% dosage level (60,000 ppm) because such has too much additive creating a waxy/sticky surface.

[0208] Players performing drills on the artificial surfaces according to the present invention felt that surfaces having 0.2% and 6% dosage levels (2,000 and 60,000 ppm) were the least good synthetic surfaces, and as such "grabbed the

stick". Surfaces having 4% and 5% dosage levels (40,000 and 50,000 ppm) were the players favourites, and in their opinion felt more like a wet synthetic surface under the stick.

[0209] The high-speed camera data also showed that during drills with both the female and male hockey players, the 4%, 5% and 6% dosage levels (40,000, 50,000 and 60,000 ppm) held the ball close to the surface.

Results Summary

[0210] Tests demonstrate that the current requirement for water can be removed using an improved system design according to the present invention. It should be noted that:

(a) The evenness of the carpet is controlled by the consistency of the residual heat shrinkage in the yarn, texturizing, and the tufting and coating processes. This gives the faster surface players like.
(b) The addition of the slip additive gives "lubrication" between the ball and surface - as demonstrated by the accelerometer data (see "Supporting Evidence" hereinabove).
(c) The addition of the slip additive gives "lubrication" between the stick and the surface as demonstrated by the accelerometer data.
(d) The addition of the slip additive gives good rotational resistance as demonstrated by EN 15301-1 (Table 1).
(e) The addition of the additive helps the ball to stay on the surface and not bounce wildly as demonstrated by EN 12235 (Table 2). The use of a shockpad under the carpet in a system can also reduce this still further.

[0211] 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 of the scope of the invention in any way.

[0212] It will be appreciated that the embodiments of the present invention may be utilised in providing a "waterless" artificial surface, such as a sports playing surface or hockey field. By "waterless" may be meant that the surface does not require to be watered or does not require the application of water so as to provide required performance characteristics. The artificial surface of the present invention can be "waterless" as the yarn has a reduced coefficient of friction as compared to the prior art.

Claims

1. A material or yarn (5) for an artificial surface (10), such as a sports surface, for example, a hockey surface, the material or yarn comprising a synthetic turf or grass yarn comprising a polyolefin or polymer material and at least one additive comprising a siloxane additive.

2. A material or yarn as claimed in claim 1, wherein the polyolefin or polymer material comprises polyethylene or nylon.

3. A material or yarn as claimed in either of claims 1 or 2, wherein:

   the at least one additive or siloxane additive comprises an at least one slip additive or permanent slip additive; and/or
   the at least one additive comprises or includes a siloxane-based additive or an additive that comprises a siloxane functional group; and/or
   the at least one additive comprises or includes an organosilicon, a silicone polymer or a silicone compound; and/or
   the at least one additive comprises or includes a cyclic siloxane; and/or
   the at least one additive comprises or includes a dimethylsiloxane or a cyclic dimethylsiloxane; and/or
   the at least one additive comprises an ultra-high molecular weight (UHMW) siloxane polymer, which is optionally dispersed in a polyolefin carrier, such as a low-density polyethylene (LDPE).

4. A material or yarn as claimed in any preceding claim, wherein:

   the at least one additive comprises or includes (at least) Octamethylcyclotetrasiloxane (D4); and/or
   the at least one additive comprises or includes at least one of, or is selected from one or more of: Hexamethylcyclotrisilaxane (D3), Decamethylcyclopentasiloxane (D5), Dodecamethylcyclohexasiloxane (D6), Hexamethyldisiloxane (HMDS).

5. A material or yarn as claimed in any preceding claim, wherein the material or yarn comprises a monofilament.

6. A material or yarn as claimed in any preceding claim, wherein the polyolefin or polymer material comprises 80% to 90% of the material or yarn.

7. A material or yarn as claimed in any preceding claim, wherein the at least one additive comprises 0.1% to 10% of the material or yarn, or 0.5% to 10%, 1 % to 6%, 4% to 6% or 2% of the material or yarn.

8. A material or yarn as claimed in any preceding claim, wherein the at least one additive comprises or forms a layer on the material or yarn or on the polyolefin or polymer material (or polyolefin/polymer material or yarn core), such as an outer layer on the material or yarn or on the polyolefin or polymer material.

9. A material or yarn as claimed in any preceding claim, wherein the material or yarn is or has been texturized or crimped.

10. A method of manufacturing a material or yarn (5) for an artificial surface (10) according to any of claims 1 to 9, the method comprising:

providing a raw material;
providing at least one additive;
extruding the raw material and the at least one additive so as to form the material or yarn.

11. An artificial surface (10) comprising at least one material or yarn (5) or a plurality of materials or yarns according to any of claims 1 to 9, the artificial surface optionally comprising:

a sports (playing) surface, such as a hockey field; and/or
a synthetic turf or grass surface or system.

12. An artificial surface as claimed in claim 13, wherein:

the artificial surface provides a rotational resistance of between 25Nm and 45Nm, 25 Nm to 33Nm, or 28Nm to 32Nm, when dry or unwatered or unwetted, the rotational resistance optionally being measured with a dimpled foot and/or in accordance with BS EN 15301-1; and/or
the artificial surface provides a ball rebound of 100mm to 400mm, 320mm to 380mm, 320mm to 365mm, or around 364mm, when dry or unwatered or unwetted, the ball rebound optionally being measured in accordance with BS EN 12235.

13. A sports field, pitch or court or a play/playing area, such as a hockey field, comprising an artificial surface (10) according to either of claims 11 to 12.

14. A method of manufacturing an artificial surface (10), the method comprising:

providing a material or yarn for an artificial surface according to either of claims 11 or 12;
tufting the material or yarn to a (primary) backing or substrate (15), wherein optionally
the material or yarn is provided according to the method of any of claims 10 to 12.

15. An artificial surface (10), such as a sports or play/playing surface, for example, a hockey field, the artificial surface comprising a synthetic turf or grass surface or system, wherein the artificial surface has a rotational resistance of 25Nm to 45Nm when dry or unwatered or unwetted.

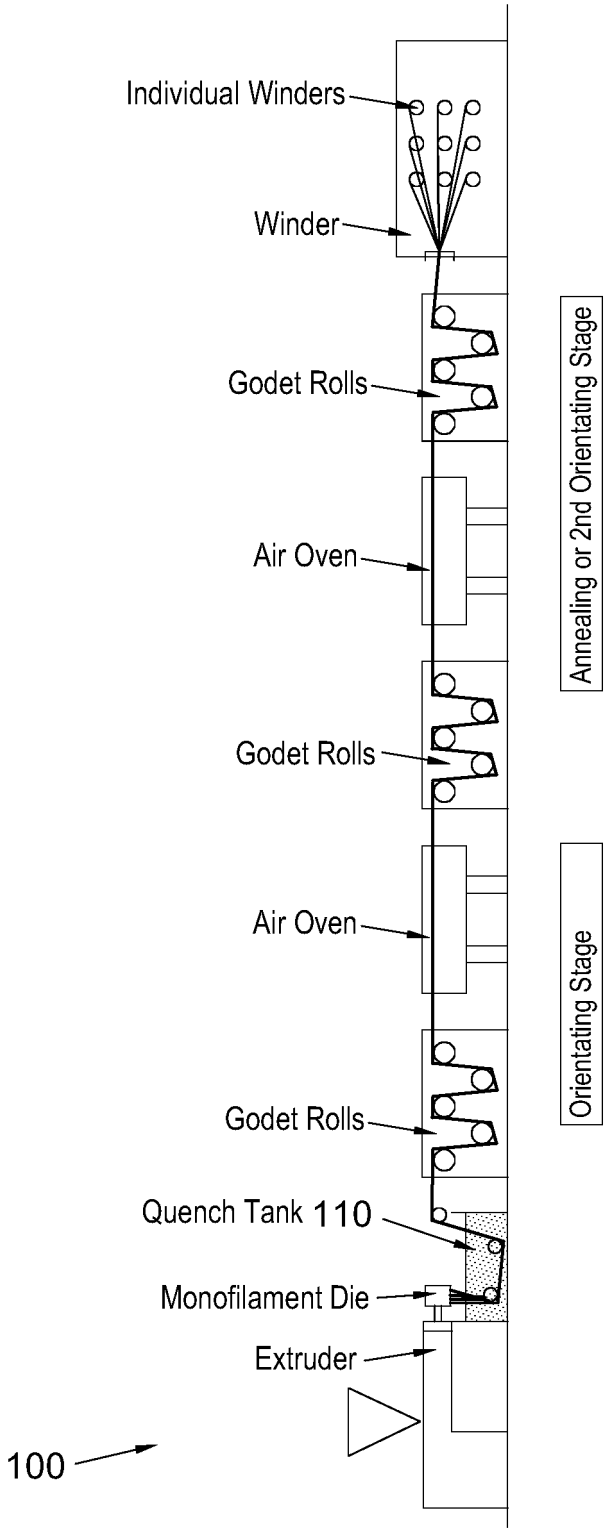

Individual Winders
Winder
Godet Rolls
Air Oven
Godet Rolls
Air Oven
Godet Rolls
Quench Tank 110
Monofilament Die
Extruder
100
Annealing or 2nd Orientating Stage
Orientating Stage

FIG. 1

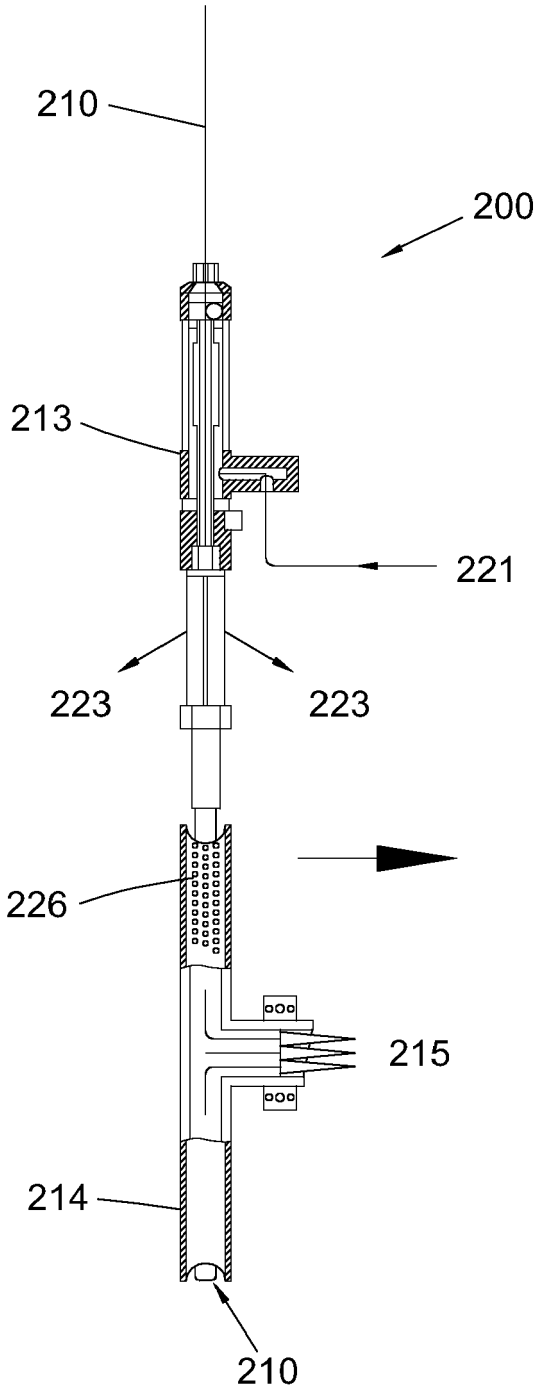


FIG. 2(a)

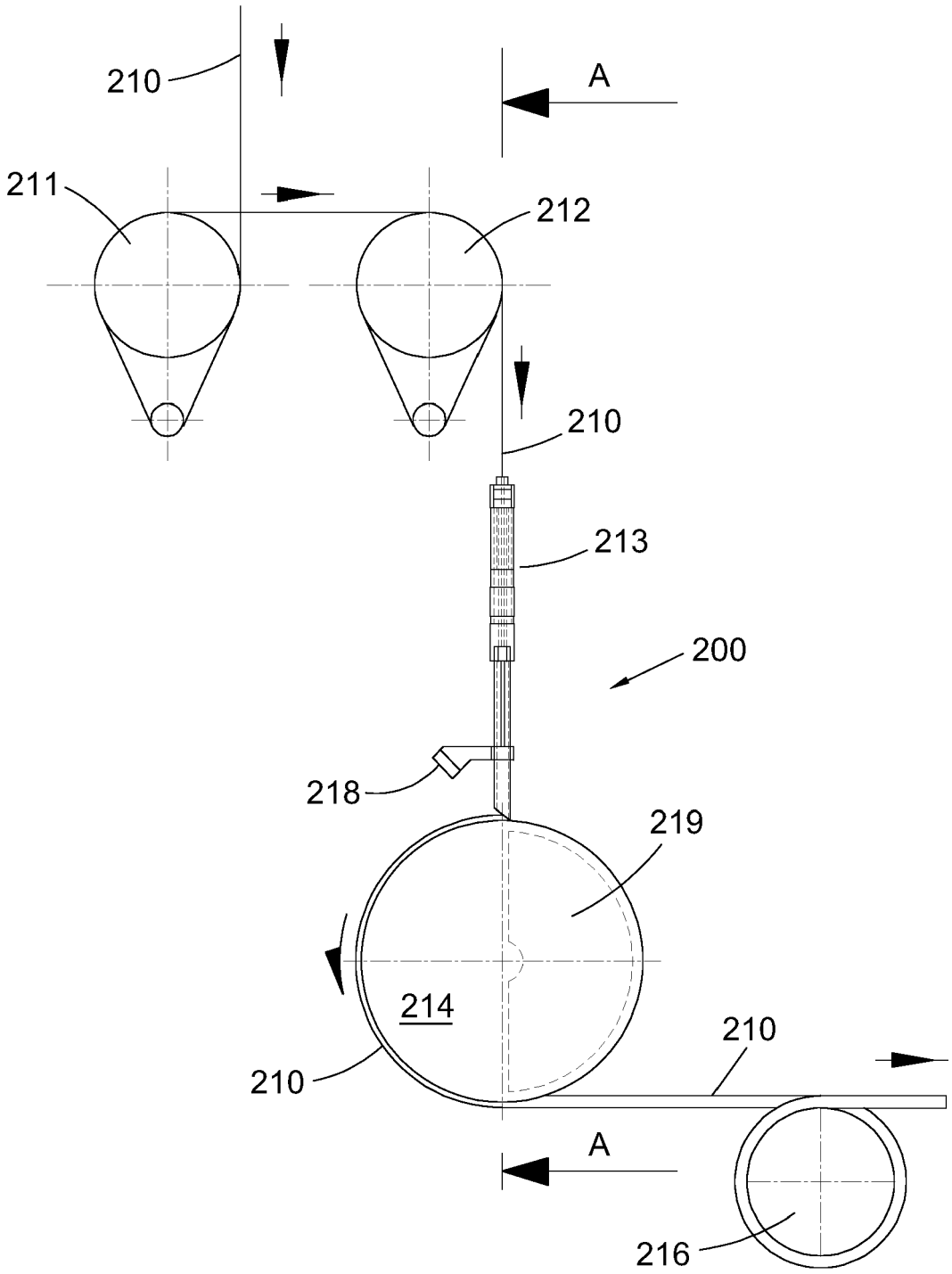


FIG. 2(b)

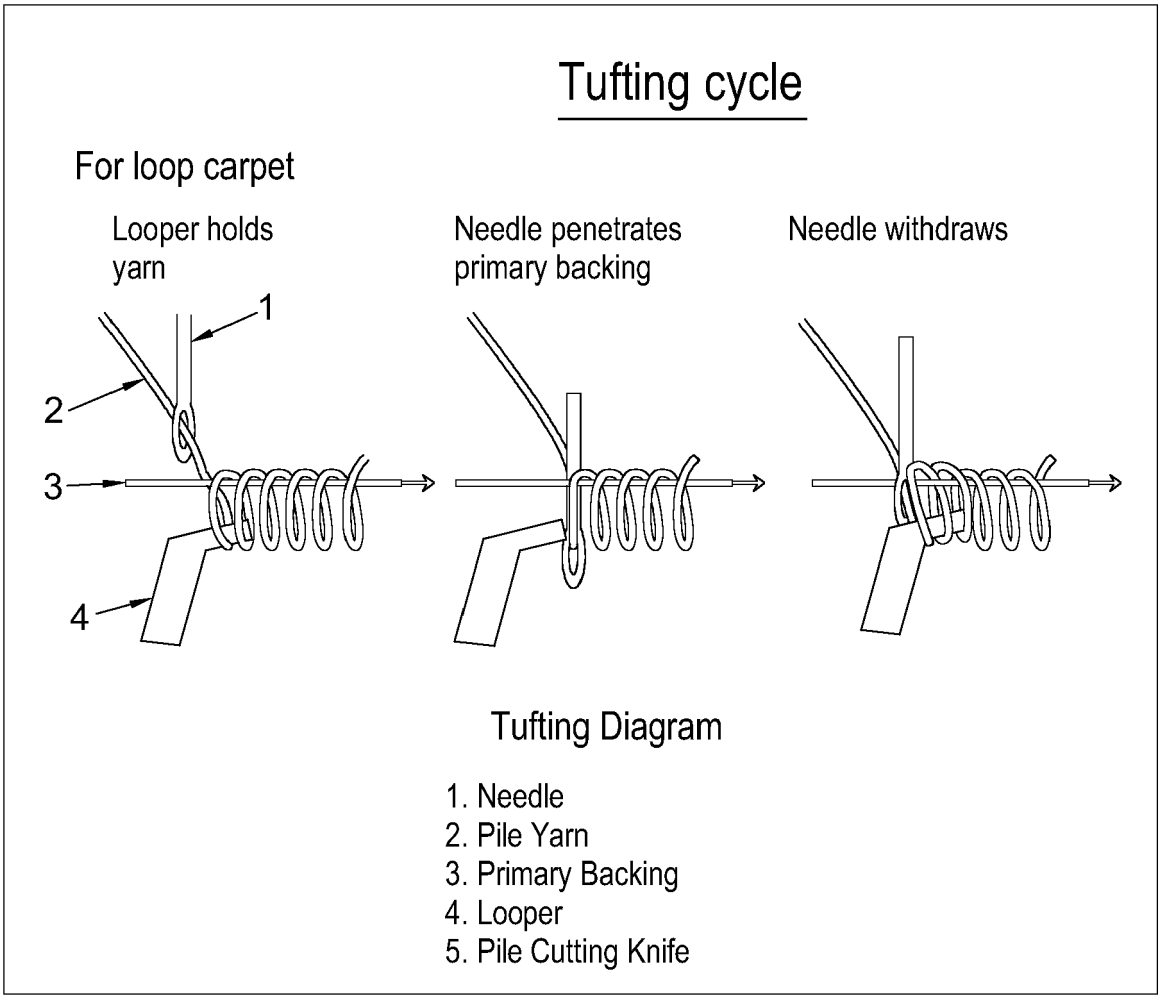
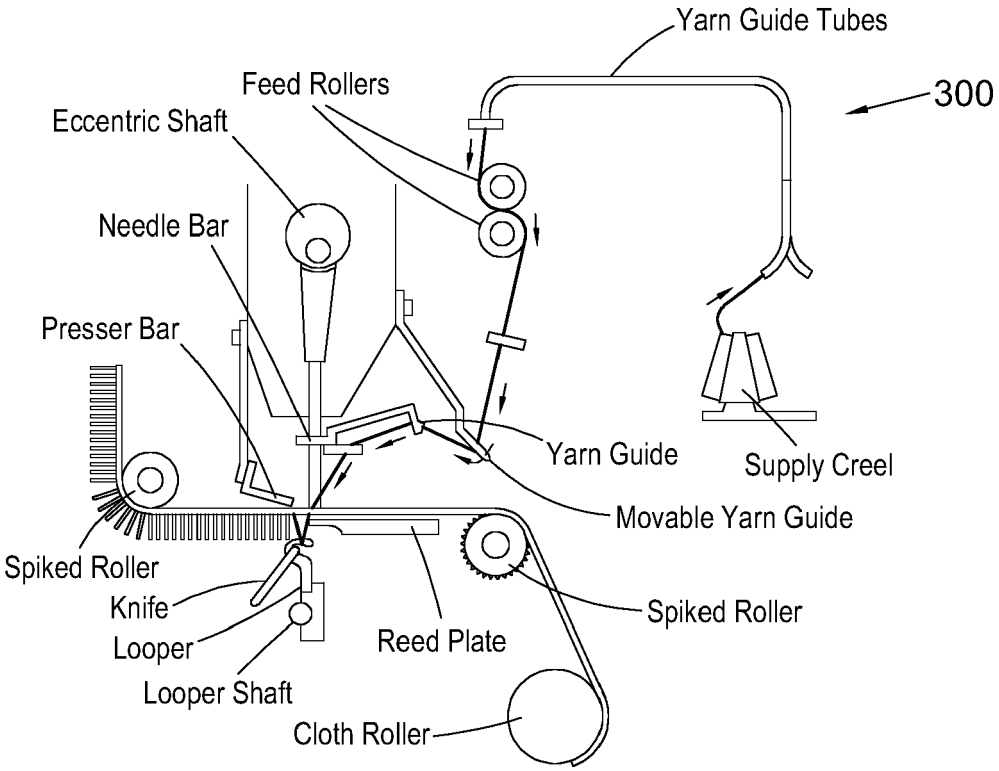

Tufting cycle
For loop carpet
Looper holds yarn
Needle penetrates primary backing
Needle withdraws
1
2
3
4
Tufting Diagram
1. Needle
2. Pile Yarn
3. Primary Backing
4. Looper
5. Pile Cutting Knife

FIG. 3(a)

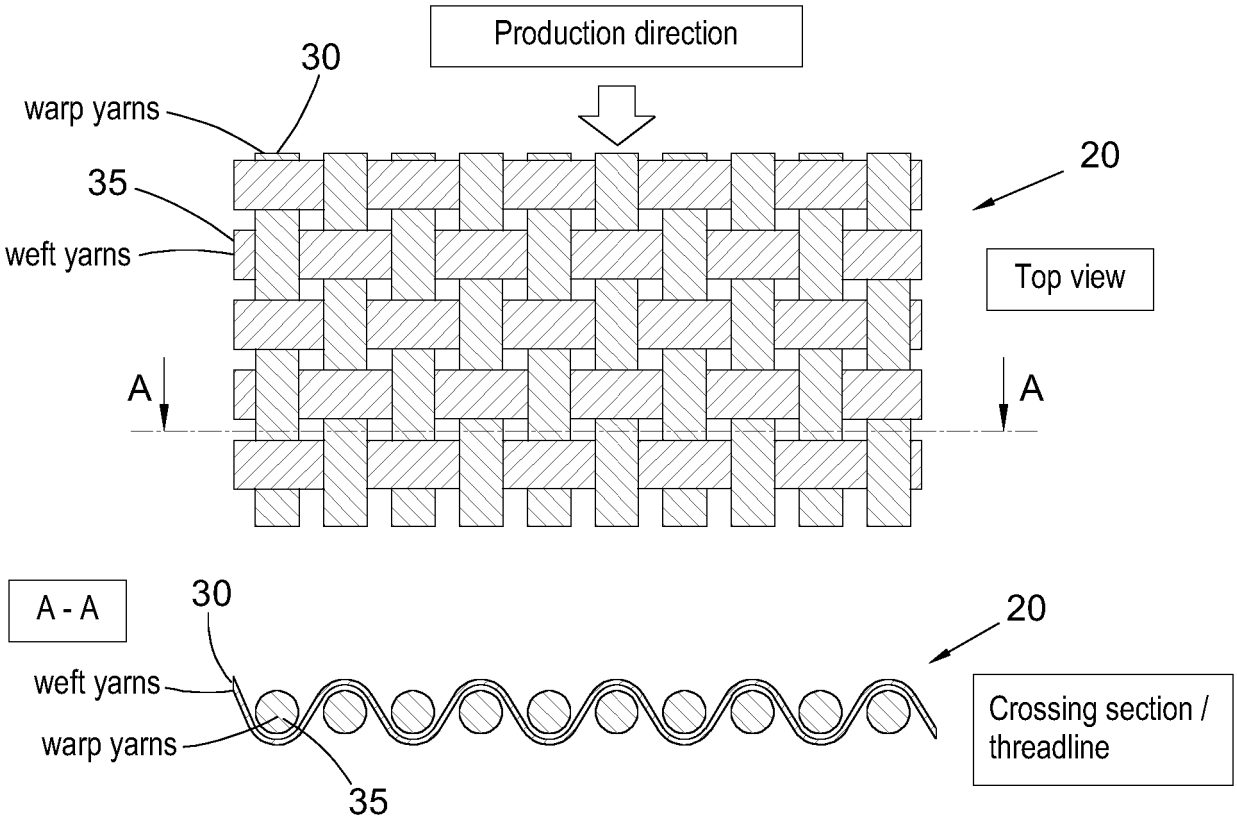
The tufting process

Below, the key steps in the tufting process are indicated



- Yarn comes from cones on creel racks (or from big spools called beams) into the machine
- The primary backing feeds into the machine
- Yarn and primary backing come together in the machine
- Yarn is fed through needles on a needle bar of a tufting machine
- Needles repeatedly penetrate or tuft into the primary backing
- Carpet is rolled onto large rolls for the next step whether it's to be dyed or to be backed)

FIG. 3(b)



Structure of a woven fabric in top view and cross section [4]

FIG. 3(c)

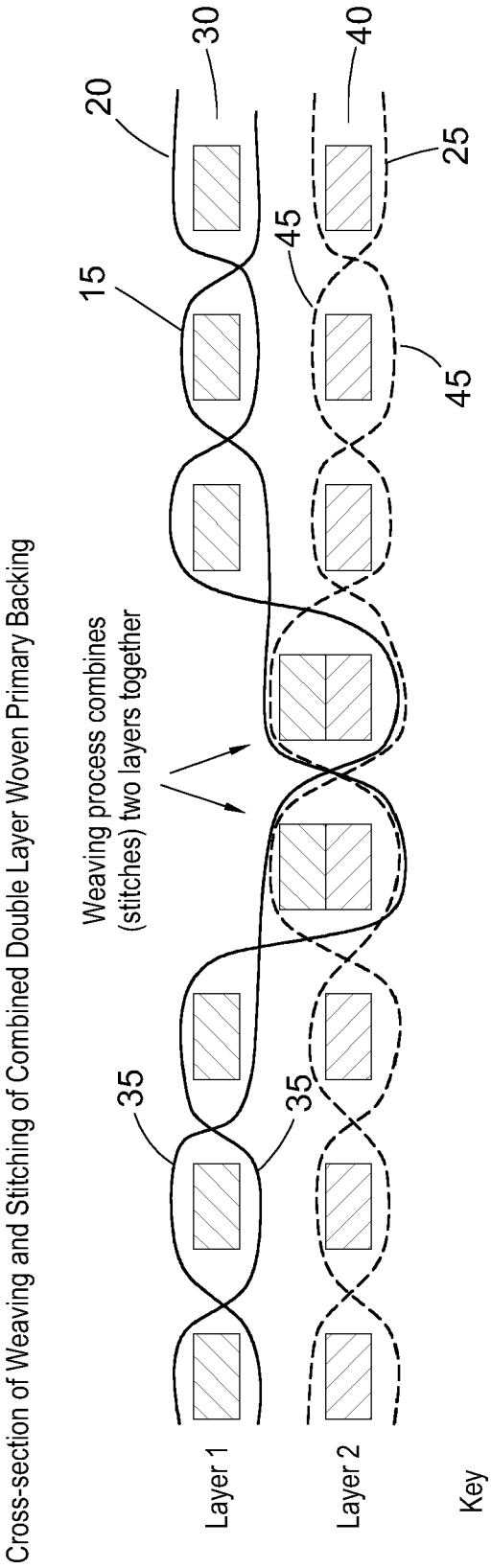

Cross-section of Weaving and Stitching of Combined Double Layer Woven Primary Backing
Weaving process combines (stitches) two layers together
Layer 1
Layer 2
Key
Warp for layer 1
Warp for layer 2
Weft of Layer 1
Weft of Layer 2
15
20
25
30
35
35
40
45
45

FIG. 3(d)

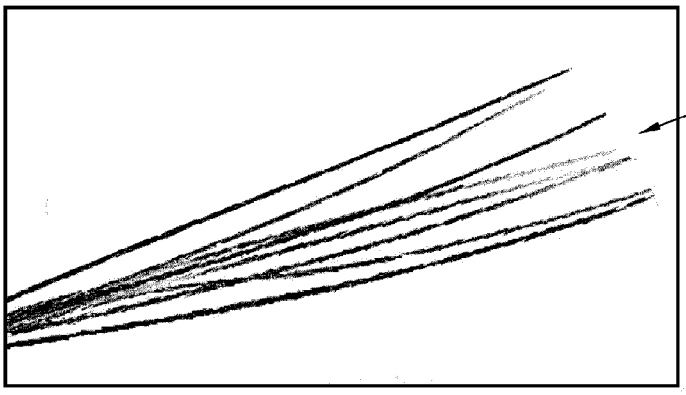


FIG. 4(a)

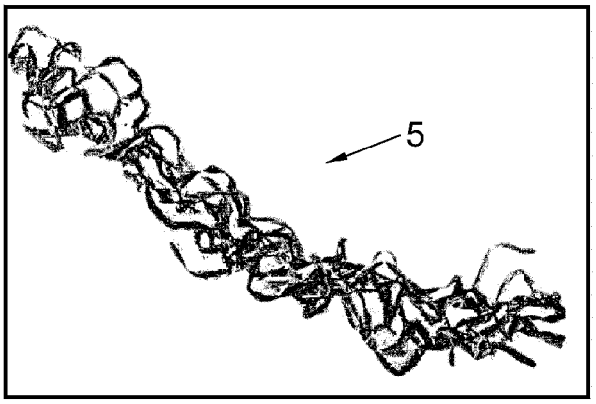


FIG. 4(b)

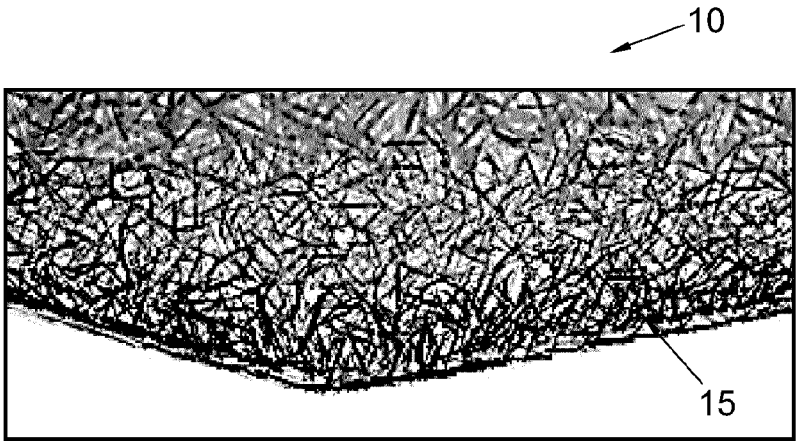


FIG. 5

Name	Hexamethylcyclo-trisiloxane (D3)	Octamethylcyclo-tetrasiloxane (D4)	Decamethylcyclo-pentasiloxane (D5)	Dodecamethylcyclo-hexasiloxane (D6)	Hexamethyldisiloxane (HMDS)
Description		Oily liquid	Oily liquid		Liquid
Melting point °C	64.5	17.5	-38	-3.0	-68
Boiling point °C	134	175	210	245	99.5
Density g/ml		0.9 at 25 °C	0.9593 at 20 °C / 4 °C		0.7638 at 20 °C
Solubility	Water solubility: 1.570 mg/l at 25 °C	Water solubility: 0.9 mg/l at 25 °C	Water solubility: 0.24 mg/l at 25 °C	Water solubility: 0.0051 mg/l at 25 °C	Water solubility: 2 mg/l at 25 °C
Odour threshold		Odourless			
Vapour pressure	3.53 mm Hg at 25 °C (470.6 Pa)	1 mm Hg at 21.7 °C (133.3 Pa)	0.2 mm Hg at 25 °C (26.7 Pa)	0.0225 mm Hg at 25 °C (3.0 Pa)	42 mm Hg at 25 °C (5600 Pa)
Concentration of saturated vapours (20 °C, 760 mmHg)	42,900 mg/m³	16,200 mg/m³	4,050 mg/m³	550 mg/m³	370.000 mg/m³
Conversion factor (20 °C, 760 mmHg)	1 ppm = 9.25 mg/m³ 1 mg/m³ = 0.108 ppm	1 ppm = 12.3 mg/m³ 1 mg/m³ = 0.081 ppm	1 ppm = 15.4 mg/m³ 1 mg/m³ = 0.065 ppm	1 ppm = 18.5 mg/m³ 1 mg/m³ = 0.0541 ppm	1 ppm = 6.75 mg/m³ 1 mg/m³ = 0.148 ppm
Henry's constant	0.064atm-cu m³/mol at 25 °C	0.42 atm-cu m³/mol at 20 °C	0.4 atm-cu m³/mol at 25 °C	0.105 atm-cu m³/mol at 23 °C	4.5 atm-cu m³/mol at 25 °C
$\log P_{octanol\ /\ water}$	4.470	5.1	5.2	6.330	4.2
BCF (L/kg)	1353	12400 (experimental)	5300	39874	900

FIG. 6(a)

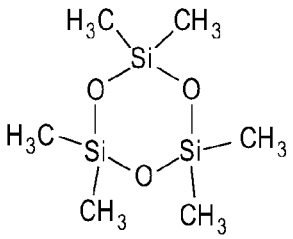
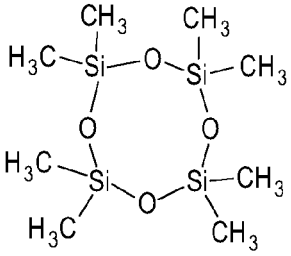
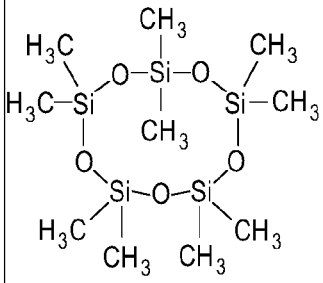
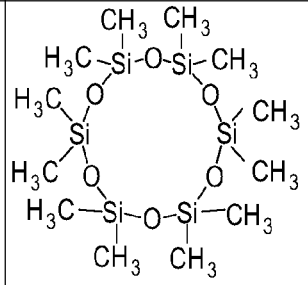
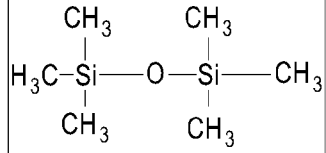
Name	Hexamethylcyclo-trisiloxane (D3)	Octamethylcyclo-tetrasiloxane (D4)	Decamethylcyclo-pentasiloxane (D5)	Dodecamethylcyclo-hexasiloxane (D6)	Hexamethyldisiloxane (HMDS)
Molecular formula	C_6-H_{16}-0_3-Si_3	C_8-H_{24}-0_4-Si_4	C_{10}-H_{30}-0_5-Si_5	C_{12}-H_{36}-0_6-Si_6	C_6-H_{16}-0-Si_2
Structural formula					
Molecular weight	222.46	296.64	370.80	444.93	162.42
CAS-no	541-05-9	556-67-2	541-02-6	540-97-6	107-46-0
Synonyms (among others)	Dimethylsiloxane cyclic trimer	Cyclic dimethylsiloxane tetramer, KF994 Part of Cyclomethicone	Cyclic dimethylsiloxane pentamer, KF995 Dow corning 245 fluid. Part of Cylomethicone	Cyclohexasiloxane	Oxybis(trimethylsilane), Bis(trimethylsilyl)ether

FIG. 6(b)

REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- *CHEMICAL ABSTRACTS,* 556-67-2 **[0029] [0117] [0171]**