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(54) **APPARATUS FOR DRY MANUFACTURING RIGID CELLULOSE PRODUCTS**

(57) The present invention relates to an apparatus for dry manufacturing rigid cellulose products (2) having essentially non-flat general shape from a cellulose blank (10), the apparatus (1) comprising a moulding tool having a male mould part (15) and a female mould part (16) having co-operating designs, wherein at least one of the male mould part (15) and the female mould part (16) is displaceable in an axial direction in relation to the other in order to press the cellulose blank (10) therebetween into final shape by applying a predetermined pressure P in the axial direction of the moulding tool, wherein the male mould part (15) comprises a main projection (18) having a bottom surface (19), a wall surface (20) extending essentially in the axial direction, and a transitional edge surface (21) located between the bottom surface (19) and the wall surface (20), and wherein the female mould part (16) comprises a main recess (17) having a bottom surface (22), a wall surface (23) extending essentially in the axial direction, and a transitional edge surface (24) located between the bottom surface (22) and the wall surface (23). The apparatus is characterized in that the friction coefficient between the wall surface (20) of the male mould part (15) and the cellulose blank (10) is higher than the friction coefficient between the wall surface (23) of the female mould part (16) and the cellulose blank (10).

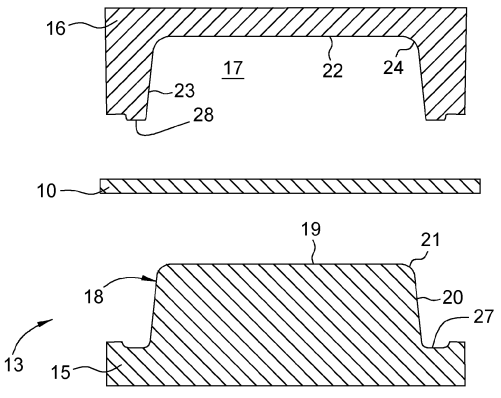

Fig. 2

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Description

Technical field of the Invention

[0001] The present invention relates in general to the field of apparatus for dry manufacturing of rigid cellulose products having non-flat general shape from a cellulose blank. The cellulose products may be used for packaging, storing, transporting and/or displaying other products such as electronics, tools, jewelry, food, dairy products, cosmetics, etc., and/or may be used as single/multiple use disposable articles. The apparatus is defined to provide rigid cellulose products having a considerable depth.

[0002] The apparatus comprises a moulding tool having a male mould part and a female mould part having cooperating designs, wherein at least one of the male mould part and the female mould part is displaceable in an axial direction in relation to the other in order to press the cellulose blank therebetween into final shape by applying a predetermined pressure P in the axial direction of the moulding tool, wherein the male mould part comprises a main projection having a bottom surface, a wall surface extending essentially in the axial direction, and a transitional edge surface located between the bottom surface and the wall surface, and wherein the female mould part comprises a main recess having a bottom surface, a wall surface extending essentially in the axial direction, and a transitional edge surface located between the bottom surface and the wall surface.

Background of the Invention

[0003] There are many situations where it is desirable to provide two-dimensional (2D) or three-dimensional (3D) shaped objects made of sustainable materials, such as biomaterials, instead of plastic/polymer materials. A biomaterial commonly used for packaging and disposable articles is wet moulded pulp based on cellulose fibres. Such wet moulded pulp has the advantage of being considered as a sustainable material, since it is produced from biomaterials and can be recycled after use. Wet moulded pulp comprises more or less only water and separated cellulose fibers, and consequently, wet moulded pulp has been popular to use for primary packaging applications (packaging next to the article), for secondary packaging applications (assembly of such primary packages), as well as for manufacturing of disposable articles/products.

[0004] One advantage of using wet-forming techniques is that the moulding tool is filled with a wet cellulose slurry and thereafter the cellulose slurry is dried and obtains the shape of the moulding tool without any risk of cracking of the moulded cellulose product at the transitional edge portion between the bottom and the wall.

[0005] However, a common disadvantage with all wet-forming techniques is the need for large amounts of water during the preparations of the cellulose pulp and the need for drying during the manufacturing/moulding of the cellulose product, which is a time and energy consuming step leading to low production speed and substantial high investment cost in machines and tooling. Meaning that the wet-forming techniques are not feasible to replace fossil-based alternatives neither in small nor large scale production of rigid cellulose products. Thereto, the aesthetical and mechanical properties of a wet-moulded cellulose product are hard to control with desirable precision, due to un-uniform cellulose pulp and due to the wet moulding manufacturing technique *per se.*

[0006] Therefore many actors/companies, starting a few decades ago, have changed their focus and investments towards dry-forming techniques wherein rigid cellulose products are manufactured from separated cellulose fibres that are introduced into a product forming unit in the shape of a cellulose blank/web, wherein the cellulose blank is moulded/formed into the shape of the intended cellulose product and wherein the cellulose fibres are bonded to each other using heat and pressure. The dry-forming techniques comprises different steps of generating an air-laid cellulose blank, that is fed into a product forming unit, i.e. a thermo-forming press.

[0007] The technical field of dry manufacturing rigid cellulose products having non-flat general shape, such as trays, lids, or the like, i.e. wherein the forming/pressing is performed in one step using a moulding tool having a male mould part and a female mould part configured to cooperate with each other, is well known. However, the technical field of dry manufacturing rigid cellulose products having non-flat general shape and great depth, such as trays, deep plates, cups, or the like, is still exposed to challenges.

[0008] During moulding/pressing of the rigid cellulose product having non-flat general shape from the more or less flat cellulose blank, material draw and elongation in the cellulose blank will take place during the insertion of the main projection of the male mould part into the main recess of the female mould part, and during the pressing of the cellulose product. For deep cellulose products, such as a rectangular tray of about 30-50 millimetres depth, cracks will arise at the bottom region and at the transitional edge regions between the bottom and the wall, especially at the bottom corners of the transitional edge region of the tray. Deep cellulose products having other shapes of the wall, such as round or the like, also experience crack formation at the bottom region and at the transitional edge regions. Thereto, uneven thickness of the final cellulose product is a problem. Thus, the possible product shapes/designs that can be manufactured is limited.

[0009] One known way to try to solve the problem of cracked cellulose products, is to provide a coating or the like to both the projection of the male mould part and the recess of the female mould part, in order to decrease the friction between the cellulose blank and the moulding tool in order to counteract material draw and elongation. Such measures may have some positive effect during moul-

ding/pressing of shallow cellulose products having uncomplicated design. However, the inventors of the present invention have concluded by thorough research that such measures do not have any beneficial effect on the problem concerning material draw and elongation during moulding/pressing rigid cellulose products having non-flat general shape and a considerable depth, on the contrary it has negative effect resulting in more cracks in the transitional edge portion of the cellulose product.

[0010] Thus, there is still a need in the art for a reliable, cheap and unharmful dry-forming technique/process for dry manufacturing rigid cellulose products having non-flat general shape and a considerable depth.

Object of the Invention

[0011] The present invention aims at obviating the aforementioned and other disadvantages and failings of previously known apparatus for dry manufacturing rigid cellulose products, and at providing an improved apparatus for dry manufacturing rigid cellulose products having non-flat general shape and a considerable depth.

[0012] A primary object of the present invention is to provide an improved apparatus for dry forming/manufacturing rigid cellulose products having non-flat general shape and a considerable depth, wherein the environmental benefits as well as time and energy saving benefits of conventional dry-forming techniques are maintained. It is another object of the present invention to provide an improved apparatus for dry forming/manufacturing rigid cellulose products having non-flat general shape and a considerable depth, wherein the moulded/-pressed rigid cellulose product is free from cracks at the bottom region and at the transitional edge regions between the bottom and the wall. It is another object of the present invention to provide an improved apparatus for dry forming/manufacturing rigid cellulose products having non-flat general shape and a considerable depth, wherein the release angle of the moulding tool may be less than 1 degrees per millimetre depth, preferably less than 0,5 degrees per millimetre depth. It is another object of the present invention to provide an improved apparatus and method for dry forming/manufacturing rigid cellulose products having non-flat general shape and a considerable depth, wherein the final cellulose product has great dimensional accuracy.

Summary of the Invention

[0013] According to the invention at least the primary object is attained by means of the initially defined apparatus having the features defined in the independent claim. Preferred embodiments of the present invention are further defined in the dependent claims.

[0014] According to the present invention, there is provided an apparatus of the initially defined type wherein the friction coefficient between the wall surface of the male mould part and the cellulose blank is higher than the friction coefficient between the wall surface of the female mould part and the cellulose blank.

[0015] Thus, the present invention is based on the insight that it is of uttermost importance to have different surface finish/friction at different parts of the moulding tool. By having a smoother wall surface of the main recess of the female mould part than the wall surface of the main projection of the male mould part, the friction between the cellulose blank and the wall surface of the male mould part will be greater than the friction between the cellulose blank and the wall surface of the female mould part and thereby the material draw and elongation at the transitional edge region of the cellulose product will be clearly decreased, leading to crack free moulding/pressing of the cellulose product. Thus, just before and during the pressing of the cellulose product, i.e. when the cellulose blank is in firm contact with both the female mould part and the male mould part and is partly compressed, the inventors have discovered that it is important that the relative speed/displacement between the projection of the male mould part and the cellulose blank has to be less than the relative speed/displacement between the recess of the female mould part and the cellulose blank, in order to prevent the projection of the male mould part from generating cracks at the bottom region and the transitional edge region of the cellulose product.

[0016] The inventors have discovered that the previously used measure to lower the friction at both the male mould part and the female mould part by means of a coating will actually increase the effect of the projection of the male mould part piercing through the cellulose blank and/or creating cracks at the bottom region and the transitional edge region between the bottom and the wall.

[0017] According to various example embodiments of the present invention the friction coefficient between the transitional edge surface of the male mould part and the cellulose blank is higher than the friction coefficient between the transitional edge surface of the female mould part and the cellulose blank.

[0018] The greatest mutual displacement between the projection of the male mould part and the recess of the female mould part in the direction perpendicular to the thickness of the cellulose blank is at the walls of the mould parts, but also at the transitional edge region of the cellulose product there is a mutual displacement between the projection of the male mould part and the recess of the female mould part in a direction perpendicular to the thickness of the cellulose blank and thereby it is further advantageous to have greater friction between the male mould part and the cellulose blank than between the female mould part and the cellulose blank also at the transitional edge region of the cellulose product.

[0019] According to various example embodiments of the present the wall surface and the transitional edge surface of the male mould part is naked metal, and thereto it is preferred that the wall surface and the transitional edge surface of the female mould part comprises a sur-

face treatment means in order to decrease the friction coefficient between the wall surface and the transitional edge surface of the female mould part and the cellulose blank.

[0020] According to various example embodiments of the present invention the friction coefficient between the bottom surface of the male mould part and the cellulose blank is lower than the friction coefficient between the wall surface of the male mould part and the cellulose blank.

[0021] Even though there is a relatively high friction between the wall of the male mould part and the cellulose blank, there is still a mutual displacement/movement between the wall of the male mould part and the cellulose blank in a direction perpendicular to the thickness of the cellulose blank, and by having a relatively low friction between the bottom of the male mould part and the cellulose blank there is a controlled elongation of the cellulose blank from the bottom region towards the wall region in order to compensate and thereby prevent cracks at the bottom region and the transitional edge region of the cellulose product.

[0022] According to various example embodiments of the present invention the male mould part comprises a brim surface at a distal end of the wall surface, and the female mould part comprises a brim surface at a distal end of the wall surface, wherein the friction coefficient between the brim surface of the male mould part and the cellulose blank is lower than the friction coefficient between the brim surface of the female mould part and the cellulose blank. This will entail that the risk of having brim cracks is decreased.

[0023] Further advantages with and features of the invention will be apparent from the following detailed description of preferred embodiments.

Brief description of the drawings

[0024] A more complete understanding of the above-mentioned and other features and advantages of the present invention will be apparent from the following detailed description of preferred embodiments in conjunction with the appended drawings, wherein:

Fig. 1 is a schematic illustration of a production line or apparatus for dry manufacturing rigid cellulose products,

Fig. 2 is a schematic illustration of an inventive moulding tool comprising a male mould part and a female mould part, wherein a cellulose blank is provided into the moulding tool,

Fig. 3 is a schematic illustration of the moulding tool according to figure 2 during forming/pressing of the cellulose product,

Fig. 4 is a schematic illustration of the moulding tool according to figures 2 and 3 after the forming/-pressing step and the cellulose product is released from the moulding tool, and

Fig. 5 is a schematic illustration of a cellulose product wherein the scrap area is removed from the cellulose product.

Detailed description of preferred embodiments of the invention

[0025] As used herein, the term "air/dry moulding/-forming or air/dry laying/laid" means a well-known method according to which separated cellulose fibres are formed into a cellulose blank/sheet.

[0026] In air-laying technique, small/short fibres having a normal length in the range of 0,5 to 70 mm, for instance 1 to 50 mm, are separated and captured by an air stream/flow, and then laid on/applied to a forming mesh/surface, usually using an under-pressure at the other side of the mesh/surface. The general terms "air/-dry laying" and "air/dry moulding" are used interchangeably herein. The cellulose fibre carrying air flow may be generated by suitable device located upstream and/or downstream the forming mesh/surface.

[0027] Reference is initially made to figures 1 and 5, wherein figure 1 disclose a schematic illustration of a generic production line/apparatus for dry manufacturing rigid cellulose products, generally designated 1. The production line 1 is configured for manufacturing rigid cellulose products, generally designated 2, having essentially non-flat general shape from separated cellulose fibres. Such a production line/apparatus 1 may be arranged and set-up according to different well-known ways.

[0028] Figure 5 disclose a rigid cellulose product 2 constituted by a rectangular container/tray, wherein the tray is formed using the inventive method. The cellulose product 2 comprises a container wall 3 and an opening 4 defined by a circumferential rim/brim 5 located at the upper/free end of the container wall 3. According to figure 5 embodiment the brim 5 has an angled shape having an essentially radially extending upper surface and a turned-down outer edge, however it shall be pointed out that the cross-section of the brim 5 may have other shapes. The tray 2 may have truncated cone shape having straight wall 3, narrowing in the direction away from the opening 4, in accordance with figure 5 embodiment, or may for instance have curved-shaped wall 3 seen in the axial plane. Thereby multiple trays 2 are stackable one inside the other when they are empty. The cross section of the wall 3 in the radial plane may have any suitable shape, circular, oval, rectangular, polygonal, etc., and may differ in shape and/or dimension along the axial extension of the tray 2. The tray 2 may comprise a flat bottom 6, or the bottom may comprise local ribs, projections, etc., for strength and rigidity of the cellulose product 2. The bottom 6 may be located at the very lower end of the wall 3, according to figure 5 embodiment, or be located at a distance from the lower end of the wall 3, or a combination thereof. The walls of the moulding tool has to be inclined in order to obtain a release angle for the cellulose product

2, and in order to obtain adequate press force to the wall region of the cellulose product 2.

[0029] In connection to the present invention, i.e. the difference in friction coefficient entails that, the release angle may be equal to or less than 1 degrees per millimetre depth of the cellulose product 2, preferably equal to or less than 0,75 degrees per millimetre depth. The present invention entails that the release angle may be as small as 0,35 degrees per millimetre depth. However, the release angle shall not be below 5 degrees independently on the depth of the cellulose product 2. In connection with the present invention and the above-mentioned release angles, the depth of the cellulose product 2 can be up to at least 50 millimetres, and the problem of cracking is of rare occurrence at depths less than 10 millimetres. It shall be pointed out that the release angle of course may be much more than 1 degrees per millimetre depth, but for such designs the problem of cracking is of rare occurrence. It shall be pointed out that the present invention is applicable also for cellulose products having minor depth, such as 0-20 millimetres.

[0030] Cellulose raw material 7 is provided to the production line, and is fed to a separating/ disintegrating unit 8 in order to obtain individualized/separated cellulose fibres. The separated cellulose fibres are thereafter transported by an air stream/flow to a dispenser of a cellulose blank/sheet forming unit 9. The cellulose fibres are laid by the dispenser on a moving or stationary perforated surface of the cellulose blank forming unit 9. The cellulose fibre carrying air flow may be generated by suitable device located upstream and/or downstream the perforated surface. Thereafter the generated cellulose blank, generally designated 10, is transported/ transferred to a product forming unit 11, whereby rigid cellulose products 2 are formed and discharged from the product forming unit 11.

[0031] The cellulose blank forming unit 9 may be configured to generate a continuous cellulose blank 10 and/or discontinuous/discrete cellulose blanks 10. Preferably discontinuous/discrete cellulose blanks 10 are fed into the product forming unit 11.

[0032] The cellulose raw material 7 may be in the form of reeled pulp or paper, bale of cellulose pulp, paper, etc. and/or sheets of paper, cellulose pulp, etc. In case said cellulose raw material 7 is in the form of sheets and/or reeled pulp or paper, it can be fed directly into the separating unit 8. However, in case said cellulose raw material 7 is in the form of a bale or compact stacks of sheets, etc. one or more shredders and/or one or more additional separating/disintegrating units 8 may be necessary to be used for separating and dosing said cellulose raw material 7 from said bale or sheets in smaller quantities. The shredder(s) prepare cellulose raw material 7 to be accepted by said separating unit 8. The separating unit 8 disintegrates the cellulose raw material 7 into separated cellulose fibres. Said one or plurality of shredder(s) are arranged before said one or a plurality of separating unit(s) 8, so that an output of one of said shredder is connected to an input of one of said separating units 8. The shredders may be arranged in parallel to each other or in series with each other, and the disintegrating units 8 may be arranged in parallel to each other or in series with each other. The shredders and the disintegrating units 8 together constitute a cellulose fibre separating unit, arranged upstream the cellulose blank forming unit 9.

[0033] Said cellulose raw material 7 may be constituted by virgin cellulose fibres and/or recycled cellulose fibres and may originate from wood pulps such as kraft pulp, sulphite pulp, mechanical pulp, thermomechanical pulp (TMP), chemical treated mechanical pulp, chemithermomechanical pulp (CTMP), and/or from non-wood pulps such as bagasse, bamboo, abaca, hemp, flax, cotton.

[0034] The separating unit 8 may according to various embodiments be constituted by a hammer mill. In said separating unit 8 the cellulose raw material is separated into fibres having a normal length in the range of 0,5-70 mm. The length of said fibres may be customized by adjusting the internal properties of the separating unit 8 and/or by choosing a different separating unit 8 and/or choosing different cellulose raw material. The fibre length for wood pulp is according to various embodiments in the range 0,5-4 mm, preferably in the range 1,7-3,6 mm. According to various embodiments the fibre length for non-wood pulp is in the range 0,5-70 mm.

[0035] The production line 1 may comprise a pre-compression and/or imprinting unit 12, located downstream the cellulose blank forming unit 9 and upstream the product forming unit 11. In the pre-compression and/or imprinting unit 12, an air-laid fluffy cellulose blank 10 having a first thickness may be compressed into a cellulose blank 10 having a second thickness, wherein said second thickness is thinner than said first thickness, and/or may be provided with an imprinting pattern. During the pre-compression/imprinting the cellulose blank is made more coherent and easier to handle, since the pre-compression/imprinting generates internal bindings between individual cellulose fibres preventing mutual separation of the cellulose fibres.

[0036] The product forming unit 11 comprises a press unit 13, and may optionally comprise a pre-heating unit 14 arranged upstream the press unit 13. According to various example embodiments said cellulose blank 10 may be heated to an elevated temperature before being fed into the press unit 13 of the product forming unit 11. In such embodiment(s) where the cellulose blank 10 is preheated before being fed into the press unit 13, said press unit 13 may or may not comprise heating. According to various example embodiment said press unit 13 may be a heated press unit 13 for heating said cellulose blank 10 during pressing. In the case of a heated press unit 13, preheating of said cellulose blank 10 using a pre-heating unit 14 is optional. According to various example embodiments preheating of the cellulose blank 10 in said pre-heating unit 14 may be combined with a heated press unit 13. Having a pre-heating unit 14 in combination with a

heated press unit 13 will speed up the manufacturing process in the product forming unit 11, and improve the quality/rigidity of the final rigid cellulose product 2. In the product forming unit 11 the cellulose blank 10 is heated to a temperature in the range 120 - 200 °C in order to obtain adequate rigidity and strength in the final cellulose product 2.

[0037] Reference is now made to figures 2-4, disclosing an example embodiment of the present invention. The press unit 13 comprises a moulding tool having a first mould part 15 and a second mould part 16 having cooperating designs, wherein at least one of the first mould part 15 and the second mould part 16 is/are displaceable in the axial direction in relation to the other, i.e. reciprocating back and forth in relation to each other, in order to exert pressure to the cellulose blank 10 loaded therebetween. In the figures the mutual displacement is disclosed as being vertical, however the mutual displacement may be horizontal or any other suitable angle. The cellulose blank 10 loaded into the moulding tool, is preferably constituted by an air-laid cellulose blank. The cellulose blank 10 may be generated upstream the product forming unit 11 in the same apparatus/production line and provided/transferred to the product forming unit 11, or may be generated at a separate location and provided/transferred to the product forming unit 11 via intermediate handling and storage.

[0038] According to various embodiments the second mould part 16 of the moulding tool is a female mould part, i.e. having a main recess 17 for receiving the cellulose blank 10, and the first mould part 15 of the moulding tool is a male mould part, i.e. having a main projection 18 for cooperation with said main recess 17 of the female mould part by being inserted therein, such that during the pressing/forming step the cellulose blank 10 is pressed into a final rigid non-flat shape, which may be any conceivable non-flat design/shape. It shall be pointed out that according to various embodiments, the male mould part 15 is located above the female mould part 16.

[0039] The main projection 18 of the male mould part 15 has a bottom surface 19, a wall surface 20 extending essentially in the axial direction, and a transitional edge surface 21 located between the bottom surface 20 and the wall surface 21. The main recess 17 of the female mould part 16 has a bottom surface 22, a wall surface 23 extending essentially in the axial direction, and a transitional edge surface 24 located between the bottom surface 22 and the wall surface 23. The cellulose blank 10 is pressed between the surfaces of the male mould part 15 and the surfaces of the female mould part 16 into final shape by applying a predetermined pressure P in the axial direction of the moulding tool.

[0040] Radially outside the final rigid cellulose product 2, the cellulose blank 10 comprises a scrap area 25 intended to be cut off during the pressing of the cellulose product 2 or after the pressing of the cellulose product 2. The scrap area may be left entirely uncompressed in the moulding tool, be partially compressed by applying a predetermined partial pressure less than said predetermined pressure P, or be fully compressed by applying said predetermined pressure P.

[0041] The predetermined pressure P is in the range 40-10000N/cm^2, preferably in the range 100-4000N/cm^2. According to various embodiments said predetermined pressures are above 1000 N/ cm^2, and according to various embodiments said predetermined pressures are below 2500 N/ cm^2. The holding time during the pressing step is in equal to or more than 0,5 seconds and equal to or less than 10 seconds, preferably less than 5 seconds, and most preferably less than 3 seconds.

[0042] According to the invention the friction coefficient between the wall surface 20 of the male mould part 15 and the cellulose blank 10 is higher than the friction coefficient between the wall surface 23 of the female mould part 15 and the cellulose blank 10. Thus, during pressing of the cellulose product 2, at a specific location of the cellulose blank 10 there is a force from the wall surface 20 of the main projection 18 acting perpendicular towards the cellulose blank 10, and there is a corresponding and opposite force from the wall surface 23 of the main recess 17 acting perpendicular towards the cellulose blank 10. Since the normal force is the same and the frictional coefficient differs, the frictional force between the male mould part 15 and the cellulose blank 10 is higher than the frictional force between the female mould part 16 and the cellulose blank 10 and thereby the mutual displacement/velocity at the specific location perpendicular to the thickness of the cellulose blank 10 is higher between the female mould part 16 and the cellulose blank 10 than between the male mould part 15 and the cellulose blank 10.

[0043] Thereby the cellulose blank 10 will follow the main projection 18 of the male mould part 15 into the main recess 17 of the female mould part 16, and the risk of cracking at the bottom region 6 and the transitional edge region 26 of the cellulose product 2 is prevented. The friction coefficient between the wall surface 20 of the male mould part 15 and the cellulose blank 10 is preferably equal to or more than a factor 1,5 times the friction coefficient between the wall surface 23 of the female mould part 15 and the cellulose blank 10, preferably equal to or more than a factor 1,75, and most preferably equal to or more than a factor 2. The greater the difference the better crack prevention. It shall be pointed out that said friction coefficient relationship is applied mutatis mutandis to the other pairs of surfaces of the male mould part 15 and of the female mould part 16. Thus, the difference in friction coefficient entails that the wall surface 20 of the male mould part 15 is rougher and/or generates higher friction than the wall surface 23 of the female mould part 16, or in other words that the wall surface 23 of the female mould part 16 is smoother and/or generates less friction than the wall surface 20 of the male mould part 15.

[0044] Preferably the wall surface 20 of the male mould

part 15 is naked metal, and the male mould part 15 is for instance made of steel and/or aluminium. Preferably the transitional edge surface 21 of the male mould part 15 is naked metal.

[0045] According to various embodiments, the wall surface 23 of the female mould part 16 comprises a surface treatment means and/or is machined in order to decrease the friction coefficient between the wall surface 23 of the female mould part 16 and the cellulose blank 10. According to various embodiments, the transitional edge surface 24 of the female mould part 16 comprises a surface treatment means and/or is machined in order to decrease the friction coefficient between the transitional edge surface 24 of the female mould part 16 and the cellulose blank 10. Surface treatment means is for instance constituted by a coating applied to the surface in question. The coating needs to be firmly connected to the surface of the female mould part 16 in order not to contaminate the cellulose product 2. The surface roughness/finish of the wall surface 20 of the male mould part 15 is preferably in the range Ra 0,8-2 micrometres, and the machined/polished wall surface 23 of the female mould part 16 is preferably in the range Ra 0,1-0,4 micrometres. It shall be pointed out that said surface roughness relationship is applied mutatis mutandis to the other parts/surfaces of the male mould part 15 and of the female mould part 16.

[0046] According to various embodiments the friction coefficient between the transitional edge surface 21 of the male mould part 15 and the cellulose blank 10 is higher than the friction coefficient between the transitional edge surface 24 of the female mould part 16 and the cellulose blank 10. This will further reduce the risk of having crack formation at the bottom region 6 and the transitional edge region 26 of the cellulose product 2. The transitional edge surface 24 of the female mould part 16 comprises a surface treatment means and/or is machined in order to decrease the friction coefficient between the transitional edge surface 21 of the female mould part 16 and the cellulose blank 10. Preferably, the friction coefficient between the transitional edge surface 21 of the male mould part 15 and the cellulose blank 10 is essentially equal to the friction coefficient between the wall surface 20 of the male mould part 15 and the cellulose blank 10. Preferably, the friction coefficient between the transitional edge surface 24 of the female mould part 16 and the cellulose blank 10 is essentially equal to the friction coefficient between the wall surface 23 of the female mould part 16 and the cellulose blank 10.

[0047] According to various embodiments the friction coefficient between the bottom surface 19 of the male mould part 15 and the cellulose blank 10 is lower than the friction coefficient between the wall surface 20 of the male mould part 15 and the cellulose blank 10. The bottom surface 19 of the male mould part 15 may comprise a surface treatment means and/or be machined in order to decrease the friction coefficient between the bottom surface 19 of the male mould part 15 and the cellulose blank 10. Thereby, during the pressing of the cellulose blank 10, there is a controlled material draw and elongation between the bottom surface 19 of the male mould part and the bottom surface 22 of the female mould part 16 in order to support the relative displacement between the main projection 18 of the male mould part 15 and the cellulose blank 10 at the wall surface of the male mould part 15. Preferably, the friction coefficient between the bottom surface 19 of the male mould part 15 and the cellulose blank 10 is essentially equal to the friction coefficient between the bottom surface 22 of the female mould part 16 and the cellulose blank 10. Preferably bottom surface 22 of the female mould part 16 comprises a surface treatment means and/or is machined in order to decrease the friction coefficient between the bottom surface 22 of the female mould part 16 and the cellulose blank 10.

[0048] According to various embodiments the male mould part 15 comprises a brim surface 27 at a distal end of the wall surface 20 of the main projection 18, and the female mould part 16 comprises a corresponding brim surface 28 at a distal end of the wall surface 23 of the main recess 17, wherein the friction coefficient between the brim surface 27 of the male mould part 15 and the cellulose blank 10 is lower than the friction coefficient between the brim surface 28 of the female mould part 16 and the cellulose blank 10. Thus, it shall be pointed out that this friction coefficient interrelationship is the opposite to the friction coefficient interrelationship between the wall surfaces of the male and female mould parts. Preferably, the friction coefficient between the brim surface 27 of the male mould part 15 and the cellulose blank 10 is essentially equal to the friction coefficient between the wall surface 23 of the female mould part 16 and the cellulose blank 10. Preferably, the friction coefficient between the brim surface 28 of the female mould part 16 and the cellulose blank 10 is essentially equal to the friction coefficient between the wall surface 20 of the male mould part 15 and the cellulose blank 10.

[0049] Preferably the brim surface 28 of the female mould part 16 is naked metal, and preferably the brim surface 27 of the male mould part 15 comprises a surface treatment means and/or is machined in order to decrease the friction coefficient between the brim surface 27 of the male mould part 15 and the cellulose blank 10. The female mould part 16 is preferably made of steel and/or aluminium.

[0050] According to various embodiments the male mould part 15 comprises a scrap surface 29 arranged radially outside the brim surface 27, wherein the friction coefficient between the scrap surface 29 of the male mould part 15 and the cellulose blank 10 is lower than the friction coefficient between the wall surface 20 of the male mould part 15 and the cellulose blank 10. According to various embodiments the female mould part 16 comprises a scrap surface 30 arranged radially outside the brim surface 28, wherein the friction coefficient between the scrap surface 30 of the female mould part 16 and the cellulose blank 10 is lower than the friction coefficient

between the wall surface 20 of the male mould part 15 and the cellulose blank 10. Thereby, during the pressing of the cellulose blank 10, there is a controlled material draw and elongation between the scrap surface 29 of the male mould part and the scrap surface 30 of the female mould part 16 in order to support the relative displacement between the main recess 17 of the female mould part 16 and the cellulose blank 10 at the wall surface 23 of the female mould part 16.

Feasible modifications of the Invention

[0051] The invention is not limited only to the embodiments described above and shown in the drawings, which primarily have an illustrative and exemplifying purpose. This patent application is intended to cover all adjustments and variants of the preferred embodiments described herein, thus the present invention is defined by the wording of the appended claims and the equivalents thereof. Thus, the equipment may be modified in all kinds of ways within the scope of the appended claims.

[0052] Throughout this specification and the claims which follows, unless the context requires otherwise, the word "comprise", and variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or steps or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

Claims

1. Apparatus for dry manufacturing rigid cellulose products (2) having essentially non-flat general shape from a cellulose blank (10), the apparatus (1) comprising a moulding tool having a male mould part (15) and a female mould part (16) having co-operating designs, wherein at least one of the male mould part (15) and the female mould part (16) is displaceable in an axial direction in relation to the other in order to press the cellulose blank (10) therebetween into final shape by applying a predetermined pressure P in the axial direction of the moulding tool,

    - wherein the male mould part (15) comprises a main projection (18) having a bottom surface (19), a wall surface (20) extending essentially in the axial direction, and a transitional edge surface (21) located between the bottom surface (19) and the wall surface (20), and
    - wherein the female mould part (16) comprises a main recess (17) having a bottom surface (22), a wall surface (23) extending essentially in the axial direction, and a transitional edge surface (24) located between the bottom surface (22) and the wall surface (23),

    characterized in that:
    the friction coefficient between the wall surface (20) of the male mould part (15) and the cellulose blank (10) is higher than the friction coefficient between the wall surface (23) of the female mould part (16) and the cellulose blank (10).

2. The apparatus according to claim 1, wherein the friction coefficient between the transitional edge surface (21) of the male mould part (15) and the cellulose blank (10) is higher than the friction coefficient between the transitional edge surface (24) of the female mould part (16) and the cellulose blank (10).

3. The apparatus according to claim 1 or 2, wherein the wall surface (20) and the transitional edge surface (21) of the male mould part (15) is naked metal.

4. The apparatus according to any of claims 1-3, wherein the wall surface (23) and the transitional edge surface (24) of the female mould part (16) are machined in order to decrease the friction coefficient between the wall surface (23) and the transitional edge surface (24) of the female mould part (16) and the cellulose blank (10).

5. The apparatus according to any preceding claim, wherein the wall surface (23) and the transitional edge surface (24) of the female mould part (16) comprises a surface treatment means in order to decrease the friction coefficient between the wall surface (23) and the transitional edge surface (24) of the female mould part (16) and the cellulose blank (10).

6. The apparatus according to any preceding claim, wherein the friction coefficient between the bottom surface (19) of the male mould part (15) and the cellulose blank (10) is lower than the friction coefficient between the wall surface (20) of the male mould part (15) and the cellulose blank (10).

7. The apparatus according to any preceding claim, wherein the male mould part (15) comprises a brim surface (27) at a distal end of the wall surface (20), and the female mould part (16) comprises a brim surface (28) at a distal end of the wall surface (23), wherein the friction coefficient between the brim surface (27) of the male mould part (15) and the cellulose blank (10) is lower than the friction coefficient between the brim surface (28) of the female mould part (16) and the cellulose blank (10).

8. The apparatus according to any preceding claim, wherein the male mould part (15) comprises a scrap surface (29) arranged radially outside the brim surface (27), wherein the friction coefficient between the scrap surface (29) of the male mould part (15) and

the cellulose blank (10) is lower than the friction coefficient between the wall surface (20) of the male mould part (15) and the cellulose blank (10).

9. The apparatus according to any preceding claim, wherein the male mould part (15) and the female mould part (16) are made of metal.

10. The apparatus according to any preceding claim, wherein the cellulose blank (10) is composed of an air-laid cellulose blank.

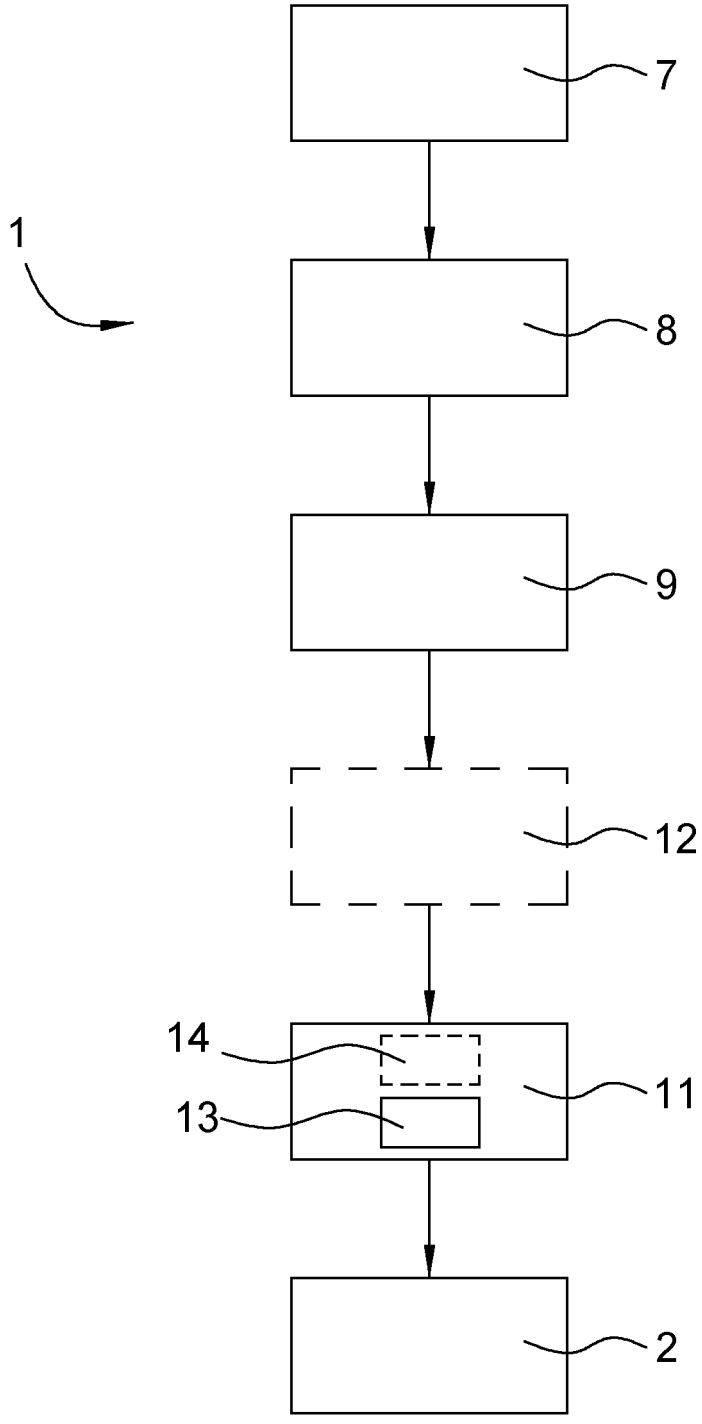

Fig. 1

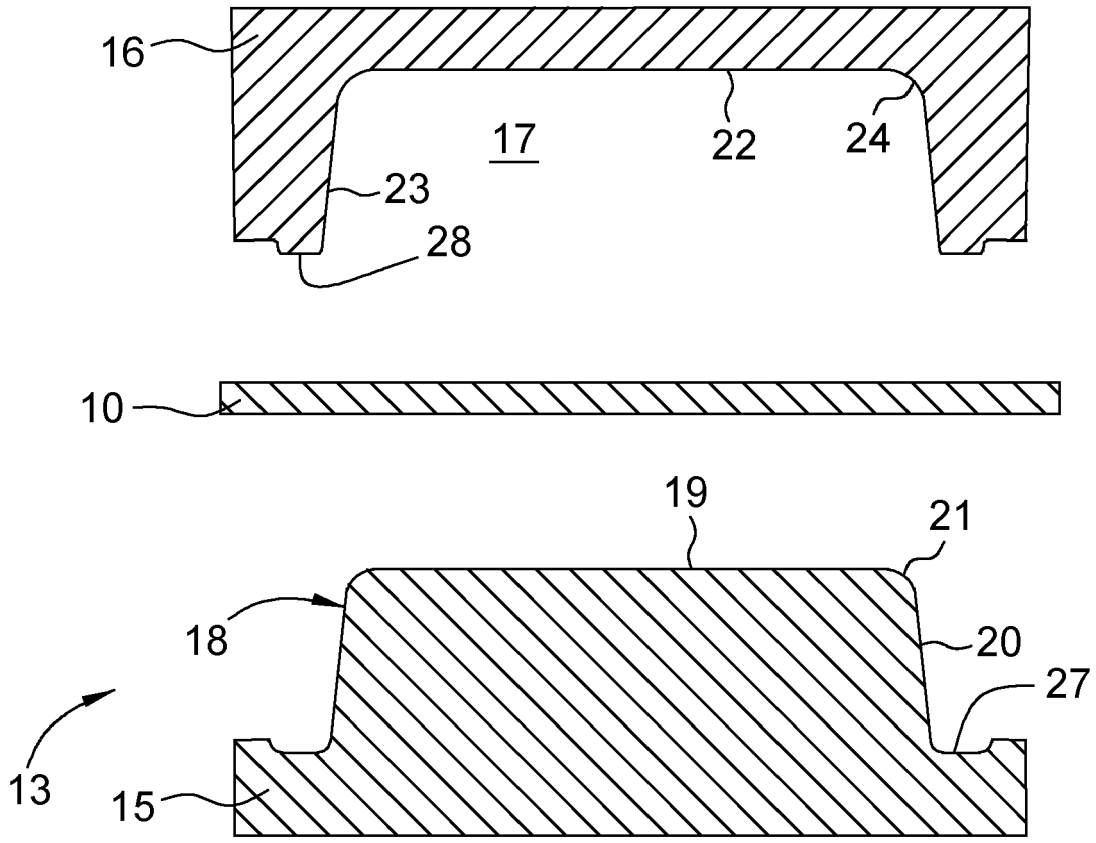

Fig. 2

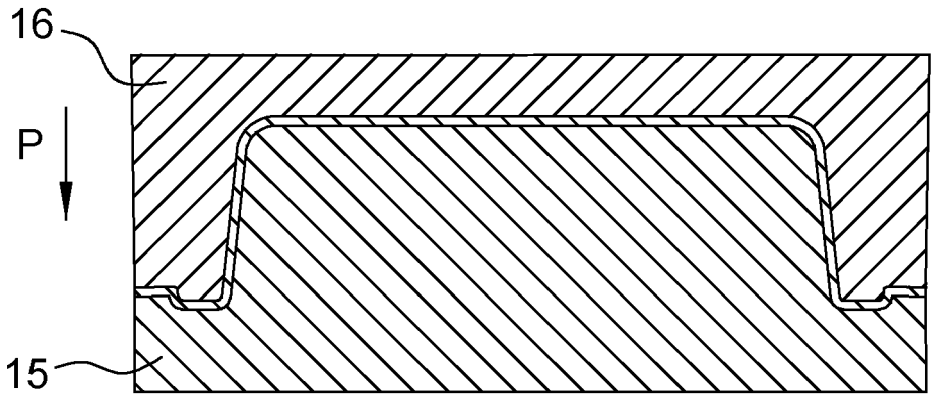

Fig. 3

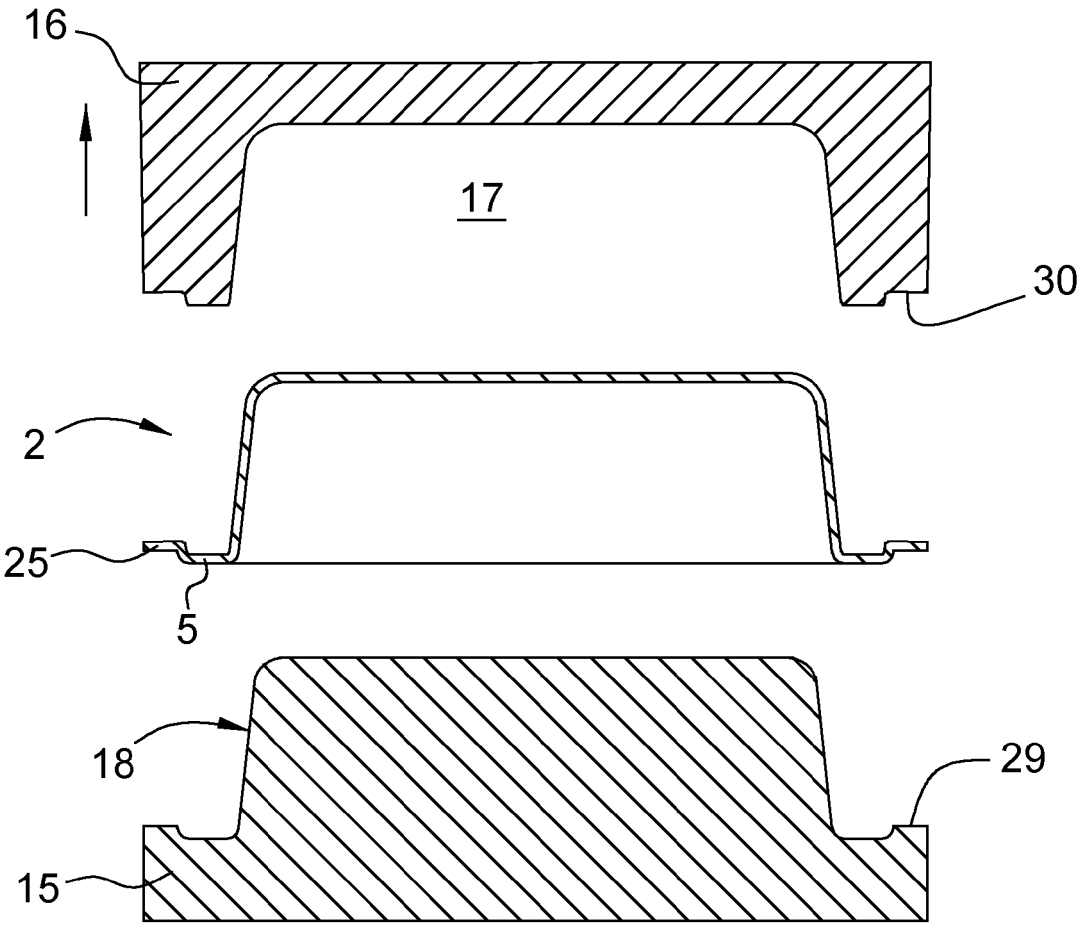

Fig. 4

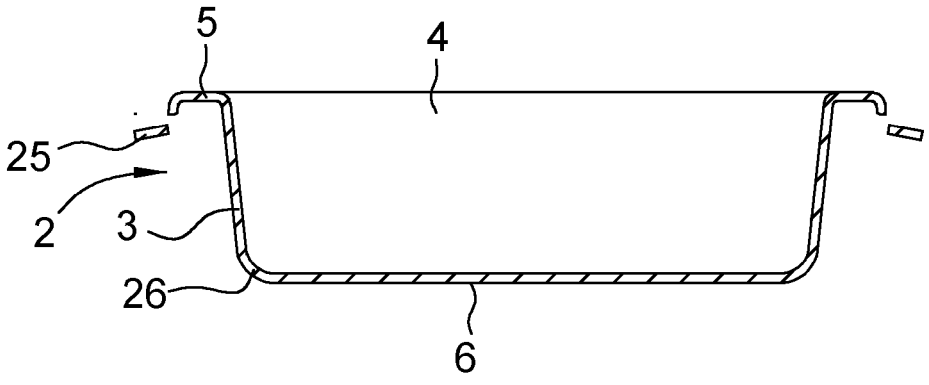

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 23 19 6469

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	WO 2021/156222 A1 (PULPAC AB [SE]) 12 August 2021 (2021-08-12) * claims 1,25; figures 1-5 * * page 10, paragraph 2 * * page 31, line 29 - page 32, line 21 *	1,2,10 6-8	INV. B27N3/20 B29C33/42 B27N5/02 B27N3/18 B31B50/14
X	WO 2010/000945 A1 (STORA ENSO OYJ [FI]; MAEAETTAE PAEIVI [FI] ET AL.) 7 January 2010 (2010-01-07) * claims 1,2,4; figures 1,2,4 * * page 9, lines 25-30 * * page 10, lines 1-4 * * page 8, paragraph 4 - page 9, paragraph 1 * * page 3, paragraph 5 *	1-5,9,10	B31B50/59 B31F1/00 ADD. B27N5/00 B27N3/12 B27N3/04
X	US 2002/068108 A1 (IWAYA JIRO [JP]) 6 June 2002 (2002-06-06) * paragraphs [0007], [0009] - [0011], [0023], [0025], [0036], [0039] * * claims 1,4; figure 1 *	1,2	

TECHNICAL FIELDS SEARCHED (IPC)

B27N
B29C
B32B
B31F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 March 2024	Baran, Norbert

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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18-03-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2021156222 A1	12-08-2021	CN 115605345 A	13-01-2023
		EP 4100245 A1	14-12-2022
		TW 202138654 A	16-10-2021
		US 2023356494 A1	09-11-2023
		WO 2021156222 A1	12-08-2021
WO 2010000945 A1	07-01-2010	NONE	
US 2002068108 A1	06-06-2002	JP 2002172432 A	18-06-2002
		US 2002068108 A1	06-06-2002

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82