

Molded Plant Fiber Manufacturing Process

This invention relates to a method of and a process for manufacturing molded shaped bodies from plant fibers or agricultural residues.

Background

In recent years, molded pulp packaging has been gaining increasing popularity due to its environmental friendliness. A number of molded pulp manufacturing processes have been developed. International Molded Pulp Environmental Packaging Association (IMPEPA) outlines some of the commonly used manufacturing technology. Molded pulp packaging is an environmental replacement in many applications of non-environmental friendly packaging such as those made from polystyrene (PS, EPS), polyethylene (PE), polypropylene (PP) and many others. Molded pulp packaging provides a partial environmental solution in the packaging world, however, further improvement is needed to make it economically and environmentally more viable.

Molded pulp packaging has several disadvantages. If a molded pulp packaging is made from bleached virgin wood pulp, it is not only costly, but has potential environmental impact. The manufacturing of virgin bleached pulp is a very capital intensive, energy consuming and chemical intensive process. Pulping and bleaching may cause environmental pollution if control procedures are not properly installed. Therefore, use of bleached pulp for making of food-ware may not be sufficiently healthy especially if chlorine bleaching is used. Recycled pulp is made from repulping of used paper. Generally, a paper recycling process includes pulping, sieving, de-inking, bleaching and refining, which again is a costly, energy intensive and polluting process if improperly handled. In the case of using recycled pulp (derived from waste paper) as the production raw feed, finished packaging may not be visually appealing, and more importantly it may not be able to meet hygiene standard of food container.

Plant fibers and agricultural residues such as straws, rice husk, coconut coir, palm oil fibers and others are abundantly available. These fibers are usually burnt or discarded improperly in the field that leads to environmental pollution. Harnessing these plant fibers as raw materials for making of molded packaging to replace pulp marks a significant advancement environmentally and economically. Unlike pulp, plant fibers need minimum preparation before it is molded into shaped packaging. The cost of plant fiber is far lower than that of pulp. It is therefore advantageous to convert existing molded pulp manufacturing to produce molded plant fiber packaging without causing major alterations to the manufacturing setup.

Molded plant fiber packaging is rather new. Most of the existing manufacturing processes are still heavily manual driven. If molded plant fiber packaging manufacturing process were unable to produce in mass with the aid of automation, its competitiveness in terms of cost-effectiveness and quality control would be out of question.

A survey of the prior arts for manufacturing molded plant fiber shows that most of the processes do not make use of low consistency and low viscosity slurry as commonly found in molded pulp or paper making process.

US patent, US5679145, of Khashoggi E Ind (US) discloses compositions, methods, and systems for manufacturing articles, particularly containers and packaging materials, having a starch-bound cellular matrix reinforced with substantially uniformly dispersed fibers.

Chinese patent CN 1230386 describes a method of producing dinnerware made from plant fiber. This patent uses plant fibers and adhesive with almost no water content. The mixture is of high viscosity and presents as a lump to be poured into a mould or die to be heated under significantly high temperature and pressure.

WO 00/39213 discloses a process for producing a shaped body made of biodegradable material. The invention uses cellulosic fibers, native starch, pregelatinized starch and intermediate amount of water to form a bakeable mass for baking into a shaped body.

Chinese patent CN1257089 discloses a production method of plant fiber foamed packaging material. The composition includes plant fibers, foaming agent and additives of starch to be heated in the mould of the desired shape.

Chinese patents CN1270912 and CN1270913 invented and assigned to SU Xiaohai describe a double-foamed plant fiber packaging material and its production process.

US patent US5849152 (PCT No PCT/EP95/00285) describes a process for the production of shaped bodies from biologically decomposable material using a viscous mass containing fiber, water and starch, which is baked in a baking mould to produce a shaped body. Reduced amount of water in the composition prior to baking is stressed.

Summary of invention

According to an objective of the present invention, low consistency slurry is made from mixing grinded plant fibers, water-based adhesive, mold release agent and water. A thorough mixing is essential to ensure majority of grinded plant fibers attached with adhesives and other additives. The so-prepared slurry is of low viscosity and can be easily transferred by conventional fluid pipes. Other functional additives such as sizing, oil repellent and wet strengthening agents can be added to the slurry if required. For those skilled in the arts, these additives are similar to those used in paper industries. Plant fibers refer to those of palm oil fibers, coconut coir, wheat straw, rice straw, flax, kenaf, hemp, rice husk and others.

According to another objective of the invention, the plant fiber slurry is vacuum formed into a semi-dried shaped body of the desired shape. This is accomplished with the aid of a mold with fabricated suction holes via the

power of vacuum. The suction holes in the mold are generally spread out evenly. A layer of sieve of the similar shape is laid on the mold. The vacuum action removes a large portion of water from the slurry and forms a uniform layer of plant fiber mixture on the sieve.

According to yet another aspect of the invention, the semi-dried shaped body is pressed and dried to form the final product. The pressure applied is in the range of 0.5 to 2 MPa. The semi-dried shaped body is heated between 120 to 200 deg C for curing and pressed to the desired thickness. A molded plant fiber shaped body package is produced as a result. The mold release agent pre-added into the plant fiber slurry helps to detach the final product from the mold. Post-processing such as edge trimming, printing or coating of functional chemicals for better finishing and enhanced properties can be carried out.

Description of drawings

Figure 1 is a block diagram of the molded plant fiber packaging manufacturing process.

Figure 2 shows the plant fiber mixture slurry in the vacuum forming station using the slurry injection method.

Figure 3 shows the water content in the plant fiber mixture slurry has been largely removed from the vacuum forming station by the vacuum pump action.

Figure 4 shows the thermal forming station where two matching molds press and heat the plant fiber mixture into the desired shape.

Figure 5 illustrates the male mold is immersed in the slurry tank in the immersion-transfer molded plant fiber process.

Figure 6 shows that a layer of plant fiber mixture is formed on the mold after the mold has been lifted up from the slurry tank.

Figure 7 shows the dip-transfer method in which the mold is dipped into the slurry tank.

Figure 8 shows the mold is lifted up from the slurry tank with a thin layer of plant fiber mixture formed on its surface.

Specific embodiment

The present invention describes a specific embodiment with a slurry injection vacuum thermal forming approach. However, it can be easily adapted to slurry tank immersion-transfer method and dip-transfer method of producing shaped body.

The manufacturing process of the molded plant fiber packaging is shown in Figure 1. Plant fibers are disintegrated (refined plant fibers) via a variety of means such as chopping, grinding or milling.

The refined plant fibers are mixed with water. Agitation is applied to facilitate fiber dispersion in the water. Once the refined plant fibers are well dispersed, additives such as sizing agent, oil/grease repellent agent, wet strengthen agent, mould release agent, etc, can be added in sequence into the refined plant fiber/water mixture giving a furnished slurry. The furnished slurry is gently agitated, and sufficient reaction time is given to maximize the performance of additives. Next, adhesive 43 (Patent application entitled: "Adhesive for molded plant fiber" inventors: Xu Yan and Toh Peng Seng; "Handbook of Adhesives & Sealants" by Edward M. Petrie, 1999; "Handbook of Adhesive Chemicals and Compounding Ingredients" by Michael Ash and Irene Ash, 1999) is added into the furnished slurry, and continuous agitation is applied to ensure a uniform dispersion among the refined plant fibers. The resultant furnished plant fiber-adhesive slurry 11 is then transferred to a buffer tank 34, where the slurry uniformity is ensured by a continuous and gentle agitation. The solid content of the slurry ranges from 0.5-5% by weight percentage, or the water content of the slurry is 95% (wt%) and above.

After the plant fiber mixture slurry 11 is transferred to the buffer tank 34, another batch of mixture is fed into a mixer tank 33 and the same processing procedures apply.

Due to the low consistency and low viscosity of the plant fiber mixture slurry 11, it can be easily pumped and transferred using conventional pumps and pipes from tank to tank. The plant fiber mixture slurry 11 is pumped to the vacuum forming station 35 through pipe 15. A typical vacuum forming station 35 consists of a mold 2 shaped according to the required packaging shape and dimension. The mold 2 consists of a plurality of tiny tunnels 14 to allow water or fluid to drain off, and the mold 2 sits on an airtight container 16. A similarly shaped sieve 5 is secured onto the mold 2. The shaped sieve 5 serves to retain the refined plant fibers and allows water or fluid to pass through the plurality of tiny tunnels 14. A vacuum pump 21 is hooked up to the outlet of airtight container 16 to extract the liquid content of the plant fiber mixture slurry 11 forming a semi-dried plant fiber shaped body 12 on the shaped sieve 5. The semi-dried plant fiber shaped body 12 usually contains 25% to 70% of water.

The semi-dried plant fiber shaped body 12 is transferred to the thermal forming station 36. A typical thermal forming process 36 consists of a pair of matching molds 3 & 4. This thermal forming process is also known as the

cure-in-the-mold process. The thermal forming molds 3 & 4 are made of good thermal conductive materials such as brass to ensure a rapid and even distribution of heat over the molds 3 & 4. During the thermal forming process, the molds 3 & 4 are heated to temperatures between 120 to 200 degree C via heating platens 25 & 26. Pluralities of tiny tunnels 27 are uniformly constructed on the matching molds 3 & 4 to allow vapor or steam to pass through. Pressure in the range of 0.5-2 MPa is applied to the matching molds 3 & 4. The semi-dried plant fiber mixture 12 is heated and pressed to the desired dryness and thickness through applied pressure and heat on the matching molds 3 & 4. Vacuum pump can be connected to the pluralities of tiny tunnels 27 of the matching molds 3 & 4 to aid dewatering and speed up the drying and curing process. The applied heat and pressure also ensures the formation of a strong shaped body through the binding power of adhesives. The cured plant fiber shaped body 8 contains 5-15 wt% of water depending on the relative humidity of the surrounding air. The plant fiber shaped body 8 is then removed from the matching molds 3 & 4, and post processing 37 such as coating and curing, printing, trimming and sterilization can be applied if necessary. Extracted water using vacuum pump 21 is returned to a water storage tank 31 for recycling.

Another embodiment of the invention is the use of the plant fiber mixture slurry 11 in the immersion-transfer process to make molded plant fiber shaped body 8. Figure 5 and 6 illustrate the immersion-transfer process. The plant fiber mixture slurry 11 in the buffer tank 34 is transferred to the slurry container 18 where it is continuously stirred to ensure that the plant fiber mixture 11 is uniformly suspended in water, or fluid medium. The mold 43, lined with at least a layer of sieve 5, is first immersed in the slurry container 18. When vacuum suction 21 is activated, a layer of the plant fiber mixture 12 is formed on its surface. The mold 43 with the layer of semi-dried plant fiber mixture 12 is then lifted from the slurry container 18. The semi-dried plant fiber mixture 12 is further subject to thermal forming 36 to produce a dried plant fiber shaped body 8.

Another embodiment of the invention is the use of the plant fiber mixture slurry 11 in the dip-suction process to vacuum form a semi-dried plant fiber shaped body 8. The vacuum forming mold 53 is dipped into the slurry container 18 which has uniformly suspended plant fiber mixtures. The vacuum suction causes a layer of the plant fiber mixture to be attached to the mold surface 53. The mold 53 is then lifted up from the slurry container 18. The semi-dried plant fiber mixture 12 formed on the mold 53 is then thermal formed 36 to produce the final shaped body 8.

Another embodiment of the invention is the use of oven to dry the semi-dried shaped body 8 instead of the cure-in-the-mold process. A conveyor carries the semi-dried shaped body 8 into the oven that is heated up to temperatures between 120 to 200 deg C. The oven is typically of the tunnel type allowing the conveyor to carry multiple of the semi-dried shaped bodies 8 to pass through slowly and dry. The temperature in the oven is profiled to heat up the semi-dried shaped body progressively and cool it down before it exits the

oven tunnel. The dried shaped body can be further subject to post processing such as coating, trimming and sterilization.



Claims

1. The method of manufacturing molded plant fiber shaped body comprises of mixing refined plant fibers with water, adhesive, additives and mold release agent, in which the water is at least 95%wt, to form a low viscosity plant fiber mixture slurry, to produce a shaped body through vacuum forming and thermal forming processes.
2. The method of manufacturing molded plant fiber shaped body as claimed in claim 1 in which a semi-dried shaped body is formed by the vacuum forming process.
3. The method of manufacturing molded plant fiber shaped body as claimed in claim 2 in which the semi-dried shaped body is thermally formed by heating to produce the final shaped body.
4. The method of manufacturing molded plant fiber shaped body as claimed in claim 1 in which the plant fiber mixture slurry is injected into a vacuum forming mold.
5. The method of manufacturing molded plant fiber shaped body as claimed in claim 4 in which vacuum is applied to the vacuum forming mold to form a layer of semi-dried plant fiber mixture shaped body.
6. The method of manufacturing molded plant fiber shaped body as claimed in claim 1 in which the plant fiber mixture slurry is transferred to a slurry container with an immersed vacuum forming mold.
7. The method of manufacturing molded plant fiber shaped body as claimed in claim 6 in which the vacuum suction is applied to the immersed vacuum forming mold.
8. The method of manufacturing molded plant fiber shaped body as claimed in claim 7 in which the immersed vacuum forming mold is lifted from the slurry and formed a layer of semi-dried shaped body.
9. The method of manufacturing molded plant fiber shaped body as claimed in claim 1 in which the vacuum forming mold is dipped into a slurry container containing the plant fiber mixture slurry.
10. The method of manufacturing molded plant fiber shaped body as claimed in claim 9 in which vacuum is applied to the dipped vacuum forming mold.
11. The method of manufacturing molded plant fiber shaped body as claimed in claim 10 in which the vacuum forming mold is lifted up from the plant fiber slurry forming a layer of semi-dried shaped body.
12. The method of manufacturing molded plant fiber shaped body as claimed in claim 1 in which the semi-dried shaped body is thermal

formed and pressed in a pair of matching mold to produce the final dried shaped body.

13. The method of manufacturing molded plant fiber shaped body as claimed in claim 1 in which the semi-dried shaped body is dried by passing it through a heated oven tunnel.

