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METHOD FOR FORMING MOLDED ARTICLES

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This invention is directed to a method for molding textiles into a variety of useful articles. More particularly, the present invention relates to a method for forming three-dimensional articles having flexibility and durable shape retention from textile materials and to such articles.

For purposes of clarity, it is to be understood that the term "textile material" is used herein in a broad and generic sense. The term is intended to include animal, vegetable and synthetic fibers, filaments, etc. in woven, knitted and non-woven form. It is also to include related materials ordinarily used in conjunction with textile materials; such related materials are foam materials including polyurethanes, vinyls, rubber, etc.

As is well known in the art, considerable attention has been given througout the last score of years to methods and techniques for molding textiles. The molding, forming. or shaping of textiles has generally been accomplished by either pneumatic or mechanical methods. Pneumatic methods involve the use of a differential or air pressure generally created by a vacuum. Mechanical methods generally involve the use of a solid tool or mold which may be moving or stationary or a combination of both.

In order to mold a textile or fabric successfully, it must have certain basic properties. It should have the ability to stretch when hot. This is a basic characteristic of thermoplastic textiles which relates to temperature, methods of heating, methods of stretching or forming, the type of mold material, and the methods of cooling the mold. Some fabrics have the ability to be drawn as little as 20%, while other fabrics can be drawn as much as 500 and 600%, over the original area.

Another important characteristic is hot strength of a textile. While some materials are almost putty-like and respond to a minimum of pressure in such a way as to faithfully record every detail of the mold, other fabrics show a strong resistance which necessitates heavier equipment and tools. This hot strength property is somewhat related to hot elongation characteristics, although not the same. It has been found, for example, that the relative difference of pressure available in vacuum methods may not be sufficient to provide some of the desired mold details when using fabrics of high hot strength.

The forming temperature at which a fabric will mold and hold its shape upon cooling and forming temperature range of a textile or fabric are important factors. Each material has its own forming temperature or temperature range which can be wide or narrow, within which it can be most effectively molded. Some fabrics may be formed in a range from 280 to 450° F. Others may be formed at 350° F. but melt at 400° F. Some fabrics may mold well at a given temperature, but tear apart if heated just a few degrees higher. Therefore, the method of heating and the controls placed upon it become highly important.

In prior art methods for forming of textiles, it has generally been necessary to treat or impregnate a textile with a suitable composition and then form the textile into the configuration desired and, then after forming, to cure the material impregnated with the textile under certain conditions of time and temperature. Fabrics of high (50% or more) cellulosic content cannot be molded without some type of pre-treatment of the fabric. For example, cottons and viscose rayons do not have thermoplastic properties found in synthetic fibers such as polyamides and acrylics.

These cellulosic fabrics, therefore, must be treated chemically in such a way as to accomplish a cure or set of the fabric during the molding operation. It means the application of a special fabric finish prior to molding. There has been a need, therefore, to rapidly form a desired product in a single forming and curing operation. The present invention is directed to meeting this need.

It is an object of this invention to impart moldability to any textile material or textile fibrous structure, without the necessity for special chemical finishes intended for, and prior to, molding. It is a further object of the invention to form from a textile material molded articles which are flexible and of durable shape retention. A further object of the invention is to mold bra cups, full breast fronts and brassieres, as well as other articles, from textile materials which hitherto could not be molded into such products without a chemical treatment or special finish. Another object is to form liners or covering shells on bust pads or similar products. Still another object is to mold bra cups, full breast fronts, brassieres, etc. from non-thermoplastic textile materials. Still another object of the invention is to provide as new articles of manufacture, three-dimensional articles having flexibility and durable shape retention. Still other objects of the invention will appear from the following description.

Broadly stated, according to the present invention, the foregoing objects are realized by a method of forming from a textile material three-dimensional articles which are flexible and of durable shape retention, the method comprising:

(a) Bringing together in layered relationship a layer of a textile material and a layer of a flexible thermoplastic material, the latter having a thickness of from about 0.0005 to about 0.004 inch, and preferably from about 0.001 to about 0.0015 inch, and

(b) compression molding the layered materials of (a) in three-dimensional configuration, at a temperature of at least the melt point of said thermoplastic material and below the melt point of said textile material.

A particular embodiment of the invention involves disposing a layer of the thermoplastic material between two layers of the textile material.

It is also contemplated that the textile material can serve as the exposed surface or the unexposed surface of the article produced in accordance with the method of this invention.

As indicated in (b) above, compression molding is a feature of this invention and is described in U.S. Patent No. 3,058,154 and copending application Ser. No. 156,021 which set forth the techniques of "hot molding" and "cold molding," respectively.

In the hot mold technique, the textile material remains cold and passes between the heated molds after which the male moves through the plane of the material or fabric. In cold molding, the textile materials is heated and presented between a pair of matched cold molds at which time the male mold moves into and through the plane of the fabric. It is to be understood that compression molding as contemplated herein includes both techniques of cold molding and hot molding.

The textile materials useful herein are of a wide variety, and have extensibility and elongation characteristics. They can be natural fibers of animal origin, representative of which are: fur, rabbit hair, wool (including extract, reprocessed, reused, etc.), and worsted. Natural vegetable fibers are also contemplated herein and include such typical materials as: cotton, flax linen, hemp, jute, kenaf, pineapple fiber, ramie, sisal, and straw. Mineral fibers, which do not burn, can also be used and include such materials as asbestos, glass fibers, spun glass. Modified natural fibers are also contemplated and are illustrated by

cyanoethylated cotton, mercerized cotton, non-shrinkable wool. Representatives of the synthetic textiles useful herein are Vinyon-N, Saran, nylon, Orlon, Dacron, Teflon and Ivalon. Vinyon-N is a resin manufactured by the Carbide and Carbon Corporation, by copolymerization of vinyl chloride and acrylonitrile. Saran is a vinylchloride polymer manufactured by the Dow Chemical Company. Nylon is a polyamide resin made by polymerization of the hexamethylene diamine salt of adipic acid. Orlon is a synthetic fiber made from polyacrylonitrile. Dacron is a synthetic fiber made by terephthalic acid and ethylene glycol. Teflon is a tetrafluoroethylene polymer. Polyolefins are also useful herein and are represented by polyethylene and polypropylene.

It is to be understood that the textile materials or fabrics useful herein can be woven, non-woven, knitted, etc. The textile materials are those given above and include as well foam structures of polyurethane, vinyls and rubber, laminated or combined with fabrics containing fibers and yarns of cotton, wool, viscose, rayon acetate, polyester fibers, polyamide fibers, acrylonitrile fibers, polyolefin fibers, and various interblends of the same fibers in fabric form.

This invention is designed to utilize the elastic and extensibility characteristics of textile materials as well as of some elastomeric foam structures. The molding technique used herein makes possible three-dimensional shapes from a two-dimensional plane of fabrics, with a resulting increase in fabric area over that of the original area of the plane of the fabric. Thus, fibers, yarns, and fabrics are drawn according to this process to varying degrees.

A flexible thermoplastic material, a material capable of being repeatedly softened by increase in temperature and hardened by decrease in temperature, is used herein in the form of a film or sheet with one or more of the textile materials mentioned above. The change upon heating of such a material is substantially physical rather than chemical. Representative thermoplastic materials are polymers or copolymers of methyl acrylate, ethyl acrylate, etc., copolymerized with styrene or acrylonitrile, or latex, etc. Other thermoplastic materials include polyvinyl alcohol, polyvinyl acetate, hydroxy ethyl cellulose, cellulose acetate, polyvinyl butyral, carboxymethyl cellulose, cellulose mixed esters such as cellulose acetate propionate and cellulose acetate butyrate, casein-formaldehyde, alkyd resins of thermoplastic character, vinyl chloride, vinyl-chloroacetate, polyvinyl chloracetates, polystyrene, polyethylene, polypropylene, etc.

While it is preferred that a film or sheet of thermoplastic material be used herein, the same material in powder or granule form can be applied, as by spraying, to the surface of the textile material.

Preferred thermoplastic films for forming bra cups, full breast fronts and brassieres, for example, are polyethylene and copolymers of polyethylene and latex. In general, the thermoplastic material should be sufficiently flexible as to be readily deformed without being subjected to temperature or pressure variation.

Although wearing apparel such as breast coverings mentioned above constitute a preferred embodiment of this invention, it is to be understood that other three-dimensional articles can be formed in accordance with the method described herein. Among such other articles are: blouses, swimsuits, hats, handbags, fabric cases, containers, casket liners, liners for other purposes such as preformed bra cups, etc. Therefore, thermoplastic films and textile materials selected from those defined above will be used preferentially depending upon the articles to be formed. For example, preferred thermoplastic films for forming headwear include ethyl acrylate copolymerized with acrylonitrile.

One essential feature of the thermoplastic film is thickness, which should be at least about 0.0005 inch and not more than about 0.004 inch. If less than about 0.0005 inch, adhesion or bonding may be insufficient. And if more than about 0.004 inch in thickness, it has been found that its film characteristics are not uniformly destroyed in the new method with the result that portions or islands of the film remain in the finished article and make for irregular textile surfaces. Preferably, the film should vary from about 0.001 to about 0.0015 inch in thickness.

Typical thermoplastic materials for use herein are the following:

Type of Thermoplastic Material	Specific Gravity	Elongation, Percent
Acrylonitrile Styrene Copolymer	1.08–1.09	20–60
Cellulose Acetate	1.28–1.31	25–45
Cellulose Triacetate	1.28–1.31	10–40
Cellulose Acetate Butyrate	1.19–1.22	40–100
Cellulose Nitrate	1.42–1.46	30–40
Ethyl-Cellulose	1.14–1.16	25–40
Polyamide (Nylon)	1.08–1.14	Orients
Polytri-Fluorochloro-Ethylene	2.1–2.2	90–300
Polymethyl Methacrylate	1.18–1.19	4–12
Polyethylene:		
Low density	0.910–0.925	200–800
Medium Density	0.926–0.940	50–650
High Density	0.941–0.965	10–650
Polyvinyl Fluoride	1.37	100–190
Polypropylene	0.885–0.9	Over 200
Polyester (P-terephthalate) e.g., Mylar	1.38–1.395	100; 50 (Type T)
Polytetra-Fluro-Ethylene	2.1–2.2	100–350
Poly-Carbonate	1.20	85–110
Polystyrene	1.05–1.06	3–20
Polyvinyl Alcohol	1.21–1.31	180–600
Polyvinyl Chloride:		
Rigid	1.35–1.45	25
Nonrigid	1.20–1.45	150–500
Vinyl Chloride-Acetate Copolymers:		
Rigid	1.30–1.59	2–10
Nonrigid	1.20–1.45	150–500
Vinylidene Chloride-Vinyl Chloride Copolymer	1.20–1.68	20–140
Regenerated Cellulose (Cellophane)	1.40–1.50	10–50
Rubber Hydrochloride	1.11	200–800
Vinyl Nitrile Rubber	1.18–1.21	250–500

Another critical feature of the new method is the temperature of the molding operation. This should be related to the textile material and to the thermoplastic material and to the thermoplastic material selected. More specifically, the temperature should be below the melt point or combustion temperature of the textile material, and preferably between about 10° F. and about 50° F. below such temperature. In addition, the molding temperature should be at least as high as the melt point of the thermoplastic temperature but below the decomposition temperature thereof. Thus, the molding temperature used is dependent upon the foregoing temperature characteristics of the textile and thermoplastic materials. Related to molding temperature, too, is the time during which the layers are so molded. In general, molding time will range from about 15 seconds to about 3 minutes.

One essential feature of the invention is that in the compression molding operation there is concurrent cure of the textile and thermoplastic material deposited thereon. There is no need for a further operation whereby the cure occurs over another time interval under specified temperature conditions, as with previous techniques for molding textiles.

A fabric or textile associated with a thermoplastic material can be molded to the desired three-dimensional configuration utilizing cold molding techniques. Accordingly, the materials are heated to a suitable temperature for a few seconds and are then placed between the cold male and female molds or dies. The time-temperature relationship of cold molding techniques can be varied as with hot molding techniques, but differs in that the materials are heated and the molds are cold. By way of illustration, two layers of cotton with a film of polyethylene there between are heated to a temperature of from about 290° F. to about 320° F. for about 15 to about 30 seconds, and then compressed into shape between the male and female molds.

One embodiment of the invention is the compression molding of layers of textile and thermoplastic material utilizing hot molding techniques as described in the afore-

mentioned U.S. Patent No. 3,058,154. Accordingly, the layers are placed on a suitable frame having a peripherally disposed V-shaped notch and positioned intermediate complementary male and female molds. The top assembly, including the female mold, is lowered to a position whereby a holding-down bar of the top assembly, having a plurality of spaced teeth extending into the V-shaped notch of the frame to hold the layers securely in place. The bottom assembly, including the male mold, is then raised causing the male mold to pass through the plane of the layers and the male and female molds are maintained in closed position for the time necessary to effect the forming of the desired article. The male and female molds are heated to the desired temperature by electrically heated wires or rods associated with plates upon which the molds are mounted. The female mold includes a groove extending around the periphery of the product piece, while the male mold includes a complementary lip which extends into the groove of the female mold when the molds are compressed, and help to hold the layers within the working portions of the mold against movement of the layers during the molding operation.

In another embodiment of the invention, layers of textile material and thermoplastic material are subjected to compression molding utilizing cold molding techniques as set forth in copending application Ser. No. 156,021, filed Nov. 30, 1961. Accordingly, the layers are stretched across a frame in a substantially taut condition. A heating rack, including heating coils or other suitable means, is positioned above the layers and the heating coils energized to heat the layers. When the layers have been sufficiently heated, the heating rack is withdrawn and the mounting plate and male mold are raised, together with the frame, to a position where the frame is halted from further movement at which point the male mold comes in contact with the layers positioned within the frame. The male mold is further raised to a position whereby the male mold fully engages the female mold with the layers therebetween and such molds are retained in closed position for a predetermined length of time to effect the forming of the desired article.

Following the hot molding or cold molding techniques set forth above, molded three-dimensional pieces are formed which are subsequently trimmed and finished to form products which are flexible and of durable shape retention. Further, these techniques substantially minimize distortion of the desired configuration of the products by firmly holding the layers of textile and thermoplastic materials in position within the molding machine during the molding operation. The products formed exhibit heretofore unattained qualities of recoverability. The products formed in this manner can be rolled in a tube, marketed, and quickly pushed back into shape without wrinkles, distortion, or loss of fit.

Typical illustrations of the method contemplated herein are given in the following examples.

EXAMPLE 1

A film of polyethylene having a thickness of 0.001 inch is disposed between two layers of cotton cloth. The layered materials are then molded into bra cups at a temperature of about 300° F. (mold temperature) for 5 to 60 seconds, in a hot molding technique. The bra cups released from the molds are flexible, retain their shape when distorted, and have smooth surfaces such that are not uncomfortable when worn. The two layers of cotton are firmly bound one to the other.

Similar articles can be formed from the same materials by selecting a temperature of about 270° F. and retaining the layers in the molds for one to two minutes; or by using a temperature of about 325° F. for about 12 to 15 seconds.

EXAMPLE 2

A film of polyethylene having a thickness of 0.0015 inch is disposed between a layer of acrylic cloth and an acetate tricot fabric. The layered material is exposed to temperature of 300° F. for 15 seconds, and compressed between sets of cold bra molds, (a cold molding technique). The layers are firmly bonded, retain their molded shape, and are flexible and durable.

EXAMPLE 3

An array of 5 layers of material consisting of the following consecutive layers: acetate tricot, polyethylene film 0.0015 inch, polyurethane foam (1/16–1/2 inches thick), polyethylene film 0.0015 inch thick, and acetate tricot fabric; is placed between hot male and female molds and compressed at a temperature of 325–340° F. for a period of 1 to 3 minutes depending on the thickness of the polyurethane foam. This produces molded polyurethane foam cups lined and covered top and bottom. Such cups are resilient, soft, and durable in shape. Depending on the covering material (and lining material) molded cups can be produced which can readily be put into a brassiere frame by the manufacturer. These cups, in this example, represent a completely shaped cup which requires no further operation other than sewing it into the frame of the garment.

EXAMPLE 4

Preformed bra cups can be lined and/or covered by this process. Preformed cups can be a scooped shell of polyurethane foam, a cut and sewn shell, or a molded rubber cup. These cups are placed in female molds. A layer of polypropylene or polyethylene film 0.0015 inch thick and a layer of acetate tricot are placed over the cups in the mold. Heated male molds at 300° F.–340° F. are compressed to the female molds at 200° F. passing through the plane of the acetate and film, for a period of 20–40 seconds. This produces a smooth, integral lining of the preformed cup. To cover the cups, the process is reversed. Namely, the preformed cups (which may now be lined) are placed over male molds at 200° F. and passed through layers of film and acetate tricot into a hot female mold of 300° F. to 340° F. for the same time period.

Obviously, high production rates are realized with the present invention since layers of textile material and thermoplastic material can be fed directly into molding equipment from banks or creels of such layers in full width without need to cut the fabric into smaller pieces. Multiple molds in banks can be used. Many conventional manufacturing steps such as pattern cutting, sewing of a plurality of seams, etc. are eliminated with the method contemplated herein.

Configurations sought in the desired articles can be obtained by changing molds of the molding equipment.

This invention makes possible moldability of fabrics of synthetic fiber content by minimizing or eliminating its creep characteristics. It also makes possible molding of natural fibers in a manner by which they can retain a durably molded shape as well as the properties attendent to fabric handle, shape, softness, or firmness. Any blend level of synthetic and natural fiber can be molded. According to molding techniques hitherto available, blends containing less than 80% of synthetic fiber were unsatisfactory in molding operations. Some fabrics of 100% synthetic fiber content, for example polyacrylonitrile, molded well but had no shape retention in laundering. When treated by the process of this invention and molded, the same fabrics have extremely good shape durability. Thus, 100% synthetic textiles or high percentage blends of synthetic fibers can be used in the process of this invention. The natural fibers, viscose rayons, acetate rayons, etc. previously could be "pressed-into-shape" only after heavy resinating treatments which had a tendency to tender the fabric, wash out easily in laundering or upon exposure to water, and/or lose its textile fabric characteristics. Such fabrics, including cottons, wools,

linens, jute, hemp, etc., can be readily molded according to this invention.

The invention makes possible a precision of product manufacturing which is repetitive and unaffected by variations inherent in conventional cut and sewn products.

The invention enables production of molded products without excessive cost increases due to higher priced materials, since conventional fabrics can be used. Furthermore, materials such as soft, knitted textile fabrics which do not lend themselves to conventional construction or manufacture can now be made to meet satisfactory end product requirements.

While the invention has been described in detail according to preferred processes and articles, it will be obvious to those skilled in the art, that changes and modifications can be made (without departing from the spirit or scope of the invention) and it is intended in the appended claims to cover such changes and modifications.

I claim:

1. The method of forming a shaped three-dimensional article having flexibility and durable shape retention, from a textile material, which comprises:

(a) bringing together in layered relationship a layer of deformable textile material and a layer of a deflexible thermoplastic material, the latter having a thickness of from about 0.0005 to about 0.004 inch;

(b) applying heat to the layered materials of (a) at a temperature of at least the melt point of said thermoplastic material and below the melt point of said textile material, whereby said layer of thermoplastic material is melted so as to completely lose its integrity across its entire surface and to flow into and become a part of said textile material; and

(c) applying pressure to said layered material in a compression mold simultaneously with the application of said heat to form said materials into a permanent three-dimensional configuration, said layers being merged, molded and set simultaneously during said molding operation.

2. The method of claim **1**, wherein a layer of said thermoplastic material is disposed between two layers of said textile material, said layer of thermoplastic material being melted and merged into both of said layers of textile material, said layers of textile material being bonded to each other by said melted thermoplastic material simultaneously with the molding and setting of said material.

3. The method of claim **1** wherein an array of five layers of material is compression molded at a temperature between about 325° F. and about 340° F. for a period of time from about 1 to about 3 minutes, said array comprising consecutive layers of: acetate tricot, polyethylene film of about 0.0015 inch thickness, polyurethane foam of about 0.06 to about 0.5 inch thickness, polyethylene film of about 0.0015 inch thickness, and acetate tricot fabric.

4. The method of claim **1** wherein a surface of a preformed bra cup is covered with a layer of polyolefin film of about 0.0015 inch thickness and the latter with a layer of acetate tricot, wherein the said materials are compression molded at a temperature from about 300° F. to about 340° F. for a period of time from about 20 to about 40 seconds, wherein the other surface is so covered and so compression molded.

5. The method of claim **2** wherein the textile material comprises two layers of cotton cloth having disposed therebetween a layer of polyethylene of about 0.001 thickness, and wherein the said materials are molded into bra cups at a temperature of about 300° F. for 5 to 60 seconds.

6. The method of claim **2** wherein a film of polyethylene having a thickness of about 0.0015 inch is disposed between a layer of arcylic cloth and a layer of acetate tricot fabric, and wherein the said materials are compression molded at a temperature of about 300° F. for about 15 seconds.

7. The method of claim **1** wherein said textile material is cotton.

8. The method of claim **1** wherein said thermoplastic material is polyethylene.

9. The method of claim **1** wherein the article is a brassiere cup.

10. The method of claim **1** wherein the article is a brassiere.

11. The method of claim **1** wherein the article is a breast front.

12. The method of claim **1** wherein a preformed breast garment is covered, substantially retaining its preformed shape, by bringing together in layered relationship the surface of said garment and said layer of textile material and said layer of said flexible thermoplastic material.

13. The method of claim **12** wherein the preformed breast garment is a brassiere cup.

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