MOLDING PROCESS USING POLYPROPYLENE STRANDS AND FABRIC FIBERS TO PRODUCE ARTICLE

Strands of scrap polypropylene and scrap non-melting fabric fibers are mixed together to form a mat. In one mode the mixing involves air-laying the strands and fibers (10, 20) and needle-punching (12, 22) the air-laid mass. The mat is then heated (14, 24) to the melting point of the polypropylene. The heated mat is placed in a cold die for molding (16, 26) to impart a desired shape to a resultant article (36, 40, 46) and wherein the molten polypropylene substantially encapsulates the non-melting fibers. The degree of rigidity of the resultant article (36, 40, 46) is controllable by such factors as the degree of pressure applied during the molding operation (16, 26) and whether one or both sides of the mat are subjected to heating. Additionally, by selectively controlling the pressure applied, articles of variable thickness and/or variable density may be easily and conveniently fabricated. The desired shape of the mold is imparted to the resultant article (36, 40, 46) which, preferably being constituted essentially entirely of scrap materials form other processes, is inexpensive to produce.
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MOLDING PROCESS USING POLYPROPYLENE STRANDS AND FABRIC FIBERS TO PRODUCE ARTICLE

Cross Reference to Related Applications
This is a continuation-in-part of U.S. Patent Application Serial Number 171,367, filed March 21, 1988, which in turn is a continuation-in-part of U.S. Patent Application Serial Number 07/052,324, filed May 21, 1987.

Background and Summary of the Invention
This invention relates generally to the formation of molded articles from a mat formed from a mixture of thermoformable materials such as polypropylene and other reinforcing materials such as nonmelting fabric fibers and more specifically to the use of scrap materials in connection therewith.

It is known in the prior art, such as in U.S. Patent 4,359,132 to Parker et al. and U.S. Patent 4,568,581 to Peoples, that two or more thermoplastic fibers can be blended together and heated. Under heat and pressure, these fibers mechanically interlock or fuse together at contact points whereby the blend of fibers becomes an article having a desired shape. Since the article relies on mechanical interlocking to acquire its shape, the article is not dense. Moreover, the mechanical interlocking of fibers permits molding of the article only into relatively simple shapes.

Raw materials typically utilized to produce various types of molded rigid articles can be costly. No one has heretofore developed an effective molding process for utilizing scrap or waste materials to form desirable rigid or semi-rigid articles, much less a molding process which is able to effectively utilize scrap or waste fabric. Such scrap materials are readily available from a variety of sources such as trimmings or clips from the various users of fabric materials.

In view of the foregoing, it is an object of the present invention to provide method and apparatus for utilizing a plurality of scrap materials to produce a molded rigid or semi-rigid article.
An advantage of the present invention is the provision of method and apparatus wherein the degree of rigidity of the molded article is controllable.

A further advantage of the present invention is the provision of method and apparatus for forming a rigid or semi-rigid article using scraps of a thermoplastic material and scraps of fabric fibers, the article being formed without damage to the fabric.

A further advantage of the present invention is the provision of method and apparatus for forming a dense rigid or semi-rigid article that is moldable into complex shapes.

In accordance with the present invention, strands of scrap polypropylene and scrap non-melting fabric fibers are mixed together to form a mat. In one mode the mixing involves air-laying the strands and fibers and needle-punching the air-laid mass. The mat is then heated to or even slightly above the melting point of the polypropylene being utilized and the heated mat is placed in a cold die for molding to impart a desired shape to a resultant article. Because the mat has been heated to a temperature sufficient to melt the polypropylene, the non-melting fabric fibers will be substantially fully encapsulated.

In a second mode, the strands of polypropylene and fabric fibers are blended together with a low temperature heat-sensitive binder such as ABS. The blended mass is then heated sufficiently to activate the binder, but not to melt the polypropylene. Activation of the binder in this manner yields a cake-like mat which facilitate handling and/or storage thereof and which may also be heated and molded as with the first mode.

The degree of rigidity and density of the resultant article is controllable by such factors as the magnitude and duration of pressure applied during the molding operation and whether one or both sides of the mat are subjected to heating. The desired shape of the mold is imparted to the resultant article which, being constituted essentially entirely of scrap materials from other processes, is inexpensive to produce. Additionally, because the molding process is carried out in unheated or cold tooling, it is possible to simultaneously form the mat and bond a suitable decorative covering to the article thus producing a finished article in a single molding
operation. Examples of such coverings include various types of materials both woven and un woven or even carpeting or the like.

Additional advantages and features of the present invention will become apparent from the subsequent description and the appended claims taken in conjunction with the accompanying drawings.

Brief Description of the Drawings

FIG. 1 is a schematic view showing steps involved in a molding method according to a first mode of the invention;

FIG. 2 is a schematic view showing steps involved in a molding method according to a second mode of the invention;

FIG. 3 is a schematic view showing one form of molding by which the mat may be transformed to a finished article via a stamping operation in accordance with the present invention;

FIG. 4 is a perspective view of an article formed via the stamping operation of Figure 3;

FIG. 5 is a section view of the article shown in Figure 4, the section being taken along line 5-5 thereof;

FIG. 6 is a view similar to that of Figure 3 but illustrating the simultaneous bonding of a decorative cover member to the mat while forming same;

FIG. 7 is a view similar to that of Figure 5 but showing the covered article formed in Figure 6;

FIG. 8 is a perspective view of an exemplary article formed by a molding process similar to that of Figure 6;

FIG. 9 is a section view of the article shown in Figure 8, the section being taken along line 9-9 thereof;

FIG. 10 is a schematic view illustrating another form of molding wherein the mat material is caused to flow thus enabling formation of a substantially more complex article; and

Figure 11 is a perspective view of an exemplary article formed by the process of Figure 10.

Detailed Description of the Preferred Embodiments

FIG. 1 illustrates steps involved in a molding method according to a first mode of the invention. The method advantageously utilizes scrap polypropylene strands and scrap fabric fibers. The
scrap fabric fiber is a non-melting fiber chosen from the group of cotton, sisal, jute, regenerated cellulose, wood, horsetail, silk, ramie, or wool. Cotton is currently preferred as the non-melting fiber, however, other materials may also be utilized including meltable fibers as long as the melting temperature of such fibers is substantially above the melting temperature of the polypropylene utilized.

The fibers and strands utilized in the method of the invention are preferably length-cut. It is currently believed that it is preferable that the length-cut strands of polypropylene be in a range of from about 1.0 inch to 2.5 inches in length, and that the length-cut fibers of the fabric be in a neighborhood of about 1.5 inches in length.

The fabric fibers and polypropylene strands are first mixed together. In the mode of FIG. 1, the mixing is a two-step operation which includes step 10 (air-laying a quantity of strands of polypropylene and a quantity of fabric fibers) and step 12 (needle punching the air-laid strands and fibers to form a mat). The quantity of strands and fibers mixed together in steps 10 and 12 should be such that the mat comprises polypropylene in a range from about 70% to 50% of the total weight of the mat, and that mat comprises non-melting fabric fiber in a range from about 30% to 50% of the total weight of the mat. The resultant mat is a two-sided mat having a thickness dimension between the two sides.

The air-laying step 10 and the needle-punching step 12 of the mode of FIG. 1 are conducted using conventional prior art apparatus employed for operating upon input material in other areas of application. For example, needle punching is well-known in the art of preparing carpet backing. Utilization of the needle-punching operation in the mode of FIG. 1 achieves a desired distribution of the polypropylene strands and fabric fibers. In this regard, for a mat of about 3/8 inch in thickness, the density of the mixture of strands and fibers is preferably in a range from about 1,000 grams per square meter (i.e., 1,000 g/m²) to about 2,500 grams per square meter (i.e., 2,500 gm/m²). The air-laying step 10 imparts a fluffy characteristic to the mass of strands and fibers prior to needle punching.
In step 14 the mat is heated to the melting point of polypropylene, which is typically on the order of about 275°F to 400°F. It should be noted that the specific temperature may vary depending upon the type of polypropylene being utilized and it is important that the heating be sufficient to achieve full melting thereof but yet not so high as to cause degradation of the non-melting fiber. In step 14 the polypropylene is heated sufficiently so that the polypropylene completely melts (i.e., becomes molten rather than fibrous) and this heating step 14 can be conducted in several different ways depending on the characteristics desired for the resultant article. For example, if the resultant article is to have both of its sides relatively rigid, the mat can be placed into an oven having two sets of heating coils with each side of the mat being proximate a set of heating coils. On the other hand, if it is desired that one side of the resultant article be rigid, the mat can be placed into an oven wherein only a set of coils proximate the desired rigid side is activated for heating purposes.

At step 16 the heated mat is placed into a mold configured to give a desired shape to the resultant article. The mold utilized in step 16 is preferably a cold compression mold. Thus, although the mat itself is warm when placed into the mold, the compression mold does not further heat the mat. The degree of pressure and duration of pressure to which the mat is subjected in the mold is controllable in accordance with the desired properties of the resultant article. For example, a pressure of about 2,000 psi for twenty seconds results in a rigid article. Mold pressures as low as 250 psi and even 10 psi for twenty seconds have been used to produce articles having less rigidity. Several different types of molding operations can be employed to achieve different types and shapes of articles as disclosed in greater detail below.

Under pressure the molten polypropylene essentially totally encapsulates substantially all cotton fibers having lengths greater than about 25 millimeters, producing a mat having homogenous polypropylene with cotton fibers as filler. Thus, unlike prior art molding techniques wherein interlock occurs at various points of contact of fibers, the non-melting fiber (i.e., cotton) is encapsulated with the polypropylene. Additionally, because the
non-melting fibers are relatively randomly oriented, they impart enhanced multi-directional strength and rigidity to the resultant article.

After molding at step 16, the resultant article is removed from the mold at step 18. The resultant article has the shape imparted by the mold and has rigidity characteristics dependent upon such factors as the degree of compression applied during molding and the number of sides exposed to heat during step 14.

According to one example of the mode of Fig. 1, a mat was produced utilizing air lay and needle punching equipment. The mat was comprises of 60 percent by weight polypropylene scrap film in bag form and 40 percent by weight denim waste. The mat was then heated to 285°F in a conventional air circulating oven. The mat was then taken from the oven and folded to form a ball, or "glob", and placed in the center of a tool utilized to make a six sided article to be used as an automotive battery case holder. The tool was placed in a press with a capacity of exerting 2000 psi. The tool was at room temperature. Thirty seconds later the pressure was released; the mold opened; and, the article molded. Sections of the molded article were tested and determined to have the following physical properties: (1) 5100 psi tensile strength; (2) 2.5% elongation; (3) 8400 psi flexural strength; and (4) 450,000 psi tangential modulus. These physical properties are about 10% to 20% higher than virgin raw polypropylene.

The mode of the invention illustrated with reference to FIG. 2 differs from the mode of FIG. 1 primarily with respect to the mixing operation. In this regard, at step 20 a quantity of polypropylene strands and fabric fibers are blended together along with a heat sensitive binder. The heat sensitive binder can be appropriate material, such as ground ABS, which has a lower melting point than the polypropylene. In one particular example, ground ABS comprises about 10% by weight of the mass of strands, fibers, and binder. The blending operation of step 18 is conducive in a variety of suitable prior art devices, such as conventional mixers, blenders, or grinders.

At step 22 the blended mass is heated to the melting point of the binder, but no greater. That is, the blended mass is heated sufficiently for the binder to exert its binding influence without causing the melting of the polypropylene. When using ABS as a binder,
for example, the blended mass is heated at step 22 to a temperature of about 250° F. The heating at step 22 results in a mat which is relatively cake-like. In one example the cake had a density of about 10 pounds per cubic foot.

Steps 24, 26, and 28 of the mode of FIG. 2 are essentially identical to steps 14, 16, and 18, respectively of the mode of FIG. 1. As mentioned before, the primary differences between the two modes is the manner in which the scrap materials are mixed, and the utilization of a binder in mode 2.

As previously mentioned, the above described mat is well suited for molding by various techniques to achieve a wide variety of finished articles. As schematically illustrated in Figure 3, the heated mat formed in the manner described above may be molded by use of a stamping process. In this process, the heated mat 30 is placed in a lower die portion 32 of a molding press and the upper die portion 34 closed. The die portions 32 and 34 are both at room temperature and pressure is applied for a time period. The time period may vary but must be sufficient to cool the thus compressed mat below the melting temperature of the polypropylene so as to thereby enable the formed article to be removed from the die portions. This process is well suited for forming various types of articles such as the automobile door trim panel 36 shown in Figure 4. As seen in Figure 5, this panel 36 has a substantially constant thickness and hence the mat has been compressed to provide a substantially uniform density over the entire article. Pressures of about 200 psi for approximately 20 seconds are believed appropriate for formation of this type of article. It should be noted that the time required for the forming process is principally dependent on the time required for cooling of the compressed mat and this will vary inversely with the density of the formed article (i.e., higher density will cool more rapidly).

It is also possible to simultaneously bond a suitable decorative covering to the article as it is being molded if desired. As shown in Figure 6, a suitable covering 38 is placed between the die sections 32, 34 followed by the heated mat 39. The die sections are then closed and placed under pressure for a sufficient length of time to cool the polypropylene below its melting point whereupon the die sections are opened and finished article may be removed therefrom.
Because the tooling is not heated, it is possible to bond virtually any type of decorative covering material without concern for damage occurring thereto. Further, because the mat has been heated sufficiently to fully melt the polypropylene, it will form a secure and substantially continuous bond to the covering over virtually the entire surface and the decorative covering will smoothly follow the contours formed in the mat.

In some applications, it is desirable to form articles having varying cross sectional thickness and/or varying density. The present invention is equally well suited for this type of application. An example of such an article 40 is shown in Figures 8 and 9. As illustrated, article 40 has a first portion 42 which is of a relatively thin cross section and another portion 44 of substantial thickness. Also, the thin section 42 is of substantially greater density than the thicker section 44 as it has been compressed to a greater extent. It should be noted, however, that while article 40 has been formed from a substantially uniform thickness mat and thus has greater density at the thinner sections, it is possible to vary either the density or the thickness of virtually any portion of the formed article independently. This may easily be done by layering the heated mat so as to vary the volume of material at desired locations. Thus, should a particular structure require high density and substantial thickness in the same area, this may be easily accomplished by increasing the thickness of the mat within this area before subjecting the mat to the molding operation.

The present invention is also well suited for fabrication of articles of much more complex shapes which may include various types of reinforcing ribs, gussets, and discrete localized protrusions or the like such as for example article 46 illustrated in Figure 11. As shown therein, article 46 incorporates portions of varying thickness, multiple reinforcing ribs, flanges and even localized protrusions. Such articles may be formed by a flow molding process wherein the heated mat is placed in a molding press 48 and subjected to substantially higher pressures than in the aforementioned processes. This pressure will cause the molten polypropylene to flow into the various ribs etc. provided in the tooling so as to thereby impart the complex shape to the heated mat. As in the above described processes,
the tooling is not heated and the part is removed once the temperature of the compressed mat has lowered sufficiently for the polypropylene to solidify. However, unlike the previously described processes, because the mat material is being subjected to sufficiently high pressure to effect the desired flow thereof, it is not possible to bond covering materials thereto during the forming operation. However, because the melting constituent of the mat is a thermoformable material, it is possible to bond suitable covering materials thereto subsequent to the forming operation without the use of additional adhesives or the like by merely reheating the formed article and thereafter subjecting it to a subsequent low pressure press operation along with the desired covering material.

As may now be appreciated, the present invention provides a material and method of utilizing same to form articles which is extremely flexible in its ability to form a wide variety of applications. By controlling the pressure to which the heated mat is subjected, articles may be formed of a wide variety of shapes and wherein the material thickness and/or material density may vary from one location to the other within a given article. Further, such flexibility is achieved without the need to inventory various thickness of mat material because it is possible to merely layer the mat in areas requiring additional materials so as to achieve the required volume. Thus, the mat material may be produced in large volume of any desired single thickness without limiting its potential applications. Also, in those applications not requiring complex shaped articles, it is possible to simultaneously form the article and bond a desired covering material thereto thus eliminating the need for a subsequent operation in order to obtain the finished product.

It should also be noted that the resulting strength and flexibility of the end product may be easily controlled by proper selection of the ratio of melting to non-melting components. Also, the ability to utilize scrap materials results in substantially lower production costs for the end product although if desired, this same process may utilize virgin materials.

While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to provide the advantages and features above stated, it will be appreciated that the invention
is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.
What Is Claimed Is:

1. A method of producing a molded article, said method comprising the steps of:
   mixing together strands of polypropylene and non-melting fabric fibers to form a mat;
   heating said mat to a temperature approximating the melting point of polypropylene, whereby said polypropylene becomes molten and substantially encapsulates said non-melting fabric fibers; and
   molding said heated mat to impart a desired shape to a resultant article.

2. The method of claim 1, wherein said non-melting fabric is chosen from a group consisting of cotton, sisal, jute, regenerated cellulose, wood, horsehair, silk, ramie, or wool.

3. The method of claim 1, wherein said strands of polypropylene are in a range of from 1.0 to 2.5 inches in length, and wherein said non-melting fabric fibers are in a neighborhood of about 1.5 inches in length.

4. The method of claim 1, wherein said strands of polypropylene and said non-melting fabric fibers are mixed sufficiently to achieve a distribution density in a range from about 1,000 grams per sq. meter to about 2,500 gram/square meter.

5. The method of claim 1, wherein said mixing step further comprises:
   air-laying said strands of polypropylene and said non-melting fabric fibers; and
   needle punching said air-laid strands and said non-melting fibers.
6. The method of claim 1, wherein said mat by weight comprises polypropylene in a range from about 70% to 50% of total mat weight.

7. The method of claim 1, wherein said mat by weight comprises non-melting fabric fiber in a range from about 30% to 50% of total mass weight.

8. The method of claim 1, wherein a thermoplastic binder having a lower melting temperature than polypropylene is mixed with said strands of polypropylene and said non-melting fabric fibers; and wherein, prior to heating said mat to the melting point of polypropylene, said mat is heated to the melting point of said binder.

9. The method of claim 1, wherein said mat has a first side and a second side, and wherein only one side of said mat is heated so that only the heated side of said mat becomes rigid.

10. The method of claim 1, further comprising the step of controlling the amount of pressure applied in said molding step in accordance with the desired rigidity of said resultant article.

11. The method of claim 1 wherein said heated mat is molded at pressures sufficient to flow said molten polypropylene and non-melting fibers to thereby enable formation of articles of complex shapes.

12. A method of producing a molded article, said method comprising the steps of:

mixing together strands of a first thermoformable material, said material having a first predetermined melting temperature, and second material fibers, said second material being non-melting at said predetermined temperature;

heating said mat to at least a temperature approximating the melting point of said thermoformable material whereby said thermoformable material becomes molten; and
subjecting said heated mat to a molding operation under pressure sufficient to cause said first thermoformable material to substantially encapsulate said second material fibers and for a sufficient time period to lower the temperature of said mat below said predetermined melting temperature.

13. The method of claim 12 wherein said first thermoformable material is scrap or waste material.

14. The method of claim 12 wherein said second material is scrap or waste material.

15. The method of claim 12 wherein said second material is a non-melting material.

16. The method of claim 12 wherein said second material has a melting temperature substantially above that of said first thermoformable material.

17. The article produced by the method of claim 1.

18. The article produced by the method of claim 2.

19. The article produced by the method of claim 3.

20. The article produced by the method of claim 4.

21. The article produced by the method of claim 5.

22. The article produced by the method of claim 6.

23. The article produced by the method of claim 7.

24. The article produced by the method of claim 8.

25. The article produced by the method of claim 9.
26. The article produced by the method of claim 10.

27. The article produced by the method of claim 12.
Air-Lay Strands Of Polypropylene And Fabric Fibers

Needle-Punch Air-Laid Strands Of Polypropylene And Fabric Fibers To Form Mat

Heat Mat To Melting Point Of Polypropylene

Mold The Heated Mat Under Pressure

Remove Resultant Article From Mold

Blend Together Strands Of Polypropylene, Fabric, Fibers And Binder

Heat Blend To Melting Point Of Binder To Form Mat

Heat Mat To Melting Point Of Polypropylene

Mold The Heated Mat Under Pressure

Remove Resultant Article From Mold
INTERNATIONAL SEARCH REPORT

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (4): D04H 1/48; B29C 43/02; B28B 17/00
US CL. 264/37, 119, 122; 156/148, 296; 428/286, 288

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III. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US, A, 4,568,581 (PEOPLES) 04 February 1986, See entire document.</td>
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<td>US, A, 3,928,693 (RUDLOFF) 23 December 1975, See entire document.</td>
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<td>Y</td>
<td>US, A, 4,582,750 (LOU) 15 April 1986, See column 2, lines 45-48.</td>
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<td>A</td>
<td>US, A, 4,518,642 (JOHNSTON) 21 May 1985</td>
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* Special categories of cited documents: 12
  - "A": document defining the general state of the art which is not considered to be of particular relevance
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  - "L": document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - "O": document referring to oral disclosure, use, exhibition or other means
  - "P": document published prior to the international filing date but later than the priority date claimed

**T**: later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

*X*: document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

**Y**: document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

*A*: document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search: 04 May 1988
Date of Mailing of this International Search Report: 07 SEP 1988

International Searching Authority:

ISA/US

Signature of Authorized Officer: M. L. FERREI