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- (54) Benævnelse: **FREMGANGSMÅDE TIL TERMOFORMNING AF ET PLADELIGNENDE ELEMENT AF KOMPOSITPOLYMERMATERIALE OG EN FORM FUNGERENDE I OVERENSTEM-MELSE MED FREMGANGSMÅDEN.**
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DESCRIPTION

Technical field

[0001] The present invention relates to a process for thermoforming a plate-like element of composite polymer material having the features set out in the preamble of the main claim. It also relates to a mould arranged to thermoform a plate-like element of composite polymer material in accordance with said process.

Technological background

[0002] The present invention is susceptible of application in the field of the processing of thermoplastic polymer-matrix composite materials.

[0003] These materials are generally composed of a polymer matrix in which reinforcing fibres made from a different material, for instance from carbon, glass or another polymer, are embedded and provide the polymer matrix with high-level mechanical properties. These latter, in combination with the relevant lightness of these materials, make them highly regarded in the market.

[0004] The presence of the thermoplastic matrix makes this type of composite material advantageously suitable to be thermoformed, making it possible to produce components of a curved shape from planar plate-like elements using relatively simple working processes.

[0005] In a known thermoforming process, the plate-like element is first heated to a temperature at which the thermoplastic matrix softens and is then subject to deep-drawing by means of a mould of male-female type shaped appropriately as a function of the shape with which the plate-like element is to be provided.

[0006] In particular, the mould for the deep-drawing step comprises a male member and a female member, respectively shaped and counter-shaped in order to fit together, which may be moved towards one another at a predetermined pressure.

[0007] The planar plate-like element interposed between the male and female members is then subject to a plastic deformation caused by the movement of the male member against the female member.

[0008] In order to prevent, or at least limit, the formation of folds and creases in the plate-like element during this process of plastic deformation, the peripheral region of the plate-like element is preferably held by appropriate clamps.

[0009] The plate-like element may be held in various ways, using fixed clamps or clamps able to move towards the male and female members of the mould during deformation (the clamps may, for instance, be secured on the mould by means of springs, or may be controlled to move by appropriate hydraulic jacks).

[0010] As a further alternative, the clamps may engage with and hold the peripheral region of the plate-like element over its entire periphery or only at specific portions of that peripheral region (for instance at the corners).

[0011] The category of composite materials also includes a family of materials in which both the polymer matrix and the reinforcing fibres are made from the same base polymer, albeit with different properties. Materials are known, for instance, in which both the polymer matrix and the reinforcing fibres are made from polyolefin materials, in particular polypropylene. In these materials, which are highly regarded because they can be fully recycled, the reinforcing fibres are oriented and are formed by a first type of polypropylene having a high melting point and high-level mechanical properties, and are at least partially covered by a coating layer formed by a second type of polypropylene having a lower melting point and inferior mechanical properties. The properties of the reinforcing fibres may be obtained by mechanical treatment, for instance by subjecting the polypropylene fibres to a "stretching" process, and/or by a different process of polymerization entailing a higher molecular weight.

[0012] Examples of composite materials of this type include the products marketed under the trade names PURE[®] (produced by Lankhorst B.V.), CURV[®] (produced by Propex Fabrics GmbH) and ARMORDON[®] (produced by Don and Low Ltd), all of which are covered by the term "self- reinforced polypropylene".

[0013] Composite materials analogous to those cited above but based on polyester polymer, in particular polyethylene terephthalate (PET), are also known.

[0014] These materials are generally supplied by their manufacturing firms in the form of sheets, wound in rolls, formed by tapes interwoven as fabric, and containing the above-described reinforcing fibres, or, as an alternative, in the form of planar plates obtained from these sheets, where a predetermined number of said sheets are superimposed and are then subject to temperature and pressure conditions such as to melt the polypropylene used as a coating layer (and having a lower melting point) so that the superimposed sheets become one single piece.

[0015] The planar plates may also be obtained from superimposed sheets formed by woven strips or fibres of stretched polyolefin material, advantageously spaced by sheets of thermoplastic material having a lower melting point which act as a binder between the fabric sheets and are then subject to temperature and pressure conditions such as to melt the thermoplastic material with a lower melting point and bind the fabric sheets together.

[0016] In addition, sheets of a different chemical nature may be provided as layers external to

the superimposed stack of fabric sheets in order to provide the plate with particular properties, for instance scratch-resistant properties, or a superior level of surface finish, or simply a different aesthetic.

[0017] In any case, the planar plates obtained in this way may be subsequently processed by thermoforming in order to provide them with the final shape of the articles to be produced, which may be, for instance, semirigid suitcase shells, motorcycle panniers, helmets, shin pads, tips for safety footwear or bumpers for motor vehicles.

[0018] The thermoforming process takes place in appropriate moulds, according to the working steps described above, and, in order to ensure that the process does not lead to an unsatisfactory surface finish, may be relatively complex both from the point of view of the regulation of the process parameters and in terms of the production and management of the mechanical components of the mould, the details of the clamps and their control devices.

[0019] DE 20207919 and JP 2008279700 disclose respective processes and moulds for thermoforming a plate-like element of polymer material.

[0020] It will be appreciated that, in the context of this specification and the appended claims, a "plate-like element" is to be understood as a member having a predominantly two-dimensional development, with a relatively small thickness which is at least one tenth lower than the two predominant dimensions, irrespective of the properties of rigidity of that member. In other words, a plate-like element may be rigid or readily deformable. In the same way, a plate-like element may be a unit which can be handled individually or may be formed by a plurality of separate and independent components such as, for instance, a stack of superimposed sheets.

[0021] Moreover, in the present specification and the appended claims, a pin designed to hold a plate-like element during a step of the thermoforming process is defined as having a "free end" when it is configured such that, during that stage, the plate-like element may be freely fitted on the pin and removed therefrom via said free end without removing further retaining members such as nuts or auxiliary frames from the pin.

Description of the invention

[0022] The technical problem underlying the present invention is providing a process for thermoforming a plate-like element of composite polymer material and a mould arranged to operate in accordance with said process, which is structurally and functionally designed to remedy the drawbacks discussed above with respect to the cited prior art.

[0023] This problem is resolved by the present invention by a process for thermoforming a plate-like element of composite polymer material and a mould operating in accordance with said process, realised in accordance with the appended claims.

Brief description of the drawings

[0024] Other advantages and features of the invention will become clear from the following detailed description of a preferred embodiment thereof, given with reference to the appended drawings which are provided purely by way of non-limiting example and in which:

- Fig. 1 is a diagrammatic view of a plant for thermoforming a plate-like element of composite polymer material, comprising a mould disposed to operate in accordance with the process of the present invention;
- Fig. 2 is a diagrammatic view of the mould of Fig. 1 in a non-operating position;
- Fig. 3 is a diagrammatic top view of a plate-like element disposed to be thermoformed in the mould of Fig. 2;
- Fig. 4 is a diagrammatic top view of a frame disposed to hold the plate-like element during thermoforming in the mould of Fig. 2;
- Fig. 5 is a diagrammatic view in cross-section of the plate-like element of Fig. 3 mounted on the frame of Fig. 4 before being processed in the mould of Fig. 2;
- Fig. 6 is a diagrammatic view in cross-section of a detail of a variant of the mould of Fig. 1.

Preferred embodiment of the invention

[0025] In the appended drawings, a mould designed to thermoform a plate-like element 10 of composite polymer material according to the process of the invention is shown overall by 1.

[0026] In the preferred embodiment described here, the plate-like element 10 comprises a stack of superimposed sheets made from self-reinforced polypropylene, a material which, as mentioned above, comprises a plurality of reinforcing fibres, made from stretched polypropylene, covered by a matrix which is also polypropylene-based but has a lower melting point than the reinforcing fibres.

[0027] In particular, the polypropylene forming the reinforcing fibres has properties of mechanical strength and a melting point greater than the polypropylene forming the matrix.

[0028] The sheets are preferably made from ARMORDON[®], produced by Don & Low Ltd or from PURE[®], produced by Lankhorst BV.

[0029] The Applicant considers, however, that the process of the present invention may also be applied to plate-like elements made from different composite polymer materials, for

instance based on polyethylene and its copolymers, for instance ethylene vinyl acetate (EVA), or self-reinforced PET, or based on polyamides or polyesters, mixed as polymers or alone, used for the reinforcing fibres and/or for the matrix.

[0030] Moreover, it is considered that the reinforcing fibres may also be formed by non-polyolefin polymers or from inorganic material such as glass or carbon.

[0031] The number of superimposed sheets of self-reinforced polypropylene used to form the plate-like element 10 is at least three and depends on the mechanical properties required of the final product and the degree of deformation to be imparted by thermoforming. The superimposed sheets of composite material are preferably between six and 20 in number.

[0032] The plate-like element 10 has a generally rectangular shape and has a central region 11 and a peripheral region 12 extending around the central region 11.

[0033] The dimensions of the plate-like element may vary widely and it may, for instance, have a length and a width of between 100 and 2000 mm and a thickness of between 0.5 and 5 mm.

[0034] The mould 1 comprises a bearing frame 2 and secured thereto a male member 3, which is appropriately shaped in a configuration which it is desired to impart to the plate-like element 10, and a female member, counter-shaped with respect to the male member 3, in order to match its configuration, according to operational steps known per se in moulding processes. The male member in particular comprises a projecting head 3a which may be received in a cavity 4a of the female member 4.

[0035] The male member 3 and the female member 4 may also be reciprocally moved between an operating position of the mould 1, in which they are pressed against one another, with the head 3a housed in the cavity 4a, and a non-operating position, shown in Fig. 2, in which they are spaced from one another, with the head 3a completely external to the cavity 4a.

[0036] The female member 4 is in particular fixed with respect to the bearing frame 2, while the male member 3 is coupled to uprights 2a of the moving frame 2 and may slide in a direction of displacement Y towards and away from the female member 4.

[0037] The mould 1 further comprises a movement device 5 disposed to displace the male member 3 towards and away from the female member 4 between said operating and non-operating positions.

[0038] The movement device 5 in particular comprises a mechanically or hydraulically actuated press associated with the male member 3 in order to displace it along direction Y and urge it against the female member 4 at a predetermined pressure.

[0039] The mould 1 further comprises a system for controlling the temperature of the male

member 3 and the female member 4 able to keep the surfaces of the head 3a and the cavity 4a at a predetermined temperature.

[0040] The mould 1 further comprises a holding device 6 on which the plate-like element 10 is secured during the moulding step. In particular, the holding device 6 may be positioned with respect to the female member 4 such that the plate-like element 10, in particular its central region 11, is interposed between the male member 3 and the female member 4 when it is secured to said holding device.

[0041] The holding device 6 is particularly configured to hold the plate-like element 10 at its peripheral region 12, while the male member 3 and the female member 4 are displaced towards one another into the operating position so that they abut (and deform) the plate-like element 10 in its central region 11.

[0042] According to a preferred embodiment of the invention, the holding device 6 comprises a plurality of pins 7 having a free end 7a by means of which the pins 7 may engage the plate-like element 10 via a corresponding plurality of, preferably through, holes 13 obtained in its peripheral region 12.

[0043] The pins 7 are preferably all secured to a frame 6a configured so as to surround the cavity 4a of the female member 4 and all project from the same side in a manner substantially parallel to the direction of displacement Y. In particular, when the frame 6a is located with respect to the female member 4, all the pins 7 stand upright from the frame 6a with their respective free ends 7a facing the male member 3.

[0044] The pins 7 preferably have a cylindrical shape and the same diameter and project from the frame 6a to a minimum height of approximately 10 mm, and more preferably a height of between 15 mm and 30 mm. The pins 7 may project from the frame 6 to a substantially identical extent, or their height may be appropriately regulated in order to differentiate, where necessary, the precise moment at which the plate-like element 10 is released, as will be described in detail below.

[0045] Moreover, the pins 7 are disposed in sequence along the frame 6a covering the entire peripheral region 12, with a spacing of between 2 mm and 10 mm between one another.

[0046] In an alternative embodiment, not shown, the pins 7 may assume different configurations, for instance a broken line configuration, with a base portion adjacent to the frame 6a extending substantially parallel to the direction Y and a second portion, comprising the free end 7a of the pin, inclined so as to be slightly folded towards the central region 11 of the plate-like element 10. In this particular configuration, the release of the plate-like element 10 from the pins 7 via the free end 7a may be facilitated at a predetermined moment of the operation to deform the plate-like element 10, as will be described in further detail below.

[0047] In other embodiments of the invention, not shown in the drawing, the holding device 6

may comprise different types of elements suitable to restrain the peripheral region 12 of the plate-like element 10, for instance fixed or movable clamps.

[0048] According to a preferred embodiment of the invention, the frame 6a is a mobile frame and is detachably associated with the mould 1 so that it may be located or removed at will from its position with respect to the female member 4, depending on the process requirements, as will be explained in detail below. In particular, the frame 6a may be simply placed resting on the female member 4 of the mould, in an appropriate position for instance defined by a groove or by ribs or by reference marks, or, in the alternative, quick coupling means, such as clamps, may be provided in order to allow quick engagement and disengagement of the frame 6a onto and from the female member 4.

[0049] To make the frame 6a easier to handle, it may be provided with grip handles 6b, preferably of telescopic type.

[0050] According to a further preferred feature, the frame 6a is positioned with respect to the female member 4 so that it may be displaced with respect thereto, away from the male member 3, in the direction Y, towards a position in which the pins 7 are disengaged from the plate-like element 10.

[0051] To that end, the frame 6a is supported on a resiliently deformable member, for instance a support 8a supported by a plurality of appropriately calibrated springs 8.

[0052] The frame 6a is displaced against the action of the springs 8 towards the disengaged position by an extractor device mounted on the male member 3 and disposed to abut on the frame 6a when the male member 3 is displaced towards the operating position. In this way, the displacement of the frame 6a towards the disengaged position is determined by the displacement of the male member 3 towards the operating position.

[0053] The extractor device preferably comprises a plurality of projections 9 mounted on the male member 3 so as to surround the head 3a and extending towards the female member 4 so as to be substantially aligned with the frame 6a with respect to the direction Y.

[0054] The extent to which the projections 9 project from the male member 3 may preferably be adjusted, for instance by a short-pitch screw coupling which enables its accurate and precise calibration.

[0055] In a preferred manner, the projections 9 are adjusted such that the frame 6a is displaced into the disengaged position, thereby releasing the plate-like element 10 from the pins 7, when the male member 3 has not yet been fully displaced into the operating position.

[0056] In a preferred manner, the projections 9 are adjusted such that the frame is displaced into the disengaged position when the male member 3 and the female member 4 are at a distance of between 5 mm and 30 mm from the operating position.

[0057] If the holding device 6 does not comprise a plurality of pins 7, but one or more clamps restraining the peripheral region 12, the disengagement of the plate-like element 10 may be obtained by providing the clamps with an actuator which causes the opening of the clamps when the male member 3 and the female member 4 are at a predefined distance from the operative position.

[0058] In the preferred embodiment shown here, the mould 1 is part of a thermoforming plant 100 shown diagrammatically in Fig. 1.

[0059] The plant 1 comprises a first station 101 for the preparation of the plate-like element 10, in which the various sheets 10a of composite material are cut from respective rolls 101a and superimposed on one another so as to form a stack with a predetermined number of superimposed sheets separate from one another.

[0060] In a preferred variant, one or a plurality of reinforcing members of a material differing from the sheets 10a may be interposed between the sheets 10a. The reinforcing members may be formed, for instance, by mesh strips of basalt, glass, carbon or polyaramide fibre positioned at the regions which, once the plate-like element has been thermoformed into the desired final product, correspond to those regions most exposed to the risk of impacts and deformation, in particular the corner regions.

[0061] These mesh strips are preferably of wide mesh so as to enable direct contact between the sheets 10a between which the reinforcing strips are interposed and therefore their stable reciprocal coupling by means of the partial fusion of the polymer material forming them.

[0062] Moreover, depending on the position that they are to assume in the final thermoformed article and their elongation properties, the mesh strips may be appropriately connected to one or a plurality of pins 7 during the stage of insertion of the stack of sheets 10a on the frame 6a, thereby making it possible also to determine the position of the mesh strips with respect to the remaining sheets of the plate-like element 10 in a more or less unequivocal manner.

[0063] In a further variant, one or a plurality of sheets of thermoplastic polyolefin material, for instance non-oriented polypropylene, may be interposed between the sheets 10a in order to form a spacing layer between the sheets 10a of composite material.

[0064] The stack of superimposed sheets 10a forming the plate-like element 10 is then conveyed to a second station 102 in which its peripheral region 12 is drilled in order to obtain the holes 13.

[0065] The holes 13 are preferably obtained by displacing previously melted composite material using an appropriate instrument provided with a plurality of pointed projections which, when heated to a temperature greater than the melting temperature of the composite material forming the plate-like element 10, are caused to pass through the plate-like element 10.

[0066] It is preferable, moreover, for each of said projections, to the rear of the point designed to pass through the plate-like element 10, to bear a flange which is also heated and disposed to bear on the area surrounding each hole 13 so as to melt the composite material in that zone without, however, displacing it. In this way, a small area of substantially homogeneous material is formed around each hole 13 and has no points that could promote the beginning of tears in the plate-like element.

[0067] The plate-like element 10 is then preferably mounted on the mobile frame 6a such that the free ends 7a of the pins 7 pass through the holes 13. In this way, the plate-like element 10 is held in engagement by the pins 7 and may be disengaged via the free ends 7a.

[0068] If the holding device 6 does not comprise a plurality of pins 7, but one or more clamps, the peripheral region 12 may not be drilled in order to obtain holes 13 and the plate-like element 10 is restrained by means of the clamps provided on the mobile frame 6a.

[0069] The mobile frame 6a, with the plate-like element 10 mounted on it, is displaced, using the grip handles 6b, to a consolidation station 103 in which the plate-like element 10 is subject to a heating and pressure stage in order at least partially to melt the matrix of the composite material so as to make the superimposed sheets rigid with one another.

[0070] This consolidation operation preferably takes place only in the central region 11, while the peripheral region 12 remains unconsolidated, with the sheets of the stack remaining separate and independent.

[0071] The consolidation station 103 comprises one or a plurality of presses 104, comprising a fixed abutment surface on which the central region 11 of the plate-like element 10 bears, while the mobile frame 6a surrounds the abutment surface.

[0072] A moving head of the press 104 is then lowered on the abutment surface at a predetermined pressure, preferably of between 5 and 30 bar, and is held in position for a predetermined time, preferably for a period of time of between 5 and 15 minutes, depending on the properties of the composite material.

[0073] The abutment surface and the moving head are also appropriately heated to a temperature of between 120°C and 180°C enabling the partial fusion of the propylene forming the matrix of the composite material.

[0074] However, if the sheets 10a forming the plate-like element 10 are made of a different material, pressure and/or temperature will be properly defined, for instance, if the material is self-reinforced polyethylene terephthalate, the correct temperature to be used in this consolidation step is from 220°C to 250°C.

[0075] In a preferred embodiment, a finish sheet 10b of thermoplastic polymer material is disposed on the stack of composite material sheets 10a, in an external position with respect to

said stack, in order to provide the plate-like element 10 with a desired surface finish.

[0076] Preferably, a sheet of paper 10c for sublimation printing ("sublimation" paper), on which a desired graphical decoration is provided, is disposed above the finish sheet 10b, on the side opposite the stack of composite material sheets 10a.

[0077] In this way, during the step of heating and pressure of the plate-like element 10 in the consolidation station 103, the printing of the graphical decoration present on the paper is obtained by sublimation printing on the finish sheet 10b.

[0078] Advantageously, the pressure and temperature conditions of sublimation printing are compatible with the pressure and temperature values of the consolidation of the composite material sheets 10a, and the relatively long times required by this stage make it possible to obtain a surface finish of the plate-like element 10 which is optimum in terms of quality.

[0079] After the consolidation station 103, the mobile frame 6a is conveyed, together with the plate-like element 10, to the mould 1 in which the plate-like element 10 is subject to thermoforming.

[0080] The plate-like element 10 reaching the mould 1 has its central region 11 consolidated, while, in its peripheral region 12, the superimposed sheets 10a and, if used, the sheets 10b and 10c, are separate from one another.

[0081] Keeping the plate-like element 10 on the frame 6a after the step of consolidation of the central region 11 makes it possible to prevent any problems of retraction of the composite material forming the plate-like element 10 caused by the heating of the central region 11 (shrinkage). In this way, the plate-like element 10 arrives at the mould 1 to be subjected to plastic deformation, with its entire perimeter pre-tensioned.

[0082] The mobile frame 6a is positioned at the location of the female member 4 on the support 8a so that the central region 11 of the plate-like element 10 is aligned between the head 3a of the male member 3, appropriately displaced into the non-operating position, and the cavity 4a of the female member 4, and such that the peripheral region 12 of the plate-like element 10 surrounds the cavity 4a.

[0083] The male member 3 and the female member 4 are both kept at a temperature controlled by an appropriate temperature control system (not shown).

[0084] Preferably, the female member 4, in particular the cavity 4a, is kept at a temperature of between 10 and 40°C, while the male member 3, in particular the head 3a, is kept at a temperature of between 10 and 50°C.

[0085] The male member 3 is then displaced into the operating position and, during that displacement, the head 3a abuts on the plate-like element 10 in its central region 11 and

subjects it to plastic deformation by displacing it within the cavity 4a.

[0086] The deformation generated in the plate-like element 10 causes the peripheral region 12 to move in traction towards the central region 11 which is countered by the presence of the pins 7 engaged in the holes 13.

[0087] The displacement of the male member 3 towards the operating position is then completed, such that the head 3a is pressed against the cavity 4a of the female member 4 at a pressure of between 15 and 40 bar.

[0088] This pressure is preferably maintained for a period of time of between 1 and 4 minutes so as to impart the configuration defined by the head 3a and the cavity 4a to the central region 11 of the plate-like element 10 and make it stable.

[0089] Thereafter, the male member 3 is raised from the female member 4 and displaced into the non-operating position so as to enable the thermoformed plate-like element 10 to be removed from the mould 1 and conveyed to a subsequent trimming station 105 in which the central region 11 of the plate-like element 10 is appropriately trimmed by removing the peripheral region 12.

[0090] In the case of small deformations, in which the traction to which the plate-like element 10 is subject does not bring about substantial tears in the sheets 10a, the pins 7 remain engaged in the corresponding holes 13, during the entire stage of displacement of the male member 3 into the operating position and the subsequent period in which it is kept pressed against the female member 4. In this type of deformation, use is made of the residual elongation of the fibres of the composite material and then the deformation to which the plate-like element is subject at the holes 13 which are elongated and allow the composite material to flow towards the cavity 4a.

[0091] In the case of more substantial deformations, in which the traction exerted by the head 3a on the plate-like element 10 could fully tear the peripheral region 12 at the holes 13, with a resulting release of the pins 7 and a lack of homogeneous action to hold the plate-like element 10, the pins 7 may be disengaged from the holes 13 before the male member 3 is fully displaced into the operating position.

[0092] The possibility that the plate-like element may tear completely at the holes 13 and allow the pins 7 to escape from the lateral edge of the plate-like element obviously depends on various factors, including the type of composite material, the number of sheets used and the degree of deformation imparted by the mould 1.

[0093] The Applicants have in particular observed that when the composite material is self-reinforced polypropylene of the type of ARMORDON® or of PURE®, with a number of superimposed sheets of between three and 30, it is preferable for the pins 7 to be disengaged from the holes 13 when the elongation required of the plate-like element is greater than a

value of approximately 15%.

[0094] The disengagement of the plate-like element 10 from the pins 7 should preferably take place at a minimum distance from the operating position so as not to cause a flow of material towards the cavity 4a which is too rapid and uncontrolled.

[0095] The pins 7 are preferably disengaged from the holes 13 when the male member 3 is at a distance of between 5 mm and 30 mm from the operating position.

[0096] The disengagement of the pins 7 from the corresponding holes 13 is determined by the displacement of the frame 6a caused by the action of the projections 9 mounted on the male member 3 which abut against the frame 6a and urge it away from the cavity 4a against the action of the springs 8. In this way, the frame 6a is lowered with respect to the mouth of the cavity 4a and the pins 7 may escape from the holes 13.

[0097] The projection of the projections 9 from the male member 3 may be advantageously adjusted so as to be able to regulate their action on the frame 6a and therefore the moment of disengagement of the plate-like element 10 from the frame 6a.

[0098] In a variant of the present invention, the peripheral region 12 of the plate-like element 10 may be accompanied in a controlled manner towards the cavity 4a of the female member 4 during the deformation of the central region 11 imparted by the head 3a.

[0099] In particular, the plate-like element 10 may be gripped at its peripheral region 12 by a clamp 20 designed to hold the plate-like element 10 when the (static) action of the pins 7 on its own could lead to tearing of the sheets 10a forming the plate-like element 10.

[0100] The clamp 20 is preferably disposed between the frame 6a and the cavity 4a and its holding action takes place as an alternative or in addition to the phase of disengagement of the frame 6a from the holes 13.

[0101] In detail, the clamp 20, as shown in detail in Fig. 6, comprises a first jaw 21 mounted on the male member 3 and a second jaw 22 mounted on the female member 4 in alignment in the direction Y with the first jaw 21.

[0102] The jaws 21 and 22 preferably have a surface of abutment 21a, 22a with the plate-like element 10, respectively profiled with a central projection 23 on one of the two jaws and a corresponding groove 24 on the other of the two jaws.

[0103] The jaws 21, 22 are clamped against one another with a predetermined force and may preferably slide in a horizontal plane perpendicular to the direction of displacement Y so as to accompany the peripheral region 12 of the plate-like element 10 towards the cavity 4a following the traction exerted by the head 3a.

[0104] To that end, the first jaw 21 is preferably mounted on a first spring 25 and on a second spring 26 operating between the male member 3 and the first jaw 21 respectively in the substantially vertical direction Y and in a substantially horizontal direction perpendicular to the direction Y.

[0105] The first spring 25 opposes the vertical displacement of the first jaw 21 against the male member 3, while the second spring 26 opposes the horizontal displacement of the first jaw 21 towards the head 3a.

[0106] In a similarly preferred manner, the second jaw 22 is mounted on a first spring 27 and on a second spring 28 operating between the female member 4 and the second jaw 22 respectively in the substantially vertical direction Y and in a substantially horizontal direction perpendicular to the direction Y.

[0107] As in the case of the first jaw 21, the first spring 27 opposes the vertical displacement of the second jaw 22 against the female member 4, while the second spring 28 opposes the horizontal displacement of the second jaw 22 towards the cavity 4a.

[0108] The first springs 25 and 27 are specifically dimensioned to exert a desired holding force on the plate-like element 10, while the second springs 26 and 28 are specifically dimensioned to control the speed of displacement of the peripheral region 12 towards the cavity 4a.

[0109] Moreover, the first and second springs 25, 26, 27 and 28 may be regulated in order to adjust the force that they exert on the jaws 21 and 22.

[0110] The Applicants have in particular observed that in a plate-like element 10 of rectangular shape, the possible drawbacks due to tearing of the sheets 10a are more likely on the long side of the rectangle. In a variant of the invention, the mould 1 may therefore be provided with a respective clamp 20 solely along the longer sides of the plate-like element 10.

[0111] The thermoforming process of the present invention advantageously makes it possible to produce articles from composite polymer material, in particular self-reinforced polypropylene, of a curved shape, such as, for instance, containers, travel and transport baggage shells, personal protection articles, sports equipment and motor vehicle protection articles.

[0112] This process makes it possible to achieve various advantages with respect to known processes, the most important of which is that it is possible to obtain thermoformed products, made in particular from self-reinforced polypropylene, with higher-level mechanical properties.

[0113] It is therefore also possible to use less material to obtain a product that has the same mechanical properties as thermoformed products obtained by known processes, with resulting savings in terms of product weight and production costs.

[0114] The Applicants consider that the improved mechanical properties of the thermoformed product may be linked to the fact that the plate-like element is kept under tension along its entire perimeter after the consolidation step and up to its plastic deformation by the mould.

[0115] In that respect, the Applicants have observed that when producing a thermoformed article, for instance a suitcase shell, there is a saving of more than 10% by weight in comparison with a shell of similar dimensions and mechanical properties produced by a thermoforming process of the prior art.

[0116] A second important advantage that may be attributed to the fact that the plate-like element is held on the frame in a tensioned condition after the consolidation step, lies in the fact that the plate-like element may achieve a greater level of deformation than a similar plate-like element thermoformed after consolidation without being kept under tension.

[0117] The Applicants have observed in that respect that, by means of the process of the present invention, the plate-like element may be thermoformed to obtain a thermoformed article, for instance a suitcase shell, having a depth of more than 10% more than a suitcase shell obtained from a similar plate-like element thermoformed by a process in which the plate-like element is not kept under tension after the consolidation stage.

[0118] A further advantage lies in the fact that, by means of the process of the present invention in which the plate-like element is kept under tension along its entire perimeter after the consolidation stage and up to its subsequent thermoforming, it is possible to carry out the moulding stage using moulds of the multi-cavity type, thereby increasing production volumes with no adverse effect on the quality of the thermoformed product.

[0119] A further advantage of the invention lies in the fact that the process may be carried out using relatively simple apparatus.

[0120] The present invention thus resolves the problem discussed above with respect to the cited prior art and, at the same time, offers advantages over and above those described above.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- DE20207919 [0019]
- JP2008279700B [0019]

P A T E N T K R A V

1. Fremgangsmåde til termoformning af et pladelignende element (10) af kompositpolymermateriale, hvori et centralt område (11) og et perifert område (12), som omgiver det centrale område, er defineret, hvor fremgangsmåden omfatter:

- 5 - at tilvejebringe en form (1), som indbefatter et hanelement (3), der er formet i en udformning som det er tilsigtet at overføre til det pladelignende element, og et hunelement (4), som er modsat formet i forhold til hanelementet, hvor han- og hunelementerne kan forskydes mellem en driftsstilling af formen, hvori de presses mod hinanden, og en ikke-driftsstilling, hvori de er anbragt i afstand fra hinanden,
- 10 - at anbringe det pladelignende element (10) på formen således, at dets centrale område (11) er anbragt mellem hanelementet og hunelementet, når det forskydes til ikke-driftsstillingen,
- at holde det perifere område (12) af det pladelignende element ved hjælp af en flerhed af stifter (7), som har en fri ende (7a), og som er tilknyttet formen, og som er i indgreb med
- 15 en tilsvarende flerhed af huller (13), som er tilvejebragt i det perifere område,
- at forskyde hanelementet (3) og hunelementet (4) hen imod driftsstillingen, indtil de støder op til det pladelignende element og begynder at deformere det pladelignende element imod udformningen af hanelementet og hunelementet, mens der fortsat holdes i det perifere område af det pladelignende element,
- 20 -at fuldføre forskydningen af hanelementet og hunelementet imod driftsstillingen og fastholde dem i driftsstillingen i en forudbestemt tid således, at det centrale område af det pladelignende element termoforms til den tilsigtede udformning,
- at forskyde hanelementet og hunelementet til ikke-driftsstillingen og at fjerne det termoformede pladelignende element fra formen,
- 25 k e n d e t e g n e t ved, at stifterne (7) er anbragt på en mobil ramme (6a), som kan fjernes fra formen (1) for at bevæge det pladelignende element til og fra formen, mens det pladelignende element holdes ved hjælp af stifterne (7).

2. Fremgangsmåde ifølge krav 1, hvor kompositpolymermaterialet omfatter en flerhed af forstærkningsfibre, som er fremstillet af et første materiale, og som coatet af en matrice,

30 som er fremstillet af et andet termoplastisk polymerbaseret materiale, hvor det første materiale er en udstrakt termoplastisk polymer, som har et smeltepunkt, der er større end smeltepunktet af det andet materiale.

3. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor kompositmaterialet er selvforstærket polypropylen.

35 4. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor det pladelignende element (10) omfatter en flerhed af overlejrede lag (10a), som er fremstillet af kompositpolymermaterialet, og som er dannet ved at overlejre flerheden af lag (10a) på hinanden for at danne en stak af lag, som er separate fra hinanden, og at tilvejebringe

hullerne (13) i deres perifere område (12), og hvor stakken af overlejrede plader (10a) er, før det pladelignende element anbringes i formen, udsat for et trin med opvarmning og tryk for i det mindste delvist at smelte det andet materiale af kompositmaterialet til at gøre de overlejrede lag stive i forhold til hinanden i det centrale område (11).

5 5. Fremgangsmåde ifølge et hvilket som helst af kravene 4, hvor et færdigbehandlingslag (10b) af termoplastisk polymermateriale er anbragt på stakken af kompositmaterialeplader i en udvendig position i forhold til stakken for at forsyne det pladelignende element (10) med en ønsket overfladebeskaffenhed og et papirlag (10c) til sublimationstryk, hvorpå der er tilvejebragt en grafisk dekoration, og som er anbragt over færdigbehandlingslaget (10b) på
10 siden, som er modsat stakken af kompositmaterialelag (10a), således at sublimationstrykket af den grafiske dekoration på færdigbehandlingslaget tilvejebringes under opvarmnings- og tryktrinnet.

6. Fremgangsmåde ifølge et hvilket som helst af kravene 4 eller 5, hvor de overlejrede lag er separate fra hinanden i deres perifere område, når det pladelignende element er anbragt
15 i formen.

7. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor stifterne (7) er frigjort fra hullerne (13), som er tilvejebragt i det perifere område af det pladelignende element, før han- og hunelementerne er fuldt forskudt hen til driftsstillingen.

8. Fremgangsmåde ifølge krav 7, hvor stifterne (7) er frigjort fra hullerne (13), som er til-
20 vejbragt i det perifere område af det pladelignende element, før han- og hunelementet er fuldt forskudt hen til driftsstillingen, når forlængelsen af det pladelignende element (10) efter termoformning er større end en værdi på ca. 15%.

9. Fremgangsmåde ifølge et hvilket som helst af kravene 4 til 8, hvor stakken af separate og overlejrede lag er fastgjort på rammen (6a) inden den gøres stiv i det centrale område
25 (11), og hvor rammen derefter transporteres sammen med det pladelignende element til formen.

10. Form (1) til termoformning af et pladelignende element (10) af kompositpolymermateriale, omfattende:

- et hanelement (3), der er formet i en udformning som det er tilsigtet at overføre til det
30 pladelignende element, og et hunelement (4), som er modsat formet i forhold til hanelementet, hvor han- og hunelementerne kan forskydes mellem en driftsstilling af formen, hvori de presses mod hinanden, og en ikke-driftsstilling, hvori de er anbragt i afstand fra hinanden,

- en bevægelsesindretning (5), som er anbragt til at forskyde hanelementet og/eller hunelementet mellem drifts- og ikke-driftsstillingerne,

35 - en holdeindretning (6) til det pladelignende element, designet til at holde det pladelignende element (10) ved dets perifere område (12), mens hanelementet og hunelementet forskydes mod hinanden hen til driftsstillingen, således at de støder mod det pladelignende element i dets centrale område (11), hvor holdeindretningen (6) omfatter et antal stifter (7) med en fri ende, som kan være i indgreb med det pladelignende element i en tilsvarende flerhed af

huller (13), som er tilvejebragt i sin perifere region (12), k e n d e t e g n e t ved, at stifterne (7) er anbragt på en mobil ramme (6a), som er aftageligt tilknyttet med formen for at bevæge det pladelignende element til og fra formen, mens det pladelignende element holdes af stifterne (7).

5 11. Form ifølge krav 10, hvor stifterne (7) er anbragt i række i en afstand fra nabostifter på mellem 2 mm og 10 mm.

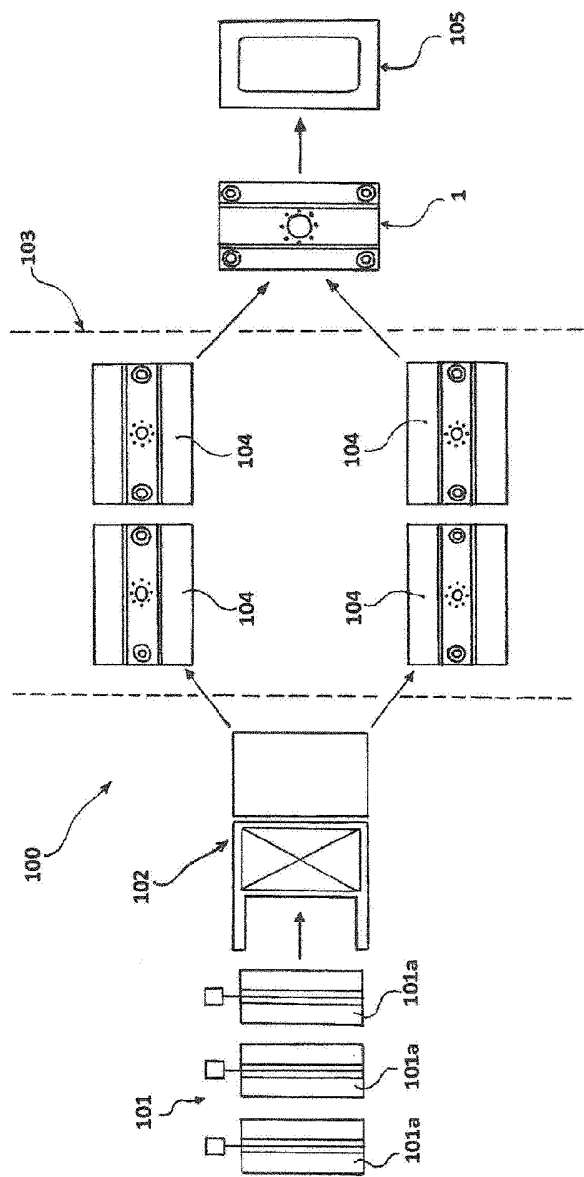
 12. Form ifølge krav 10 eller 11, hvor rammen (6a) er anbragt i forhold til hunelementet (4), således at den kan bevæge sig, i forhold til hunelementet, væk fra hanelementet efter forskydningen af hanelementet hen mod driftsstillingen for at muliggøre frigørelsen af det pladelignende element (10) fra rammen (6a) via den frie ende (7a) af stifterne (7).

10 13. Form ifølge et hvilket som helst af kravene 10 til 12, hvor en første kæbe (21) og en anden kæbe (22) er fastgjort på henholdsvis hanelementet (3) og hunelementet (4) og er designet til at støde imod og holde det pladelignende element (10) ved dets perifere område (12), når hanelementet og hunelementet forskydes hen imod hinanden, inden de når driftsstillingen.

15 14. Form ifølge krav 13, hvor den første kæbe (21) og den anden kæbe (22) er fastgjort på respektive første fjedre (25, 27), som er designet til at tvinge den første og anden kæbe mod hinanden.

20 15. Form ifølge krav 13 eller 14, hvor den første kæbe (21) og den anden kæbe (22) kan glide hen imod et hoved (3a) af hanelementet (3) og et hulrum (4a) af hunelementet (4) og er forsynet med respektive anden fjedre (26, 28) for at styre glidningen af den første og anden kæbe mod hovedet og hulrummet.

DRAWINGS



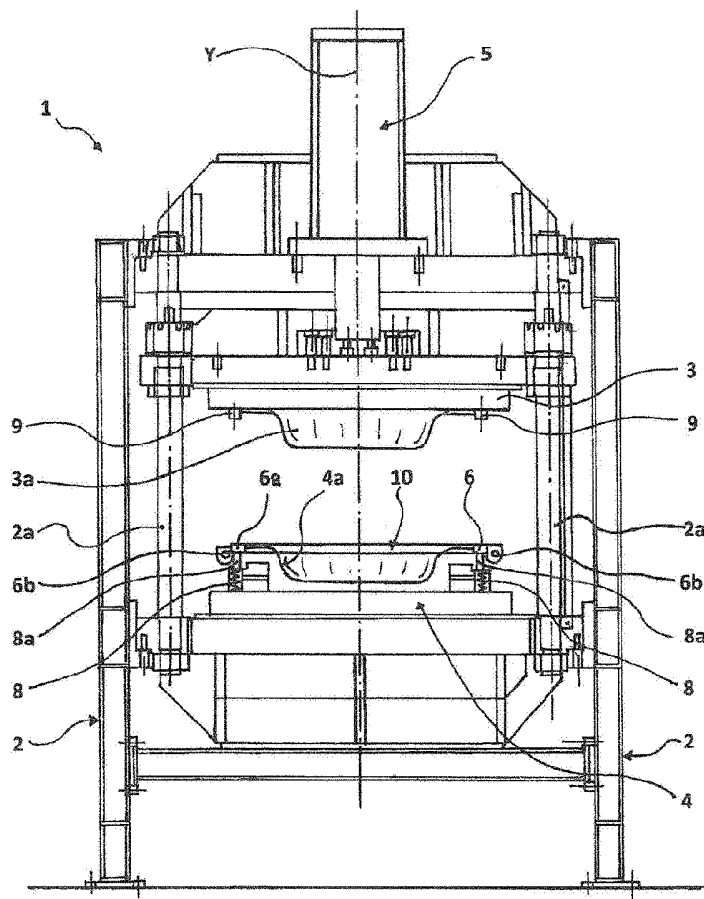


FIG.2

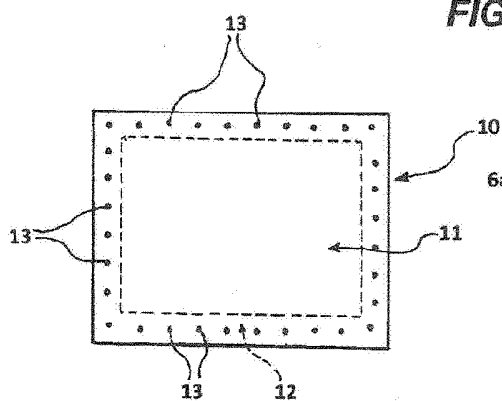


FIG.3

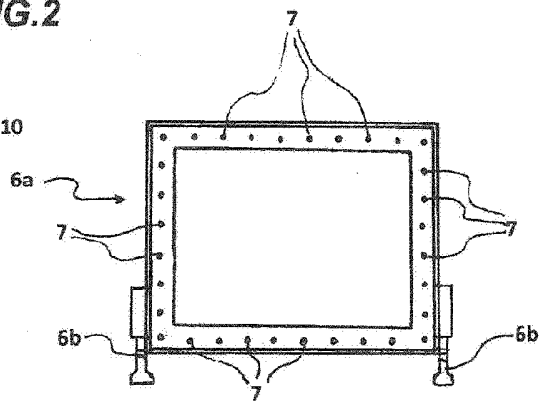


FIG.4

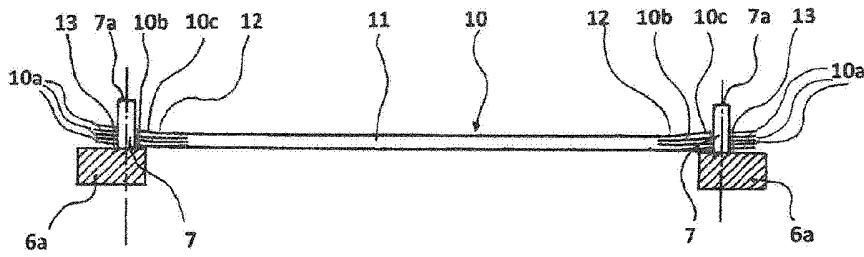


FIG. 5

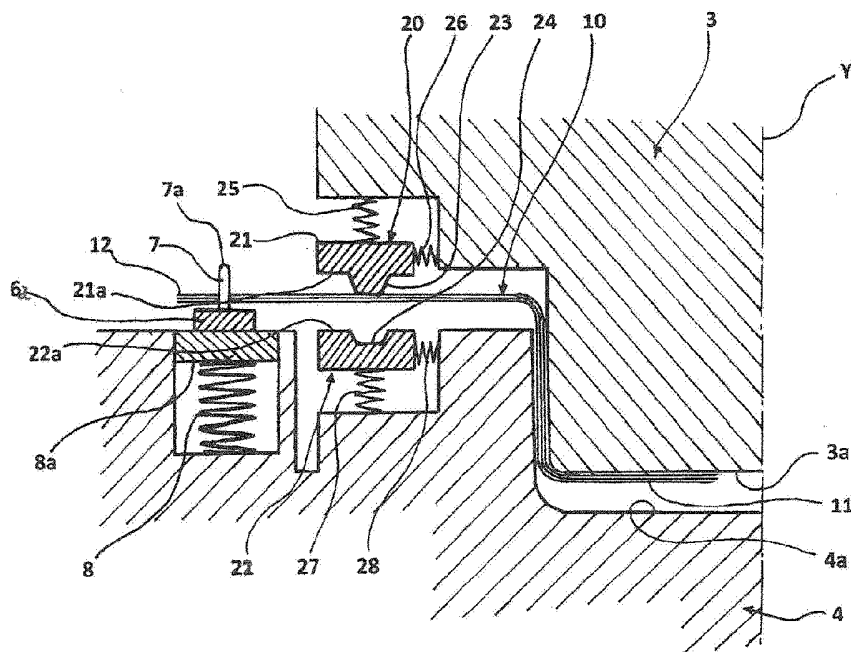


FIG. 6