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(54) MOLDED FIBER MANUFACTURING

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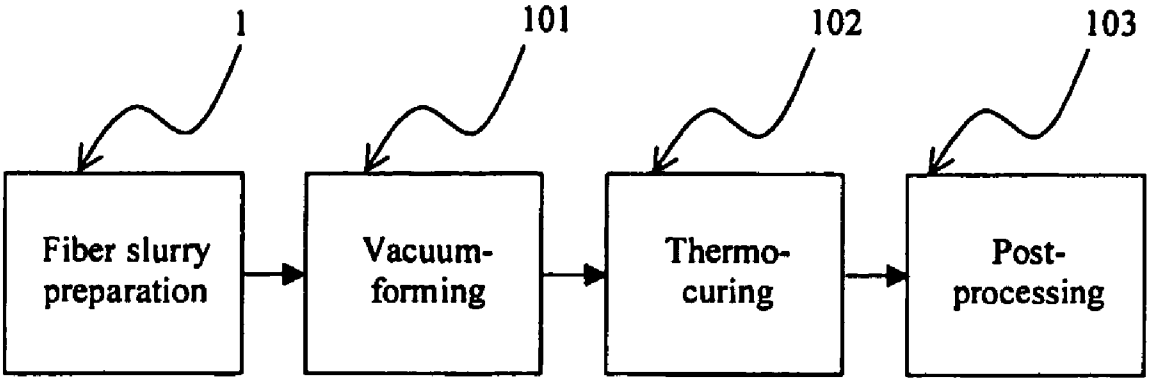
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(57) **ABSTRACT**

Molded fiber products using agriculture residues are economical and environmentally beneficial. Molded fiber manufacturing is different from molded pulp. The present invention discloses a method of and an apparatus for the manufacturing of molded fiber shaped body **(10)** using low consistency fiber slurry **(12)** subject to vacuum-forming and thermo-curing. The use of porous material as mold inserts for both vacuum-forming **(101)** and thermo-curing **(102)** stations provides improved productivity and enables ease of mold release. The incorporation of self-cleaning techniques further ensures consistent performance of the manufacturing system.



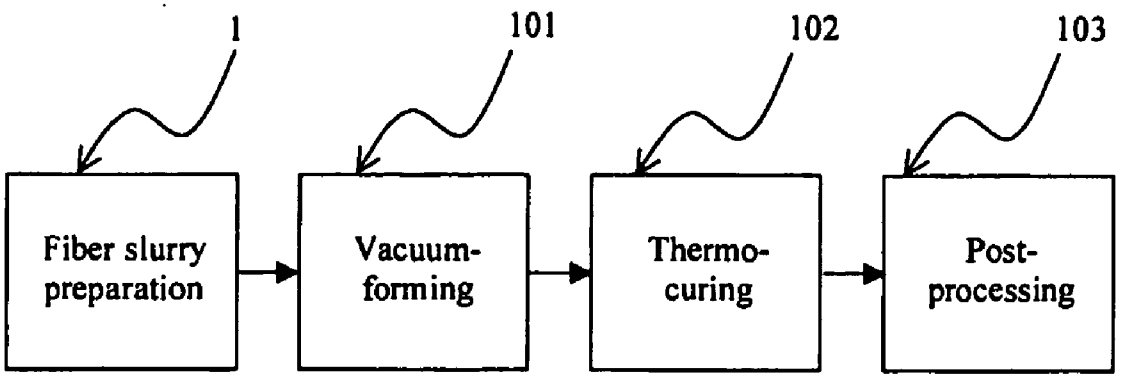

1
101
102
103
Fiber slurry preparation
Vacuum-forming
Thermo-curing
Post-processing

Figure 1

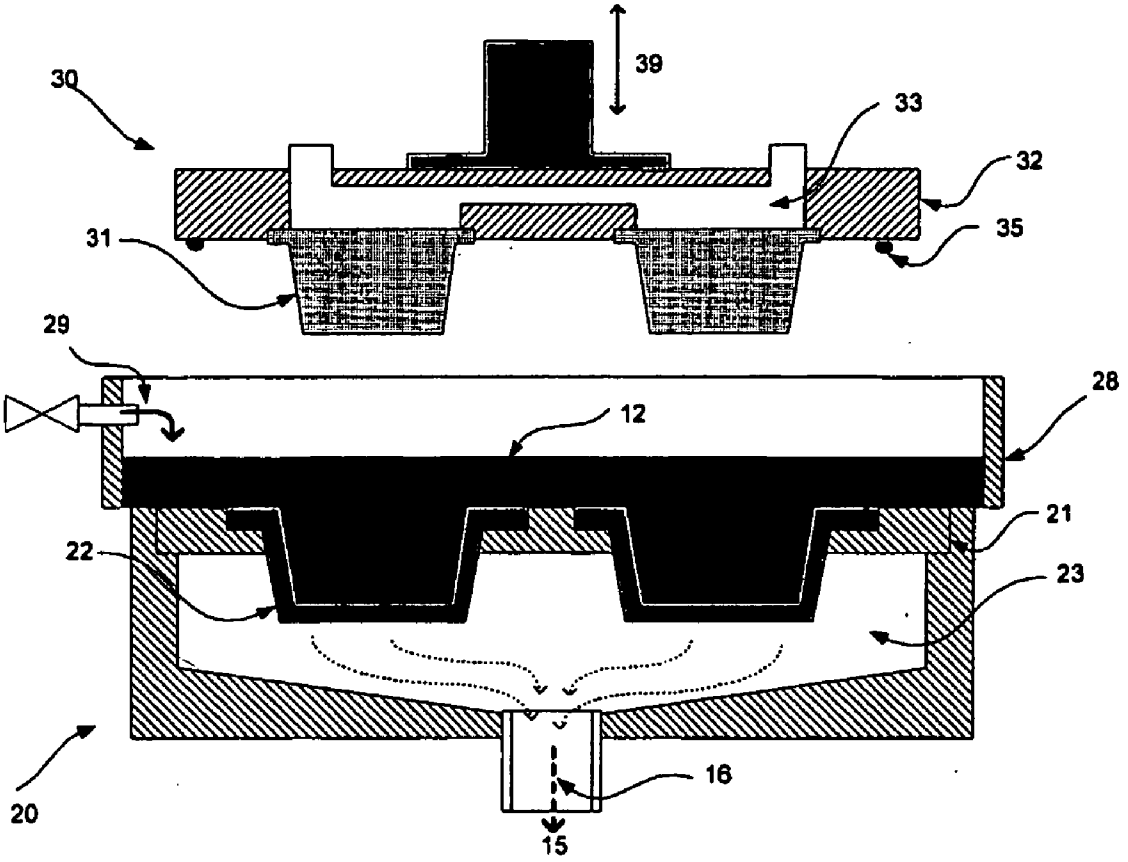


Figure 2

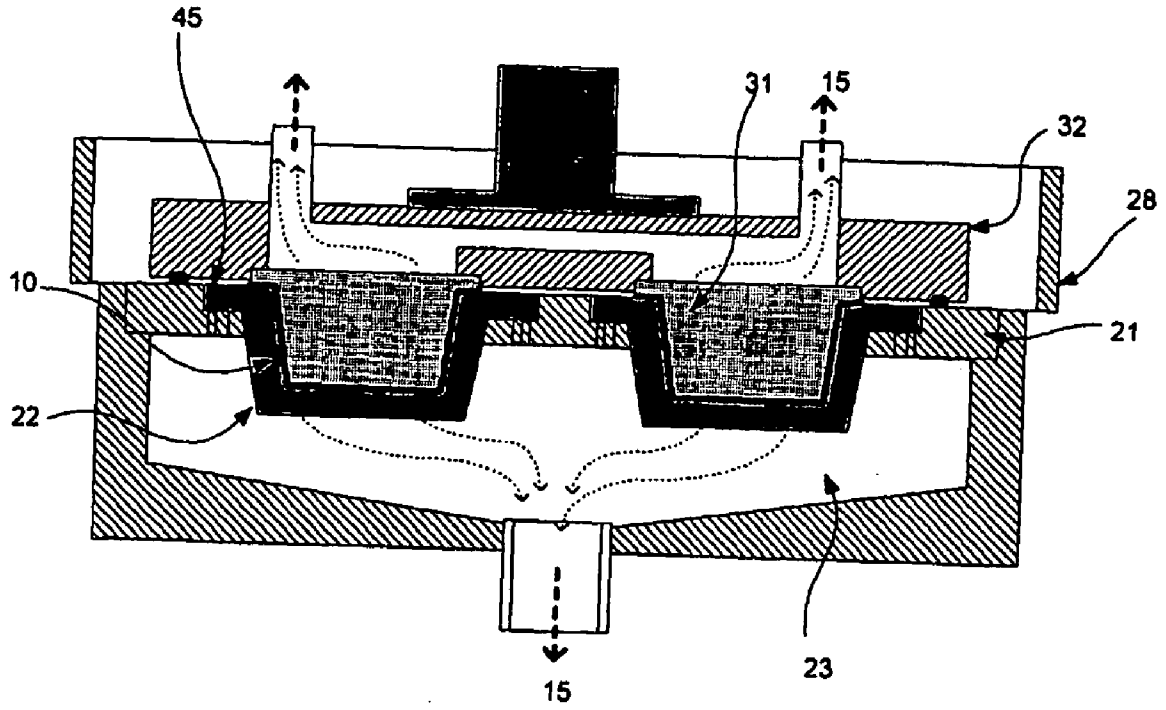


Figure 3

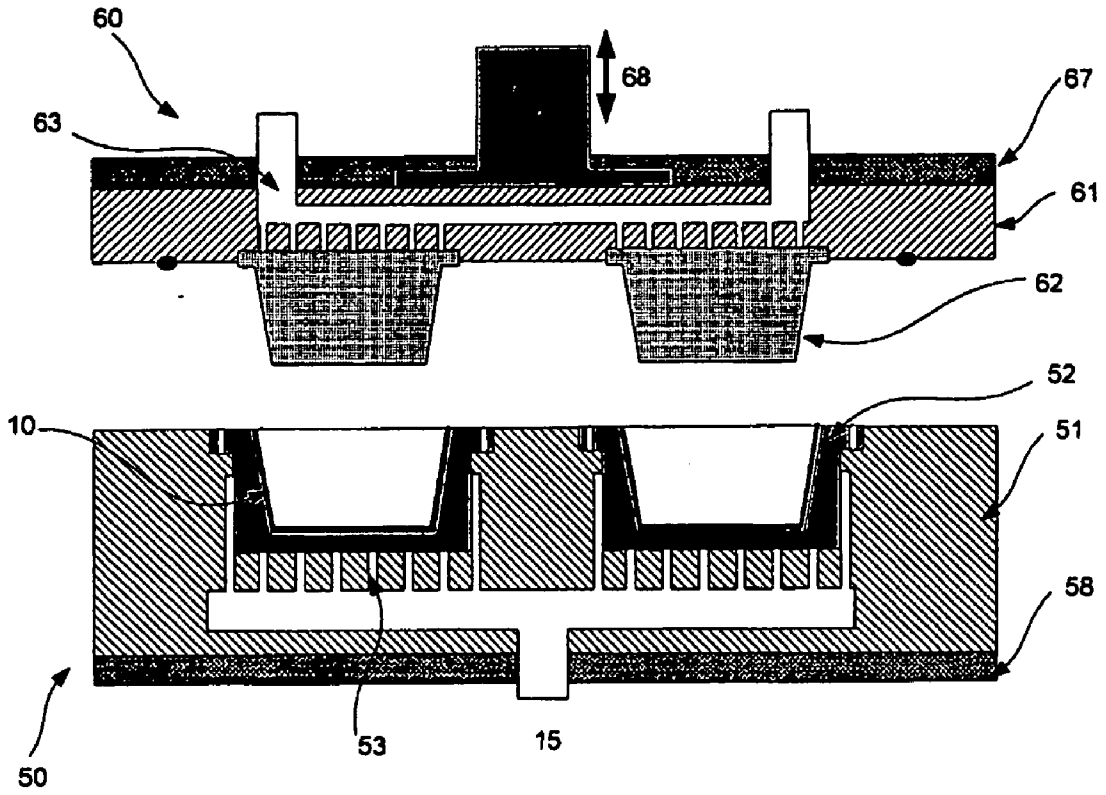


Figure 4

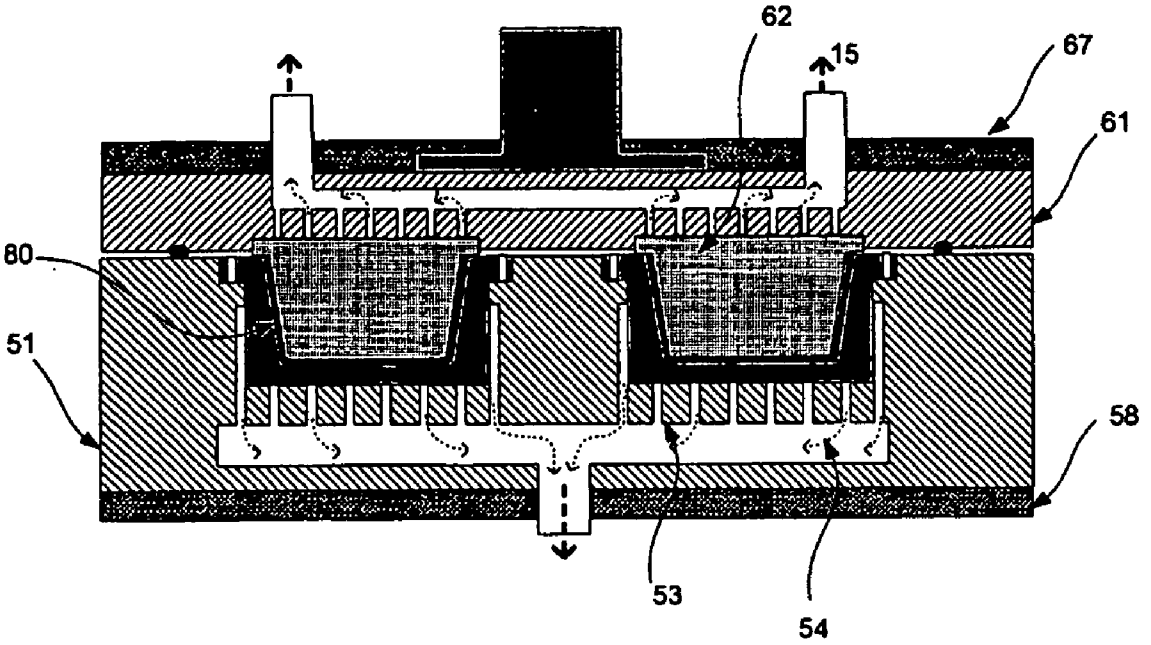


Figure 5

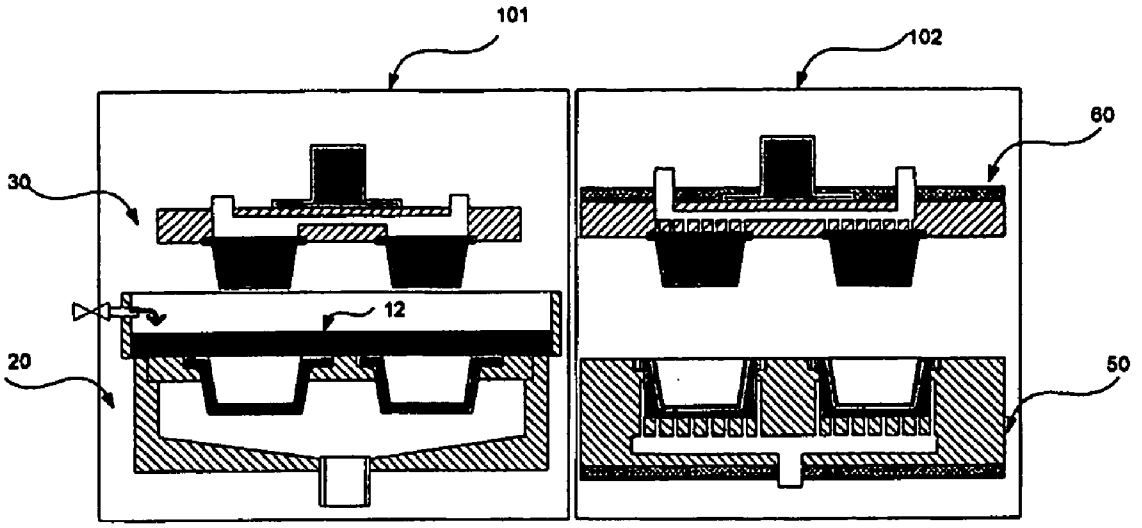


Figure 6

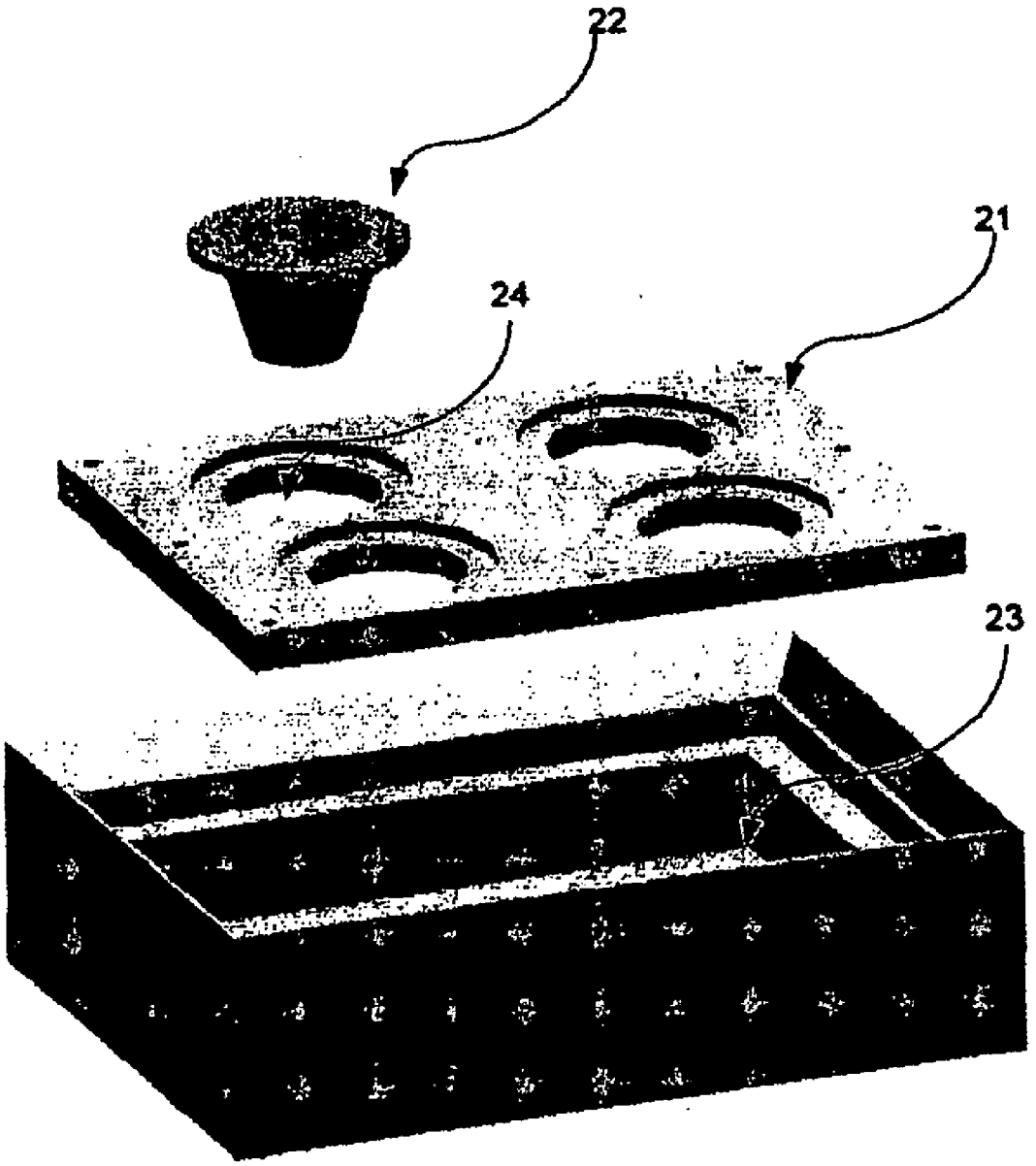


Figure 7

MOLDED FIBER MANUFACTURING

[0001] This invention relates to a method of and an apparatus for improving the manufacturing of molded fiber shaped body.

BACKGROUND

[0002] Products made of molded fiber are environmental friendly. Raw materials for manufacturing molded fiber products are derived from agriculture residues which are usually treated as waste. Unlike pulp, fibers from agriculture residues do not need to be rigorously treated before they are used. When molded fiber products are disposed, they are biodegradable and are emission neutral.

[0003] Molded fiber shaped bodies can be used as packaging for food, industrial goods, consumer products and many others. It has very good cushioning property and is ready to be used without the need to cut, bend and fold. It is also light and stackable which reduce storage and shipping space. Molded fiber packaging is a cost economical and environmental friendly choice to replace existing plastics and paper packaging.

[0004] Vacuum thermoforming method using low-consistency fiber slurry with water-based adhesive binder can be used for producing molded fiber shaped bodies (refer to patent application SG20016232-2). A low-consistency fiber slurry, usually with less one percent (weight) of fiber in water, is poured into the vacuum-forming mold. Existing vacuum-forming molds consist of drilled holes evenly spaced out which allow fluids and air to pass through. The drilled holes are connected to vacuum means. A sieve must be placed over the vacuum-forming mold to ensure a uniform layer of fiber is deposited on its surface after the activation of the vacuum-forming process. The sieve is usually made of wire mesh shaped according to the mold. The sieve serves two main purposes. Firstly, to act as filter such that fibers are retained on the sieve while the fluid is drawn away by vacuum force; Secondly, to redistribute the vacuum force evenly over its entire surface so that the deposition of fiber is uniform.

[0005] The deposited fibers are subject to curing by heat and pressure to produce the final product. The applied heat and pressure on the mold will also cause the sieve to deteriorate rapidly. As a result, the wire mesh sieve will be worn and torn after a limited number of cycles in the thermoforming process. Furthermore, fiber residues entangled on the sieve accumulate after every cycle reduces the vacuum efficiency and distribution. Eventually, the sieve will be choked and ceased to function.

[0006] The use of wire mesh sieve has been proven in the manufacturing of paper and molded pulp products. However, there are several disadvantages such as frequent changing of the sieve is required due to wear and tear; the surface of the product in contact with the sieve is usually coarsely textured and may not be aesthetically acceptable to some users; the wire sieve needs to be secured onto the mold and this takes up valuable space on the mold. It is apparent that productivity is significantly affected due to the need to clean and eventually replace the wire mesh sieve.

[0007] Although molded pulp shaped bodies has been using wire mesh sieve in the manufacturing process rather successfully, molded fiber is different in many aspects. Fibers from agriculture residues are lignocelluloses. Molded fiber uses adhesive to bind fibers together produces a tough shaped body that is mechanically stronger than equivalent molded pulp. Molded pulp does not need external adhesive as cellulose fibers can be bonded to one another naturally. As a result, molded fiber manufacturing causes the wire mesh to wear out faster than molded pulp. Mold release is yet another problem to molded fiber manufacturing due to the use of adhesive. Alternative mold design and materials have to be sought in order to overcome the problems associated with the use of wire mesh sieve in the manufacturing of molded fiber shaped bodies.

[0008] The energy consumption for producing molded pulp is considerably high. Much of the energy is consumed in drying the molded shaped body by heat. Two main techniques of thermal drying of molded pulp exist: drying tunnel and dry-in-the-mold. The drying tunnel technique takes up huge space and causes the molded shaped body to buckle. The dry-in-the-mold technique applies heat to the molded shaped body while it is still in the mold and hence produces products with better accuracy and performance. It also requires a smaller space. Most of the existing literatures addressed dry-in-the-mold as cure-in-the-mold. This is technically misleading as molded pulp does not need curing, it merely needs to be dried. Molded fiber, on the other hand, needs thermal curing to chemically activate the adhesive and thus bind the lignocelluloses fibers together. Drying is a physical phenomenon whereas curing is a chemical phenomenon.

[0009] It is understandable that solving the abovementioned problems will lead to huge productivity improvement in manufacturing molded fiber products and thus their cost competitiveness.

PRIOR ARTS

[0010] U.S. Pat. No. 6,083,447 titled "Fibrous Slurry vacuum-forming" discloses a method and an apparatus for producing molded pulp articles using porous mold that dips into a fibrous slurry. This invention does not resolve the thermoforming process where heat and pressure are applied. Mold release issue is not discussed and it is limited to molded pulp instead of molded plant fiber.

[0011] U.S. Pat. No. 5,529,479 titled "Thermoformable mat mold with hot gas supply and recirculation" discloses the use of porous mold for the release of gas from the mold cavity when the plastics parts are being heated.

[0012] U.S. Pat. No. 6,302,671 titled "Porous mold for a roll support and spacing structure" describes a method porous mold for fabricating a formed mold pulp structure to protectively support at least one roll of web material.

SUMMARY OF INVENTION

[0013] The present invention of manufacturing molded fiber shaped bodies discloses improved manufacturing method and apparatus using vacuum-forming and thermo-curing of low-consistency fiber slurry.

[0014] It is an objective of the present invention to increase the productivity of manufacturing molded fiber shaped bodies. Porous materials fabricated into the desired shape are used as mold inserts in the vacuum-forming molds and the thermo-curing molds to eliminate the use of sieves.

As a result, production downtime is reduced as there is no longer a need to maintain and change sieves on the vacuum-forming and thermo-curing molds. With the use of porous material as mold inserts in the vacuum-forming process, a uniform layer of wet fiber is deposited on the porous mold inserts after the application of vacuum to draw fluid away from the slurry. The porous mold insert redistributes the vacuum force evenly over its entire surface. The porous mold inserts have open and interconnected pores to allow fluids and air to pass through from one surface to another. The pore size of the porous mold insert range between 5 micrometer to 200 micrometer depending on the size distribution of the fiber material. It is preferred that the pore size is smaller than the smallest fiber size in order not to cause blockage to the pore channels.

[0015] Another objective of the invention is to enable the finished molded shaped bodies to be released from the thermo-curing molds after the thermo-curing process. The thermo-curing process uses a pair of mating molds where heat and pressure are applied. The applied heat and pressure produces steam and the steam must be released from the closed mating molds. At least one of the mating molds' inserts is made of porous material so that steam can be extracted away by vacuum means. In the case where only one mold has mold inserts that are made of porous material, then the other mold surface is to be sufficiently roughened to prevent the heat cured molded fiber shaped body from sticking to the mold. The porous mold surface and the roughened mold surface have a roughness in the range of 8 micrometer to 40 micrometer. Larger than 40 micrometer roughness is allowable but will affect the aesthetic appearance of the finished shaped body. Unlike smooth surfaced mold, the designed roughness enables a large number of microscopic air pockets to be built up between the mold surface and the molded fiber shaped body. The air pockets reduce the adhesion of the molded fiber shaped body to the thermo-curing mold. It is to be noted that the surface of the porous mold inserts are inherently rough. The porous materials, preferably porous metal, have sufficient mechanical strength to withstand the amount of heat and pressure applied in the thermo-curing process. The heating temperature ranges from 100 degree C. to 200 degree C. The applied pressure is in the range of 0.5 MPa to 5 MPa.

[0016] Yet another objective of the invention is to reduce the energy consumption in manufacturing molded fiber shaped body. Most of the energy is consumed in the thermo-curing process where large amount of thermal energy is used to dry excessive water in the wet fiber shaped body. It is understood that reducing the amount of water in the wet fiber shaped body will reduce the thermal energy. The present invention optimize the use of mechanical dewatering means to reduce the water content in the wet fiber shaped body formed by the vacuum-forming process. The vacuum-forming process uses a pair of matching molds namely top and bottom molds. The top and bottom molds are opened to allow the fiber slurry to be added. Water in the fiber slurry is extracted away by vacuum means through the porous mold inserts to form a uniform layer of wet fiber shaped body on the bottom mold. In order to extract more water out of the wet fiber shaped body, the top mold and bottom mold are closed and sealed to prevent air infiltration during vacuum dewatering of the wet fiber shaped body. Simultaneously, the top mold and bottom molds apply a slight pressure to the wet fiber shaped body. The mechanical dewatering process stops when the water content in the wet fiber shaped body reaches some pre-determined level, usually in the range of 20% to 50% (wt). It is to be noted that if the top and bottom molds are not sealed when closed, vacuum dewatering will not be effective as ambient air instead of water in the wet fiber shaped body will be extracted.

[0017] Yet another objective of the present invention is to reduce maintenance by incorporating built-in self-cleaning means for the porous mold inserts. The self-cleaning means include the use of ultrasonic transducers and back-flushing. The vacuum-forming porous mold inserts are susceptible to clog due to fibers entrapped in the pores. Clogged vacuum-forming mold inserts will affect molded fiber shaped body uniformity and increase energy consumption. Eventually, the clogged vacuum-forming mold inserts will cease to function. According to the present invention, the vacuum-forming mold inserts are cleaned with ultrasonic meaning and back flushing.

DESCRIPTION OF DRAWINGS

[0018] **FIG. 1** is the block diagram of the improved molded fiber shaped body manufacturing process.

[0019] **FIG. 2** shows the cross-section view of the vacuum-forming station at an opened position with fiber slurry in the fiber slurry container.

[0020] **FIG. 3** shows the cross-section view of the vacuum-forming station with the top mold and bottom mold closed.

[0021] **FIG. 4** shows the cross-section view of the thermo-curing station at an open position and wet fiber shaped bodies are placed on the bottom mold inserts.

[0022] **FIG. 5** shows the thermo-curing station at a closed position.

[0023] **FIG. 6** shows an exemplary system with both vacuum-forming and thermo-curing station side by side to facilitate the transfer of wet fiber shape body.

[0024] **FIG. 7** shows an exploded view of the vacuum-forming bottom mold with a porous mold insert, mold platform with openings and the vacuum chamber with slurry container.

SPECIFIC EMBODIMENTS OF INVENTION

[0025] The improved molded fiber shaped body manufacturing process consists of four major steps. These are (1) fiber slurry preparation; (2) vacuum-forming and (3) thermo-curing and (4) post-processing.

[0026] The manufacturing process begins with the preparation of fiber slurry. Sufficiently refined plant fibers such as fibers obtained from palm oil, coconut coir, hemp, kenaf and other fibrous plants are added to a mixer tank. The mixer tank can be pre-filled with water or water can be added simultaneously with the fiber. The amount of fiber is 0.1 to 5 percent (wt) with respect to 99.9 to 95 percent (wt) of water. The fibers are agitated by an agitator such as an impeller to disperse them in the water. The low consistency fiber mixture is sufficiently agitated until a homogenous slurry is obtained. Water based adhesive binder is then added to the mixer tank and the entire mixture is continuously

agitated. The agitation action causes the adhesive binder to attach to the fiber. Functional additives such as sizing agent, wet strength agent and small amount of mold release agent such as paraffin wax are added to the slurry. The entire mixture is agitated until a homogenous mixture is obtained. The fiber mixture slurry is ready to be fed to the vacuum-forming process. The fiber mixture slurry is usually stored in a buffer tank with sufficient capacity for feeding to multiple vacuum-forming thermo-curing machines. The buffer tank is constantly agitated to ensure that the fiber slurry remains in a homogenous phase.

[0027] The purpose of the vacuum-forming process **101** is to produce a wet fiber shaped body **10** from the fiber slurry **12**. The wet fiber shaped body **10** is of the desired shape, thickness and uniformity. The water content in the wet fiber shaped body **10** is controlled such that it should not be too wet to consume too much of thermal energy in the thermo-curing stage; and it should not be too dry such that the thermo-curing process **102** cannot fully activate the adhesive to bind the fibers.

[0028] The vacuum-forming station **101** consists of a top mold **30** and bottom mold **20**. The top mold **30** is a male mold and the bottom mold **20** is a matching female mold with the desired shape contour. The top and bottom molds **30** & **20** are precisely fabricated and match one another when closed. Guiding means such as guide pins can be used to assist in the alignment of the top and bottom molds **20** & **30** during closing. The bottom mold **20** consists of three major parts: fiber slurry container **28**, mold platform **21** and porous mold inserts **22**. The fiber slurry container **28** is a water-tight container attached to the mold platform **21**. The mold platform is made of non-porous material and sits on a vacuum chamber **23** connected to vacuum means **15** such as a vacuum pump. The vacuum chamber **23** can also allow compressed air to pass through when vacuum means **15** are not in use. Suitable sealing means are applied to ensure that mold platform **21** and the vacuum chamber **23** are joint together in an air-tight manner. The mold platform **21** has a plurality of openings **24** to house the mold inserts **22**. The mold inserts **22** are fabricated into the desired shape contour and can be tightly inserted into the openings **24** on the mold platform **21**. Positive attachment means such as screws can be used to fix the mold inserts **22** onto the mold platform **21**. The porous mold inserts **22** have open pores that permit air and fluids to pass through from one side to another. In this case, the shaped contour surface of the porous mold inserts **22** is connected to the vacuum chamber **23** through the pores.

[0029] In one embodiment of the present invention, the top mold **30** of the vacuum-forming station **101** is constructed in a similar manner as the bottom mold **20**. The top mold also consists of two parts: the male porous mold inserts **31** and the mold platform **32**. Vacuum chamber **33** is built into the mold platform **32**. Vacuum means **15** is connected to the vacuum chambers **33**. The mold platform **32** has a plurality of openings **36**. The male porous mold inserts **31** are fixed onto the openings **36** of the mold platform **32**. The porous mold inserts **31** are connected to the vacuum means **15** through the vacuum chamber **33**. The vacuum chamber **33** also allows compressed air to pass through to the porous mold inserts **31**. The mold platform **32** is made of non-porous material.

[0030] The top mold **30** of the vacuum-forming station **101** is able to move vertically **39** so that the top mold **30** can be lowered and matched precisely with the bottom mold **20**. Appropriate guiding means are built into the top and bottom molds **20** & **30** to assist in precision matching when the two molds are closing. When the vacuum-forming top mold **30** and bottom mold **20** are fully closed, the space **45** in between the two molds **20** & **30** is largely air tight. A slight pressure can be asserted on the closed molds **20** & **30** to assist in squeezing water from the wet fiber shaped body **10** while concurrent vacuum suction is applied. The air-tight space **45** enhances the effectiveness of vacuum dewatering since no ambient air infiltration takes place. It should be noted that vacuum dewatering is very energy efficient as compared to thermal dewatering. Without a proper air sealed between the top and bottom molds **20** & **30**, vacuum energy will be wasted as ambient air instead of water in the wet fiber shaped body **10** will be extracted.

[0031] A suitable amount of fiber slurry **12** is dispensed **29** into the slurry container **28** on the vacuum-forming station **101**. The fiber slurry **12** fills up the slurry container **28** and covers the bottom mold **20**. Once the appropriate volume is reached, vacuum means **15** is activated to extract the water away. Under vacuum suction, the water in the fiber slurry **12** passes through the pores in the porous mold inserts **22** into the vacuum chamber **23** and out of the vacuum-forming station **101**. A layer of wet fiber is then deposited on the surface of the mold insert **22** forming a wet fiber shaped body **10**. Due to the average pore size of the porous mold is smaller than the fiber dimension, fibers are prevented from passing through the pores. The uniformly distributed pores help to distribute the vacuum suction evenly over the entire porous mold inserts **22** surface. This results in producing a uniform layer of wet fiber shaped body **10** on the mold inserts **22** surface. At this stage, the wet fiber shaped body **10** usually contains more than 50% of water. The wet fiber shaped body **10** is not cured at this stage.

[0032] The top mold **30** is then lowered and pressed the wet fiber shaped body **10** on the bottom mold **20**. Vacuum means **15** is activated to draw further amount of water away from the wet fiber shaped body **10** through both the top and bottom porous mold inserts **31** & **22**. A pressure of several atmospheres is applied to facilitate water extraction from the wet fiber shaped body **10** by vacuum suction **15** while the top and bottom molds **30** & **20** are tightly closed and air sealed **35** to prevent air infiltration. Vacuum dewatering is most effective without the infiltration of external air as vacuum suction is directed to remove the water molecules in the wet fiber shaped body **10**. This process helps to reduce the amount of thermal energy required to dry the product in the subsequent thermo-curing stage **102**. This also leads to a reduction of overall production cycle time due to the fact that less time is needed to cure the molded fiber shaped body **80**.

[0033] After the vacuum-forming process **101**, the wet fiber shaped bodies **10** are ready to be thermally cured to activate the adhesive in the wet fiber shaped body **10**. The thermo-curing process also presses the molded fiber shaped body **80** to the desired thickness.

[0034] In one preferred embodiment, the wet fiber shaped bodies **10** are picked up by the vacuum-forming top mold **30**. At the moment when the closed top and bottom molds **30**

& **20** begins to separate, vacuum **15** is applied to the top mold **30** while vacuum **15** is cut off from the bottom mold **20**. In order to further facilitate the release of the wet fiber shaped body **10** from the bottom mold **20**, compressed air is pumped through the vacuum chamber **23** and through the pores of the bottom mold inserts **22**. The compressed air coming out of the bottom mold surface helps to propel the wet fiber shaped body **10** away. The pull action of the top mold **30** together with the push action of the bottom mold **20** ensure a smooth transfer of the wet fiber shaped body **10** to the top mold **30**. The top mold **30** then moves in the necessary path to transfer the wet fiber shaped body **10** to the thermo-curing station **102**.

[**0035**] The purpose of the thermo-curing station **102** is to apply heat and pressure to cure the adhesive and hence bind the fibers together to form the final shape and size. The thermo-curing station **102** also consists of a pair of matched molds **50** & **60** similar to that of the vacuum-forming station **101**. The fundamental differences are the ability of the thermo-curing molds in withstanding higher pressure and temperature than the vacuum-forming molds. Temperature in the range of 100 to 200 degree C. is applied to the thermo-curing molds. The pressure applied is in the range of 0.5 MPa to 5 MPa. The pair of matched molds is thermo-curing top mold **60** and thermo-curing bottom mold **50**. The thermo-curing bottom mold **50** consists of three major parts. These are the thermo-curing mold base **51**, mold inserts **52** and heating means **58**. The thermo-curing mold base **51** consists of a plurality of cavities to house the mold inserts **52**. Sufficient amount of holes **53** serving as air passage are built into the mold base **51** to connect the cavities to the vacuum means **15**. These holes **53** also enable compressed air to pass through. When the porous mold inserts **52** are fitted to the thermo-curing mold base **51**, they are also connected to the vacuum means **15**. The mold inserts **52** are preferably made of porous metals such as copper alloy (bronze) or aluminum alloy. The mold base **51** is heated by heating means **58**. In one preferred embodiment, the heating means **58** are electric heating elements fixed to the base of the mold base **51**. The heating means **58** can also be heating tubes containing heat transfer fluids that circulate in the mold base **51**. Maximum surface contact between the heating means **58** and the mold base **51** must be ensured to obtain high thermal transfer efficiency. It is also equally important to ensure maximum surface contact between the mold base **51** and the porous mold inserts **52** for the similar reason. The major difference in design between the vacuum-forming mold and thermo-curing mold become obvious. Vacuum-forming molds **20** & **30** have large vacuum chambers **23** & **33** and channels to optimize vacuum transfer and water extraction; while the thermo-curing molds **50** & **60** have smaller vacuum channels **53** & **63** and have large surface contact between heating means **58** & **67** and mold inserts **52** & **62** to optimize heat transfer.

[**0036**] The thermo-curing top mold **60** also consists of three major parts which are the mold base **61**, mold inserts **62** and heating means **67**. The top mold inserts **62** are precisely matched with the corresponding bottom mold inserts **52**. When the top mold **60** and bottom mold **50** are fully closed, it leaves a gap which is equal to the thickness of the dried molded fiber shaped body **80**. Guiding means such as guiding pins can be used to assist in alignment of the top and bottom molds **60** & **50** during closing. An air-tight space is created between the two facing surfaces of the top and bottom molds **60** & **50**. Vacuum is produced within this space and hence the temperature needed to vaporize the water content in the wet molded fiber shaped body **10** can be reduced. This is similar to the concept of vacuum oven. The applied heat and pressure cure the adhesive binder in the molded fiber shaped body and shaped it into the final desired shape and thickness. The steam due to vaporization of the water content in the molded fiber shaped bodies **80** escape through the vacuum channels **53** & **63** and out of the station **102**. Upon the completion of the thermo-curing cycle, the top and bottom molds **60** & **50** then open to release the molded fiber shaped body **80**. Compressed air blows through the vacuum chamber **54** helps to detach the molded fiber shaped body **80** from the mold insert **52**. Either the thermo-curing top mold **60** or an addition pick and place means can be used to move the molded fiber shaped body **80** to the appropriate collection area. Similarly, compressed air blow also helps to detach the molded fiber shaped body from the top mold inserts **62**.

[**0037**] Mold release is a major problem in molded fiber shaped body manufacturing. The present invention uses porous mold inserts and roughened surfaces to reduce the adhesion of the molded fiber shaped body to the mold surface. It is to be noted that the surface of a porous mold is sufficiently rough. In the case when the top mold inserts are not made of porous material, then the surface of the top mold inserts is to be sufficiently roughened. One of the commonly technique to roughen the mold surface is by sandblasting usually in the range of 8 to 40 micrometer roughness. The porous molds and roughened mold surfaces created random distributed microscopic air pockets between the molded fiber shaped body and the mold surface that drastically reduce their adhesion to one and another. With the further help of air purge coming out of the porous mold inserts, the molded fiber shaped body **80** can be easily detached from the mold.

[**0038**] The porous mold inserts **22** on the vacuum-forming station **101** are susceptible to clog by fine fibers entrapped in the pores. The entrapped fibers with adhesives must be cleared to maintain the functionality of the porous mold inserts **22**. Depending on the types and size of fibers used, as well as the pore size, thickness and porosity of the mold inserts, the porous mold inserts **22** will lose their effectiveness after certain operating cycles.

[**0039**] The present invention discloses the use of ultrasonic cleaning technique and back flushing for performing self-cleaning of the porous mold inserts. Without the incorporation of self-cleaning function, the usability of the porous molds will be limited due to the lost of porosity by fibers and impurities clogging. Ultrasonic transducers are installed on the fiber slurry container **28** of the vacuum-forming mold **20**. Water is injected into the bottom mold slurry container **28** and sufficiently covers all the porous mold inserts **22**. The ultrasonic transducers are then turned on. The ultrasonic transducer produces ultrasonic sound waves that generate microscopic bubbles which penetrate into the pores. These microscopic bubbles are generated and exploded continuously. The explosion of the microscopic bubbles help to release the trapped fibers and other impurities in the pores. In order to further facilitate the cleaning of the porous mold inserts, back flushing is used. Back flushing is accomplished by pumping compressed air into the vacuum chamber which forces water, fibers and impurities to move out of the porous

mold inserts. The combination of ultrasonic cleaning and back flushing restore the effectiveness of the vacuum-forming mold. The built-in self cleaning function described herein usually takes a few seconds to complete and needs only to be carried out once in several hundred cycles.

[0040] The thermally cured molded fiber shaped body can be further processed by the post-processing station **103** such as coating, printing, trimming, sterilizing, and packing. These post-processing methods and apparatus are well known in the arts and are not deliberated herein.

[0041] The preferred embodiment of the present invention discloses the use of independent vacuum-forming station, thermo-curing station with each station uses porous mold inserts to enable mold release and improved molded fiber shaped body uniformity. It further disclosed the use of mechanical dewatering means especially vacuum dewatering to achieve high rate of water removal from the wet fiber shaped body which resulted in reducing energy consumption. It further enables self-clean of the porous mold inserts by incorporating ultrasonic transducers and introducing back flushing using compressed air. The preferred embodiment of the invention increases the overall productivity of manufacturing molded fiber shaped body.

1. An improved method of manufacturing molded fiber shaped body comprises of using low-consistency plant fiber slurry subject to vacuum-forming to form a wet fiber shaped body and thermo-curing the wet fiber shaped body to produce the final molded fiber shaped body; wherein porous materials are used as mold inserts for both vacuum-forming and thermo-curing;

2. The improved method of manufacturing molded fiber shaped body as claimed in claim 1 wherein the vacuum-forming process consists of a pair of matching molds with porous mold inserts to produce a uniform thickness wet fiber shaped body under vacuum means.

3. The improved method of manufacturing molded fiber shaped body as claimed in claim 2 wherein the vacuum-forming molds are effectively sealed when closed to achieve highly effective vacuum dewatering of the wet fiber shaped body.

4. The improved method of manufacturing molded fiber shaped body as claimed in claim 1 wherein the thermo-curing process consists of a pair of matching molds with porous mold inserts that are heated by heating means.

5. The improved method of manufacturing molded fiber shaped body as claimed in claim 4 wherein the thermo-curing molds are effectively sealed when closed to reduce the heating energy required to cure the molded fiber shaped body.

6. The improved method of manufacturing molded fiber shaped body as claimed in claim 1 wherein the porous mold inserts in the vacuum-forming molds are cleaned by ultrasonic waves and back-flushing means.

7. The apparatus for manufacturing molded fiber shaped body comprises of three stations namely fiber slurry preparation station, vacuum-forming station and thermo-curing station.

8. The apparatus for manufacturing molded fiber shaped body as claimed in claim 7 wherein the vacuum-forming station comprising of a pair of matching molds arranged in a top and bottom arrangement.

9. The apparatus for manufacturing molded fiber shaped body as claimed in claim 8, the vacuum-forming bottom mold consists of a mold platform with openings for installing porous mold inserts, a fiber slurry container and vacuum chamber for connecting to vacuum means and compressed air means.

10. The apparatus for manufacturing molded fiber shaped body as claimed in claim 7 wherein the vacuum-forming top mold consists of mold platform with openings for mold inserts that matched the shaped the bottom mold inserts.

11. The apparatus for manufacturing molded fiber shaped body as claimed in claim 10 wherein the vacuum-forming top molds platform consists of vacuum chamber that are connected to vacuum means and compressed air means.

12. The apparatus for manufacturing molded fiber shaped body as claimed in claim 11 wherein the vacuum top and bottom molds are able to move vertically and closed with air sealed to prevent ambient air infiltration to the wet fiber shaped body during the vacuum dewatering process.

13. The apparatus for manufacturing molded fiber shaped body as claimed in claim 12 wherein ultrasonic transducers are mounted onto the fiber slurry container.

14. The apparatus for manufacturing molded fiber shaped body as claimed in claim 7 wherein the thermo-curing molds comprises a pair of matching molds arranged in a top and bottom molds arrangement.

15. The apparatus for manufacturing molded fiber shaped body as claimed in claim 14 wherein the thermo-curing top mold consists of non-porous mold base with optimized air passage and heating contact surfaces.

16. The apparatus for manufacturing molded fiber shaped body as claimed in claim 15 wherein the thermo-curing bottom mold consists of non-porous mold base with optimized air passage and heating contact surfaces.

17. The apparatus for manufacturing molded fiber shaped body as claimed in claim 16 wherein the thermo-curing top and bottom molds is able to move vertically and closed to apply heat and pressure to cure the wet fiber shaped body to produce the molded fiber shaped body.

18. The apparatus for manufacturing molded fiber shaped body as claimed in claim 7 wherein the porous mold inserts for the thermo-curing station are preferably made of porous metal.

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