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(54) APPARATUS FOR THE PRODUCTION OF PILE SURFACED PRODUCTS

(71) We, IMPERIAL CHEMICAL INDUSTRIES LIMITED, Imperial Chemical House, Millbank, London, SW1P 3JF, a British company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an apparatus for the production of pile surfaced products.

The invention provides apparatus for use in the production of a pile surfaced product comprising a heated roll having a smooth, polished or roughened surface, means for holding a foundation layer against a filament forming composition and the filament forming composition against said heated roll, means for heating said heated roll to a temperature at which the filament forming composition adheres thereto, a guide rod over which the filament forming composition is withdrawn from the heated roll so that filaments are drawn out from the composition and means for cooling the filament forming composition as it is so withdrawn.

Filament forming compositions which may be processed on the apparatus of the invention include addition polymers, for example polymers and copolymers of ethylene, propylene, butadiene, vinyl chloride, vinyl acetate, vinylidene chloride, acrylonitrile and styrene and condensation polymers, for example polyamides and polyesters, e.g. of glycols and aromatic dicarboxylic acids. Blends of filament forming polymeric compositions may be used.

As specific examples of thermoplastic

polymeric compositions that can be processed on the apparatus of the invention we may mention polyethylene, polypropylene, nylon, polyethylene terephthalate and polyvinyl chloride. Such thermoplastic polymeric compositions are preferably used in the form of a sheet; such may be, for example, a continuous film or a perforated web. The thickness of the sheet of polymeric composition is not critical although it will be recognised that generally the use of thicker sheets will yield heavier duty and more expensive products while the thinner ones will be lighter, cheaper and more flexible.

Other thermoplastic compositions which may be processed on the apparatus of the invention include glasses, particularly low melting inorganic oxide glasses, and the term filament forming composition as used herein may be understood to include these, unless otherwise specified.

The foundation layer is fed to the apparatus and bonds to the filament forming composition to provide a backing for the filaments drawn out from the composition. The foundation layer may be of any suitable material or synthetic material, as an example of a natural material we may mention regenerated cellulose (e.g. "Cellophane" Registered Trade Mark). Synthetic materials from which the layer may be made include for example those described above as being suitable for use as the filament forming compositions. It is essential for bonding of the filament forming composition and the foundation layer to occur, at least sufficiently to prevent their separation when the foundation layer and the filament forming composition is withdrawn from the heated roll. Selection of

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the foundation layer and filament forming composition which bond together easily under the operating conditions of our apparatus is therefore desirable. Very smooth surfaced foundation layers are generally less easy to bond than those having a rough, pitted or uneven surface, and a pretreatment to reduce the smoothness of the surface, e.g. by abrasion, can be advantageous.

Examples of porous or perforated foundation layers are woven and unwoven textile webs, which may be of any desired material including metal (although where a synthetic material is used as the foundation layer it may be preferred that it is not softened by the conditions to which it is exposed during the process). It is often convenient to use a woven textile as the web. For example, we have obtained satisfactory results with hessian, cotton net, glass fibre scrim, linen scrim and the like. The layer may also be of paper or other material, e.g. metal, cardboard or paper having holes formed e.g. punched in it. It may also be of expanded metal, expanded plastic or extruded plastics net. Plastics foam sheeting e.g. of polyurethane has been pile surfaced on the apparatus of the invention particularly open celled relatively thin (e.g. 1—5 mm thick) foam although much thicker forms may be treated also. Bonded, unwoven or unbonded, unwoven layers can be used. Bonding of an unbonded, unwoven layer may occur by means of a bonding agent, which may be for example a thermosetting polymer, or even by means of the filament forming composition itself, although care may be needed in the pull-off, until the bonding agent has hardened sufficiently to maintain the integrity of the product.

For convenience hereinafter, the word "web" will be used, unless otherwise specified, to refer to all forms of foundation layer i.e. to continuous sheet surfaces as well as to porous or perforated webs described above.

The apparatus may be such that the filament forming composition is contacted with the web prior to or after contacting the heated roll, or simultaneously therewith as desired and as is convenient. For example the filament forming composition may be supplied in a form other than a homogenous sheet such as in the form of an external layer of a laminate in which the outer layer of the laminate may comprise a filament forming thermoplastic polymeric material while another layer may be, for example, of wear resistant material, e.g. filled plastics or fabric reinforced plastics. Thus a previously formed laminate (in which the laminae may or may not be bonded together) of the layer and a web, sheet or film of the filament

forming composition may be contacted with the heated roll. Alternatively the layer and the filament forming composition may be offered, separately to the heated roll.

The apparatus is preferably capable of "continuous" operation so that extended production runs can be accomplished. Thus, if a backing means is used to hold the layer against the filament forming composition and the composition against the heated roll this backing means which is optionally resilient may be, for example, a conventional pressure roll which may be surfaced with a resilient material, for example, a foam or rubber material having the desired resilience characteristics, and this is the preferred system. However, it is apparent that any endless surface may be employed as the backing means and we may employ a roller or endless belt which in combination with the heated roll, forms the nip to which the filament forming composition and the layer may be supplied continuously and from which the product may be withdrawn continuously. It will be appreciated that a roll or belt having a resilient surface includes rolls and belts made substantially or wholly of resilient material, although these may not be preferred.

We prefer that the means which holds the web and the softened filament forming composition against the heated roll is resilient since this tends to give a product having a well-bonded pile. The resilient means may be a resilient roller or any other suitable pressure-applying means which is preferably at a temperature and/or has surface properties such that the web will not stick to it. (Note that "pressure-applying means" as used herein covers means simply for holding the web and filament forming composition in contact with the heated roll.) By "resilient" in the context of this specification we mean that the pressure-applying surface is not hard and unyielding as is the case, for example, if a steel or ceramic surface pressure roll is employed. Materials having a wide range of resilience or hardness may be employed e.g. up to a shore hardness of 20, 40 or even 70 as measured on a Shore Durometer Type AS (ASTN D676). A minimum hardness is one consistent with the ability to hold the web against the filament forming composition and the heated roll. The resilient material preferably is one having a minimum value of 8 being the load in pounds required to produce an indentation of 0.25 inch in a sheet of the material 1" thick when the material is placed between two square plates each 50 sq. in. in area (see ASTM D1564/64T). We have found that a minimum thickness of resilient material of about 1mm, preferably 2—6 mm is desirable, although the thickness may be increased, with ad-

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vantage, particularly when harder resilient materials are employed. Examples of resilient materials, which in use should be chosen with regard to their ability to withstand the operating conditions, particularly high temperature and repeated compression include silicone rubbers, neoprene rubbers and polyurethane forms. Open or closed cell foams may be used. As examples of natural resilient materials we may mention cork and rubber.

The operating conditions of the apparatus of the invention are such that the softened filament forming composition adheres both to the heated roll and to the foundation layer and, when the layer and the filament forming composition are parted from the heated roll, filaments or tufts of the composition are formed. These filaments or tufts are then hardened by the means for cooling the combination of the foundation layer and the filament forming composition as it is withdrawn from the heated surface. In this way as the layer/heated roll distance is progressively increased the filaments part from the heated roll to form a hardened fibrous or tufted pile on the layer.

The length and form of the filaments or tufts forming the pile is influenced by the rate at which they are hardened (e.g. by the cooling), the temperature of the hot roll and the rate of parting of the layer and filament forming composition and the roll. The mechanical properties of the filaments or tufts will be influenced by the nature of the filament forming composition and the degree to which the filaments or tufts are stretched during the process. Thus, by varying the choice of filament forming composition or layer and of the settings of the apparatus, products having a wide range of properties, texture and appearance may be obtained. We have found it particularly advantageous that the cooling means directs a stream of cooling fluid, preferably a gas, e.g. air, or, where aerial oxidation is likely to prove troublesome, an inert gas such as for example nitrogen, on the filaments or tufts as they are drawn.

The nature of the product depends largely upon the temperature of the drawn filament forming composition at the point in time at which it separates from the heated roll. Thus the degree of retraction of the filament forming composition, is influenced by its temperature at this point. This will, of course, be influenced by the temperature of the heated roll and the temperature, flow rate and direction of any cooling means employed. Where the cooling means is a stream of cooling fluid the flow of coolant may be varied across the width of the product and/or with time, an increase in flow rate tends to reduce the length of the filaments and vice versa. In addition the

distance between the point at which the tufts or the like are produced and the coolant supply means may be varied across the width of the product and/or with time and this technique may be used to alter the nature of the fibres, in particular their curliness. The temperature of the coolant may be varied across the width of the product and/or with time, where this technique is employed we prefer that the coolant supply means take the form of a series of orifices or a slit extending across the width of the product. The effect produced by any of these variables may be further modified by such factors as the directional arrangement of the slit or orifices and their distance from the point of fibre production, but, in general, a series of orifices can if desired, be used to produce products having regular variations of height of pile across the width of the product.

If desired the apparatus may be modified to prevent production of a pile surface in predetermined areas of the product to give a patterned effect. This may be achieved for example by rendering part of the surface of the heated roll non-adhesive to the filament forming composition, e.g. by applying a coating to the said surface to which the filament forming composition does not adhere under the operating conditions employed. As an example, where the filament forming composition is polyethylene, selected areas of the roll surface may be provided with a coating of polyethylene wax, which may easily be removed after use. Alternatively, the surface of the heated roll may be embossed such that some parts are recessed to adjacent parts so that the filament forming composition fails to contact the recessed parts. Another alternate method is to interpose a suitable stencil between the filament forming composition and the heated roll. Such a stencil, of course, would be one to which the filament forming composition does not adhere to a degree sufficient to produce a pile surface on the eventual product.

We have found that it may be advantageous that the means for cooling the combination of the foundation layer and the filament forming composition cools from the side away from the heated roll as the combination emerges from the nip. This cooling from the back may be in addition to, or as an alternative to the cooling by direct impingement of coolant upon the fibrils. The cooling means employed may be, for example, a stream of fluid, preferably gas, especially air or nitrogen, at a temperature below that of the layer, or it may be for example a cooled roller, rod or tube with which the layer makes surface contact, and preferably is slightly tensioned around or

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which provides a local cold environment which is effectively a heat sink. This roller, rod or tube may be the same as the guide rod over which the foundation layer and the filament forming composition are withdrawn from the heated roll. When, however, a fluid is to be employed as the cooling means we have found compressed air, at ambient temperature or lower and at a pressure between 10 lb/sq. in. and 60 lb/sq. in. particularly between 20 and 30 lb/sq. in. to be suitable. As an example of a cooling means of tubular form we may mention a tube suitably of a highly heat conductive material e.g. copper or other metal, through which flows a stream of cooling fluid, which may be a liquid, for example water or a liquified gas, or gas. The temperature of the cooling fluid is chosen to bring about the desired degree of cooling of the layer, having regard to the materials being employed thickness of the layer, rate of throughput of the layer, etc.

Where the cooling means comprises a surface, e.g. the tube or rod disposed across the width of the layer, and preferably at right angles to its direction of travel we prefer that the layer is pulled to effect its removal from the heated surface at a relatively sharp angle — preferably between about 30 and 80°, more preferably between 50 and 75° to the tangent to the surface of the heated roll at the point where it leaves the roll. Back cooling is facilitated by use of this aspect of the invention, but cooling by direct impingement of cooling fluid on the fibres by directing a stream of cooling fluid into the existing nip is the preferred method. Direct impingement of cooling fluid together with back cooling is a particularly appropriate combination.

The invention is now described in more detail with reference to a number of alternative embodiments adapted for continuous operation and with the aid of the accompanying drawing which illustrates diagrammatically in side view an apparatus according to the invention in the drawing 1 is a foundation layer, e.g. a woven fabric for example 'Terylene' (Registered Trade Mark) voile, and 2 is a film of a thermoplastic polymeric composition which is fed into the nip between contra-rotating rolls 3 and 4, preferably at least one of the rolls is driven. The surface of the roll 3 may be of metal if desired but it may be advantageous to use materials of lower thermal conductivity, e.g. stoneware, ceramic, concrete or glass. The surface may be smooth or polished but the use of surfaces that have been roughened, e.g. by abrasion (e.g. to produce a "satin" finish), grinding, shot-blasting or knurling, is not excluded and may be preferred. The film is separated from roll 4 by the layer. Roll 3 is

heated to a temperature at which the filament forming material will adhere to it, the heat being supplied, for example by heating the interior with e.g. steam, electricity or hot oil in conventional manner. Roll 4 has a resilient surface and is preferably maintained at a temperature below the softening point of the polymeric material and, if desired, contains cooling means, e.g. a supply of fluid to the interior of the roll at a suitable temperature, to prevent the polymeric material sticking to it. The use of a non-stick surface on the surface of the roll 4, e.g. a thin layer of polytetrafluoroethylene or silicone, may be desirable. 5 is a nozzle, slotted tube or series of nozzles connected to a suitable supply, by means not shown for projecting a stream or streams of cooling fluid, suitably compressed air, into the out-running nip between the heated roll 3 and the outcoming composite layer and film, to cool the layer and the filaments or tufts at a point before separation of the filaments from the heated surface occurs. The layer is withdrawn from the heated roll 3 over the tube 7, through which is passed a cooling fluid. The tube is disposed at right angles to the direction of travel of the layer and parallel with the axis of roller 3. 6 is a pile surfaced product leaving the nip.

The temperature of the rolls and the temperature and pressure of the coolant fluid will be chosen with regard to the nature of the filament forming composition employed and the type of product (e.g. length and density of the filaments or tufts forming the pile) required, and their selection will present no difficulty to the skilled man. For example, if the composition is a thermoplastic and is too hot it may sag, although this may be avoided by feeding it vertically downwards into the nip. Again, at too high a temperature, degradation may occur unless precautions are taken. Where aerial oxidation is likely a cooling of inert gas, for example nitrogen, helium or carbon dioxide may be employed instead of air, and where very oxygen-sensitive polymers are employed blanketing using nitrogen or another suitable inert gas may be necessary. If the film is not hot enough the pile may be of poor quality or discontinuous in nature.

The temperature of the hot surface affects the nature of the fibrous or tufted surfaces of the product. Thus, if the composition is a thermoplastic polymer as the temperature of the roll is increased above that at which individual filaments or tufts are formed in substantially regular and dense fashion, more of the polymer tends to stick to it leading initially to the fusion of the tops of adjacent filaments or tufts and the subsequent production of a more or less continuous surface over irregular areas and

at very high temperatures, some of the thermoplastic may remain stuck to the roll thus spoiling the surface. On the other hand, if the roll is too cool, the filament or tuft formation may become sparse and irregular.

The temperature of the other (or backing) roll or surface is less critical but when the web is porous it has either to be cool enough to prevent any polymer sticking to it but not so cool as to unduly increase the viscosity of the plastics and prevent its penetration of the layer and/or it has to be rendered non-stick either by being itself of inherently non-stick material or by having a coating of non-stick material, e.g. 'Fluon' (Registered Trade Mark) or a silicone.

Attention is drawn to our cognate Application Nos. 55241/70 (Serial No. 1378638), 55242/70; 61326/70 and 61325/70 from which this is divided as in our Cognate Application 21307/74 (Serial No. 1378639), 21308/74; 21309/74 and 21310/74 to which attention is also drawn.

We are aware of United States Specification 3390403 which discloses an apparatus for pile formation containing a roller into specially shaped small openings each having a neck which restricts the flow of polymer into a cavity beyond the neck restriction. We make no claim to such an apparatus.

WHAT WE CLAIM IS:—

1. Apparatus for the production of a pile surfaced product comprising a heated roll having a smooth, polished or roughened surface, means for holding a foundation layer against a filament forming composition and the filament forming composition against said heated roll means for heating said heated roll to a temperature at which the filament forming composition adheres thereto, a guide rod over which the filament forming composition is withdrawn from the heated roll so that filaments are drawn out from the composition and means for cooling the filament forming composition as it is so withdrawn.

2. An apparatus according to claim 1 in which the means for holding the filament forming composition against the heated roll is resilient.

3. An apparatus according to claim 2 in which the resilient means comprises a cooled roller covered with a resilient coating.

4. An apparatus according to any one of the preceding claims in which the surface of the means for holding the filament forming composition against the heated roll is coated with a non-stick coating.

5. An apparatus according to any one of the preceding claims in which the means for cooling is situated on the side of the filament forming composition distant from the heated roll.

6. An apparatus according to any of the preceding claims in which the guide rod is cooled.

7. An apparatus according to any of the preceding claims in which the means for cooling comprises means for directing a stream of fluid at the side of the filament forming composition away from the heated roll.

8. An apparatus according to claim 7 in which the means directs a stream of gas at a pressure between 10 lb/sq. in. and 60 lb/sq. in.

9. An apparatus according to any of the preceding claims in which the surface of the heated roll has a satin finish.

10. An apparatus according to any one of the preceding claims in which the surface of the heated roll is coated with a non-stick coating.

11. An apparatus according to any of the preceding claims in which part of the surface of the heated roll is rendered non-adhesive to the filament forming composition.

12. Apparatus substantially as hereinbefore described with particular reference to the accompanying drawing.

P. C. BAWDEN,

Agent for the Applicants.

at very high temperatures, some of the thermoplastic may remain stuck to the roll thus spoiling the surface. On the other hand, if the roll is too cool, the filament or tuft formation may become sparse and irregular.

The temperature of the other (or backing) roll or surface is less critical but when the web is porous it has either to be cool enough to prevent any polymer sticking to it but not so cool as to unduly increase the viscosity of the plastics and prevent its penetration of the layer and/or it has to be rendered non-stick either by being itself of inherently non-stick material or by having a coating of non-stick material, e.g. 'Fluon' (Registered Trade Mark) or a silicone.

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We are aware of United States Specification 3390403 which discloses an apparatus for pile formation containing a roller into specially shaped small openings each having a neck which restricts the flow of polymer into a cavity beyond the neck restriction. We make no claim to such an apparatus.

WHAT WE CLAIM IS:—

1. Apparatus for the production of a pile surfaced product comprising a heated roll having a smooth, polished or roughened surface, means for holding a foundation layer against a filament forming composition and the filament forming composition against said heated roll means for heating said heated roll to a temperature at which the filament forming composition adheres thereto, a guide rod over which the filament forming composition is withdrawn from the heated roll so that filaments are drawn out from the composition and means for cooling the filament forming composition as it is so withdrawn.

2. An apparatus according to claim 1 in which the means for holding the filament forming composition against the heated roll is resilient.

3. An apparatus according to claim 2 in which the resilient means comprises a cooled roller covered with a resilient coating.

4. An apparatus according to any one of the preceding claims in which the surface of the means for holding the filament forming composition against the heated roll is coated with a non-stick coating.

5. An apparatus according to any one of the preceding claims in which the means for cooling is situated on the side of the filament forming composition distant from the heated roll.

6. An apparatus according to any of the preceding claims in which the guide rod is cooled.

7. An apparatus according to any of the preceding claims in which the means for cooling comprises means for directing a stream of fluid at the side of the filament forming composition away from the heated roll.

8. An apparatus according to claim 7 in which the means directs a stream of gas at a pressure between 10 lb/sq. in. and 60 lb/sq. in.

9. An apparatus according to any of the preceding claims in which the surface of the heated roll has a satin finish.

10. An apparatus according to any one of the preceding claims in which the surface of the heated roll is coated with a non-stick coating.

11. An apparatus according to any of the preceding claims in which part of the surface of the heated roll is rendered non-adhesive to the filament forming composition.

12. Apparatus substantially as hereinbefore described with particular reference to the accompanying drawing.

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