THERMAL TRANSFER LAMINATING METHOD

Field of the Invention

The present invention relates to a thermal transfer laminating method. Particularly, the present invention relates to a one-step vacuum thermoforming method combined with a thermal transfer printing process.

Background of the Invention

Currently, expanded plastics have been widely applied in the fields of commodities, traffics, industrial productions, aeronautics and the like due to their superior properties such as low density, high specific strength, strong energy absorption ability and good performance in sound insulation and thermal insulation, etc.

In the manufacture of helmets such as those for bicycle, skiing/skating, ice hockey, mountain climbing, horse riding, aquatics, industrial uses, and the like, a vacuum thermoforming process is normally required for the expanded polypropylene plastic used in above products to further increase their strength, since there is a strict requirement for the strength of the final products.

Currently, a secondary molding method is adopted for combining the plastic-expanding process with the vacuum-hermoforming process, which involves vacuum-forming a thermoformed part with specific shape by using a vacuum-thermoforming mold, and then subjecting said thermoforming part to punching and trimming processes, so as to finish the specific shape. Expandable beads are subjected to injection-foam molding (first molding) to obtain a polyfoam preform, followed by integrated molding (second molding) of the polyfoam preform with the vacuum-thermoformed part. However, the production procedure of said method is complex and time-consuming. Moreover, the bonding strength between the polyfoam preform and the thermoforming part is insufficient, which adversely affects the production period and the product strength.

In view of the above problems in the prior art, the present inventor developed a one-step molding method for producing an expanded polypropylene vacuum-thermoformed product (Chinese patent application No. 201010568086.X), which comprises silk-screen printing on a

plastic sheet; subjecting the plastic sheet to vacuum-thermoforming molding process to provide a vacuum-thermoformed part; and foaming expandable polypropylene materials and integratedly molding the expanded polypropylene part with the vacuum thermoformed part. In accordance with the method, the expanded polypropylene vacuum-thermoformed product exhibits improved impact resistance, and that the production process is also improved.

However, silk-screen printing or ink-jet printing of a molded plastic sheet involves a procedure of printing a single color and then drying before printing another color. The identical procedure has to be repeated 5~6 times to achieve the semi-product having a colored pattern, and that the product thus prepared usually has poor quality.

Similarly, the current water-transfer printing process involves firstly immersing a water-transfer printing film with a desired pattern in water, followed by adhering the immersed film onto a target substrate, removing the bubbles and water present in between the film and the substrate. Once the film adheres completely onto the substrate, it is subjected to drying process at 45 to 50 °C for 2 to 5 hours. After complete drying, the film layer is removed to obtain the product having the desired pattern. However, the bubble or water in between the film and the substrate cannot be entirely removed, resulting in insufficient adhesion. The quality of products thus obtained is not promised with scratch, peeling or even cracking occurred frequently.

Accordingly, novel methods are still required for producing expanded plastic products exhibiting resistance to scratching and peeling.

Summary of the Invention

In order to overcome the problems present in the prior art, the objective of the present invention is to provide a method for producing expanded plastic products exhibiting resistance to scratching and peeling.

To achieve the objective of the present invention, the present invention provides a thermal transfer laminating method, which comprises the following steps:

1) subjecting a plastic sheet to thermal transfer printing process;

2) subjecting the plastic sheet obtained from step 1) to vacuum thermoforming process to provide a vacuum-thermoformed part; and

3) foaming an expandable plastic material to provide an expanded part and laminating the expanded part with the vacuum-thermoformed part.

In the above thermal transfer printing process, a plastic sheet is subjected to thermal transfer printing instead of skin screen printing, ink-jet printing or water transfer printing.

The thermal transfer printing process can also be conducted following the laminating process in step 3), or conducted once prior to step 2) and once after step 3), under the requirement.

Thus, in an embodiment, the thermal transfer laminating method of the present invention may comprise the following steps:

2) subjecting a plastic sheet to vacuum-thermoforming process to provide a vacuum-thermoformed part;

3) foaming an expandable plastic material to provide an expanded part and laminating the expanded part with the vacuum-thermoformed part; and

4) subjecting the laminated part to thermal transfer printing process.

In another embodiment, the thermal-transfer laminating method of the present invention may comprise the following steps:

1) subjecting a plastic sheet to thermal transfer printing process;

2) subjecting the plastic sheet obtained from step 1) to vacuum thermoforming process to provide a vacuum-thermoformed part;

3) foaming expandable plastic materials to provide an expanded part and laminating the expanded part with the vacuum-thermoformed part; and

4) subjecting the laminated part to thermal transfer printing process.

According to an embodiment of the present invention, a thermal-transfer printing film is printed a pattern with ink in the thermal transfer printing process. The ink is preferably a commercially available thermal-resistant ink that typically comprises polyvinyl chloride acrylic resin as well as solvents and pigments commonly employed in the art. Suitable ink can be obtained, for example, from Kenbang Printing Material Factory (Dongguan, China), which can be suitably selected by a person skilled in the art according to the actual requirements for printing.

In a specific embodiment, upon ink-printing, the thermal transfer printing film with printed pattern is dried by heating. In an embodiment, after printing with the ink, the thermal transfer printing plastic film is subjected to transient heating at about 50° C for drying.

The thermal transfer printing film is commercially available. In a specific embodiment, the thermal transfer printing film may be a polyethylene terephthalate (PET) film or a polypropylene (Oriented Polypropylene, OPP) film.

In the method of the present invention, the pattern printed on said thermal transfer printing film is transferred to a plastic sheet by heating. The heating temperature may range from 150 to 200° C, preferably 160° C. The heating period may from 1 second to 30 seconds.

It should be understood that the plastic sheet employed for the method of the present invention may be any materials suitable for thermoforming, including but not limited to polyvinyl chloride (PVC) sheets, polycarbonate (PC) sheets and acrylonitrile-butadiene-styrene (ABS) sheets.

In the method of the present invention, the expandable plastic material employed in step 3) may be, but not limited to, expandable polypropylene (EPP), modified expandable polypropylene, expandable polystyrene (EPS), modified expandable polystyrene or any combinations thereof.

In the method of the present invention, the laminating process in step 3) may preferably be conducted under a pressure ranging from 80kPa to 120kPa.

In the method of the present invention, the laminating process in step 3) may preferably be conducted at a temperature ranging from 125 ° C to 150 ° C.

In the method of the present invention, the laminating process in step 3) may preferably be conducted by heating for 25 seconds to 60 seconds. In a specific embodiment, the laminating process in step 3) may involve, for example, steam heating. The time for steam heating can be suitably determined by a person skilled in the art according to the properties desired for the products such as quality, thickness, and the like.

According to the present invention, said expanded part may be prepared by any methods commonly known in the art, for example, injection foaming molding, extrusion molding or compression molding. In a preferable embodiment, said expanded part is prepared by injection foaming molding. In another embodiment, said expanded part is prepared by

extrusion molding or compression molding.

The advantages and beneficial effects of the one-step method of the present invention lie in that the thus produced vacuum-thermoformed products exhibit an improved resistance to scratch, and the production process is more superior.

Brief Description of the Drawings

Figure 1 is a flow chart showing the thermal transfer laminating method of the present invention.

It should be understood that merely the basic steps of the preferable technical solution of the present invention are shown in the drawing. Other process steps and examination procedure can also be included.

Detailed Description of the Invention

In order to further describe the principle and the structure of the present invention, detailed description of the preferred examples of the present invention will be made in reference to the accompanying drawing. However, the examples are only provided for illustration and explanation, which cannot be construed as a limitation of the protection scope of the present application.

Example 1

Step 1: Thermal Transfer Printing of Plastic Sheet

1) Transferring the pattern on a thermal transfer printing film (PET film) to a plastic sheet by heating at 160° C in a thermal transfer printer (Xingiiarun Printing Machinery Co., Ltd, China).

Step 2: Vacuum-Thermoforming and Processing of the Plastic Sheet

1) Baking the plastic sheet obtained from Step 1 at about 95° C for 90 minutes;

2) Adjusting the parameters of a vacuum-thermoforming machine (heating temperature: about 500° C; heating period: 18 seconds; cooling period: 10 seconds);

3) Vacuum-thermoforming the baked plastic sheet with a vacuum thermoforming

mold to obtain a vacuum-thermoformed part with specific shape;

4) Processing the vacuum-thermoformed part, including punching and trimming so as to finish the specific shape.

Step 3: Foaming expandable polystyrene and expanded polypropylene (EPS & EPP) to provide an expanded part, and laminating the expanded part with the vacuum-thermoformed part

1) Adjusting the parameters of a foam-molding machine (steaming pressure: 100 kPa; steaming period: 35 seconds; cooling period: 120 seconds; vacuum period: 20 seconds; temperature in the mold during molding: about 130° C);

2) Placing the finished vacuum-thermoformed part into a polyfoam mold;

3) Turning on the machine, feeding the raw materials of EPS & EPP, and conducting foaming of EPS & EPP according to the parameter setting to provide an expanded EPS & EPP part and laminate the expanded part closely with the vacuum-thermoformed part, so as to achieve a product having the polyfoam laminated with the vacuum-thermoformed part;

4) Upon de-molding, the polyfoam and the vacuum-thermoformed part are closely bonded together.

Example 2

In the following example, the method of the present invention is exemplified with modified expandable polystyrene (EPS; available from: Polysource, US; Japan JSP EPP Material; Japan Kaneka; Austria Sunpor) as the raw material. The method comprises the following four steps: thermal transfer printing of a plastic sheet, vacuum-thermoforming and processing of the plastic sheet, foaming modified expandable polystyrene to provide an expanded part and laminating the expanded part with the vacuum-thermoformed part, and thermal transfer printing process.

Step 1: Thermal Transfer Printing of Plastic Sheet

1) transferring colored pattern on a thermal transfer printing film (PET film) to a plastic sheet at 160° C in a thermal transfer printer (Xingiiarun Printing Machinery Co., Ltd, China).

Step 2: Vacuum Thermoforming and Processing of the Plastic Sheet

1) Baking the plastic sheet obtained from Step 1 at about 95° C for 90 minutes;

2) Adjusting the parameters of the vacuum-thermoforming machine (heating temperature: about 500° C; heating period: 18 seconds; cooling period: 10 seconds);

3) Vacuum-thermoforming the baked plastic sheet with a vacuum-thermoforming mold to obtain a vacuum-thermoformed part with specific shape;

4) Processing the vacuum-thermoformed part, including punching and trimming so as to finish the specific shape.

Step 3: Foaming modified expandable polystyrene to provide an expanded part, and laminating the expanded part with the vacuum-thermoformed part

1) Adjusting the parameters of a foam-molding machine (steaming pressure: 100 kPa; steaming period: 35 seconds; cooling period: 120 seconds; vacuum period: 20 seconds; temperature in the mold during molding: about 150° C);

2) Placing the finished vacuum-thermoformed part into a polyfoam mold;

3) Turning on the machine, feeding the raw materials, and conducting foaming of the modified expandable polystyrene according to the parameter setting to provide an expanded part and laminate the expanded part closely with the vacuum-thermoformed part, so as to achieve a product having the modified expanded polystyrene polyfoam laminated with the vacuum-thermoformed part;

4) Upon de-molding, the modified expanded polystyrene and the vacuum-thermoformed part are closely bonded together.

Step 4: thermal-transferring the colored pattern on a thermal transfer printing film (PET film) onto the molded helmet in a thermal transfer printer (Xingjiarun Printing Machinery Co., Ltd, China) at 150° C to 200° C.

In Step 3 of Examples 1 and 2 above, the expandable polystyrene or the modified expandable polystyrene is molded by injection foaming process. However, it should be understood that the expandable polystyrene and the modified expandable polystyrene can be molded by any other methods capable of producing the desired shape, such as extrusion

molding, compression molding and the like.

The peeling resistance of the products obtained from Examples 1 and 2 were tested according to the standard method of National standard GBT9286-1998 or ASTM D3359-09. The testing results showed that all the products passed the standard tests and achieved at least the level of ISO Classification 2 (or Classification 3B in ASTM D3359-09). That is, the resistance to peeling of the product according to the present invention is up to the satisfying level.

In contrast, under the same conditions, the products obtained by replacing the thermal transfer printing with water transfer printing process exhibited poor resistance to peeling, and did not achieve the level of ISO Classification 2 (or Classification 3B in ASTM D3359-09). In other words, the products obtained with water transfer printing process did not pass the standard test.

Although the embodiments of the present invention have been described in details, it should be understood that various alterations or modifications may be made therein without departing from the spirit or scope of the invention, and that all modifications or alternatives equivalent thereto are within the spirit and scope of the invention as set forth in the appended claims.

Claims

1. A thermal transfer laminating method, comprising the steps of:

1) subjecting a plastic sheet to thermal transfer printing process;

2) subjecting the plastic sheet obtained from step 1) to vacuum thermoforming process to provide a vacuum-thermoformed part; and

3) foaming an expandable plastic material to provide an expanded part and laminating the expanded part with the vacuum-thermoformed part.

2. A thermal transfer laminating method, comprising the steps of:

2) subjecting a plastic sheet to vacuum thermoforming process to provide a vacuum-thermoformed part;

3) foaming an expandable plastic material to provide an expanded part and laminating the expanded part with the vacuum-thermoformed part to provide a laminated part, and

4) subjecting the laminated part to thermal transfer printing process.

3. The method according to claim 1 or 2, which comprises the steps of:

1) subjecting a plastic sheet to thermal transfer printing process;

2) subjecting the plastic sheet obtained from step 1) to vacuum thermoforming process to provide a vacuum-thermoformed part;

3) foaming an expandable plastic material to provide an expanded part and laminating the expanded part with the vacuum-thermoformed part to provide a laminated part; and

4) subjecting the laminated part to thermal transfer printing process.

4. The method according to any one of claims 1 to 3, wherein a thermal transfer printing film is printed a pattern with a thermal-resistant ink in the thermal transfer printing process.

5. The method according to claim 4, wherein upon the ink-printing, the thermal transfer printing film with printed pattern is dried by heating.

6. The method according to claim 4 or 5, wherein said thermal transfer printing film is a PET film or an OPP film.

7. The method according to any one of claims 1 to 6, wherein the pattern printed on said thermal transfer printing film is transferred to a plastic sheet by heating at a temperature ranging from 150 to 200° C for a period from 1 second to 30 seconds.

8. The method according to any one of claims 1 to 7, wherein said expandable plastic material employed in step 3) is selected from expandable polypropylene, modified expandable polypropylene, expandable polystyrene, modified expandable polystyrene or any combinations thereof.

9. The method according to any one of claims 1 to 8, wherein said laminating process in step 3) is conducted under a pressure ranging from 80kPa to 120kPa and a temperature from 125 °C to 150 °C.

10. The method according to any one of claims 1 to 9, wherein said laminating process in step 3) is conducted by heating for 25 seconds to 60 seconds.