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SUSTAINABLE FIBER TECHNOLOGIES : TO CONVERT AGRO-WASTE INTO AGRO-PULP SUITABLE FOR MOLDED FIBER PACKAGING

(ALTERNATIVE PACKAGING TO REPLACE SINGLE USE PLASTICS)

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Abstract:

The article shows how single use plastics have harmful effects on the environment and why it is important to ban its uses for the future. Sustainable Fiber Technologies specializes in sustainable, environmentally friendly non-wood pulping.This technology uses agriculture residue as well as fiber specific crops as the raw material to make pulp for sustainable papers and packaging. Agro-waste is the prime source for the production of Molded fiber. Agricultural waste is plant residues from agriculture. These waste streams originate from arable land and horticulture. Agricultural waste are all parts of crops that are not used for human or animal food. Molded fiber can be manufactured by using a two step process: Forming process and Drying process. Molded fiber can be used for packaging that has a series of benefits. Renewable and natural resources made from agro waste material,100% biodegradable and compostable, Microwave safe, freezer friendly, heat resistance, recyclable, etc.

There are significant incentives/pressures on decreasing the use of plastics and their related products in the packaging industry, correspondingly, strong demands are emerging for clean, renewable, recyclable/ biodegradable packaging products. In this context, molded fiber/pulp products have attracted increasing attention, due to their green/sustainable advantages, simply because the raw materials used are plant-based and/or recycled fibers. Many companies have switched their packing practices from plastics to more environmentally friendly products, such as molded fiber products, which already have had and will continue to have obvious effect on packaging industries. This paper initially provides an overview on the general concept of molded pulp products, and further summarizes the different types of molded fiber products in terms of natural fiber sources, manufacturing processes, current and emerging applications as well as the environmental sustainability of molded products.

WHAT ARE SUPS (SINGLE USE PLASTICS)

Single-use plastic products (SUPs) are used once, or for a short period of time, before being thrown away.They are made up of a combination of formaldehyde and phenols whose examples are: resol, novolac.These monomeric units sustain in the environment for a longer period as they have more shelf life resulting in plastic waste compilation. Single-use plastics are a glaring example of the problems with throwaway culture. Instead of investing in quality goods that will last, we often prioritize convenience over durability and consideration of long-term impacts. Our reliance on these plastics means we are accumulating waste at a staggering rate. We produce 300 million tons of plastic each year worldwide, half of which is for single-use items. That's nearly equivalent to the weight of the entire human population.

Single use plastics don't really break down; they just break up. Over time, sun and heat slowly turn plastics into smaller and smaller pieces until they eventually become what are known as microplastics. These microscopic plastic fragments, no more than 5 millimeters long, are hard to detect—and are just about everywhere. Some microplastics are even small by design, like the microbeads used in facial scrubs or the microfibers in polyester clothing. They end up in the water, eaten by wildlife, and inside our bodies. They've even made their way up to the secluded Pyrenees mountain range and down to the bottom of the Mariana Trench. For wildlife, microplastics can be particularly dangerous; when eaten they can easily accumulate inside an animal's body and cause health issues, like punctured organs or fatal intestinal blockages.

Single-Use Plastics and Pollution

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And recent studies found plastic in the guts of 90 percent of the seabirds tested and 100 percent of the turtles. Alarmingly, scientists estimate that there will be more plastic than fish in the ocean by weight in 2050. Not only is plastic estimated to kill millions of marine animals and seabirds each year, but it's also contaminating seafood that humans have relied on for millennia, particularly with microplastics in animals' guts.

Ban on SUPs

The Plastic Waste Management Rules, 2016, as amended, provide the statutory framework and the prescribed authorities for enforcement of the rules, including ban on identified single use plastic items. The following identified single use plastic items, which have low utility and high littering potential, have been prohibited, with effect from 1/07/22.

a) Earbuds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice- cream sticks, polystyrene [Thermocol] for decoration;

b) Plates, cups, glasses, cutlery such as forks, spoons, knives, straw, trays, wrapping or packaging films around sweet boxes, invitation cards, and cigarette packets, plastic or PVC banners less than 100 micron, stirrers.

The notification also prohibits manufacture, import,stocking, distribution, sale and use of plastic carry bags having thickness less than 75 microns with effect from 30/09/21, and having thickness less than thickness of one hundred and 20 microns with effect from the 31st December, 2022

A Sustainable Option: Sustainable Fiber Technologies (SFT)

Sustainable Fiber Technologies specialises in sustainable, environmentally friendly non-wood pulping.This technology uses agriculture residue as well as fiber specific crops as the raw material to make pulp for sustainable papers and packaging and a byproduct that can be biopolymers, fertilizers and other natural products. Sustainable fiber technology's goal is to create solutions for a more sustainable future using less chemicals and energy than traditional manufacturing methods.

Prime source of SFT: Agricultural waste

Agricultural waste are plant residues from agriculture. These waste streams originate from arable land and horticulture. Agricultural waste are all parts of crops that are not used for human or animal food. Crop residues consist mainly of stems, branches (in pruning), and leaves.It is estimated that, on average, 80% of the plant of such crops consists of agricultural waste.

The four most commonly grown agricultural crops worldwide are sugarcane, maize, cereals and rice. The total weight of all these crops is more than 16,500 billion kilograms per year. Since 80% of this consists of agricultural waste, many tens of thousands of billions of kilograms of agricultural waste remain worldwide. Some 700 million tonnes of agricultural waste is produced annually by the EU.

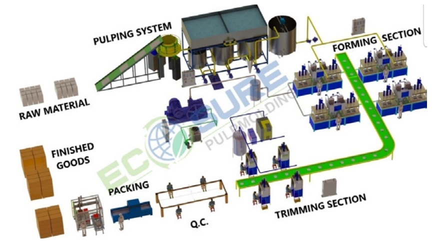
Impact of agricultural waste on the environment

Agriculture based industries produce a vast amount of agro-waste from various agricultural activities. One-third of the total food produced globally per year for consumption remains unutilized and therefore wasted as stated by Food and Agricultural Organization (FAO). Food waste is one of the arduous tasks the world is facing currently. Major food losses occur during the post-harvest stage. Fruits and vegetables contribute to a significant amount of waste. As stated by the FAO, 20-30% of fruits and vegetables are disposed of as waste during post-harvest handling and processing operations. Agriculture waste include field residues such as stems, stalks, leaves, seedpods, and process residues like husks, seeds, roots, bagasse, molasses. Waste from food processing units consists of organic residues such as fruit seeds, citrus peels, potato peels, coconut shells, wheat straw, rice husks, pomace, etc. These wastes are commonly disposed of at landfill sites or employed in preparing compost. Due to the varied composition of cellulose,hemicelluloses, proteins, lipids, these wastes serve as a raw material for the production of biodegradable and sustainable packaging material.

Applications of Agro-waste for development of Biodegradable Packaging

Applications of Agro-waste for development of Biodegradable Packaging Starch, which is mainly extracted from cassava, potato peels, rice husk, wheat bran, is rich in amylose, and exhibits thermoplastic properties that could be used in development of packaging material. These can be easily obtained from agricultural waste at zero cost. Corn starch-based biocomposites added with rice husk and walnut shell were effective in enhancing the physical, mechanical, and thermal properties of biocomposites and could be of advantage as a sustainable packaging material . Pectin, extracted from citrus peels and by-products of juice processing has diverse functionalities in sustainable packaging applications. It is the most pliable polysaccharides suitable for the formation of an effective biomaterial film due to its biodegradability, biocompatibility, and non- toxicity . Cellulose from agro-waste such as rice straw, wheat hull, wood chips, wood pulp, maize stalk, sorghum waste, is used as raw material for the formation of biodegradable film packaging. It is the most abundant polysaccharide biopolymer available worldwide. Multiple hydroxyl groups of cellulose in cellulosic materials can be modified either partially or wholly on treating with numerous chemicals to produce a variety of end products stated as cellulose derivatives (Israel et al., 2008). Cellulose Nanocrystals (CNCs) and cellulose nanofibers (CNFs) are non-toxic, biodegradable, have high strength and barrier protection.

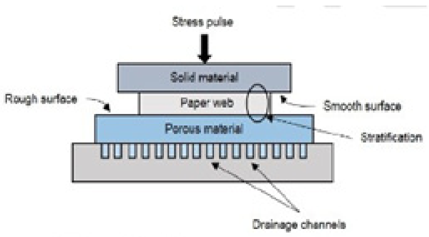
Manufacturing of Molded Fiber



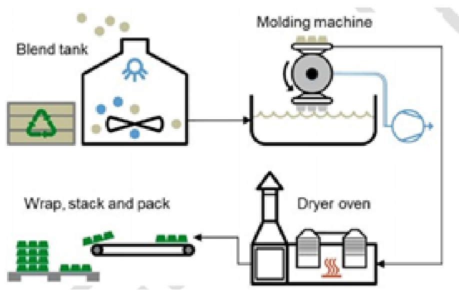
Fibre Products Most of the packaging products, such as Tetra Packs, cartons, start with the manufacturing of flat sheets which are then assembled into three-dimensional packages. Production of moulded pulp involves a series of manufacturing steps. The process is tailored to the geometry and usage of the final product. There are two main steps involved in the manufacturing process: vacuum-forming of the pulp into the desired shape and drying the product to remove the remains of the water .

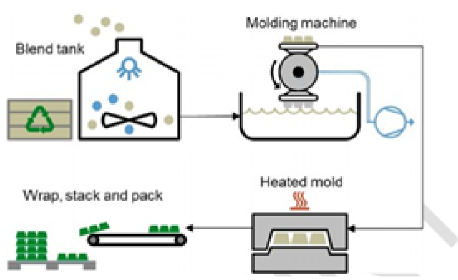
1.1 Forming process

In the forming process, the dies are immersed in a tank filled with pulp (stock pond) where the pulp is sucked onto the mold, via a vacuum-assisted process. The pulp consists mainly of water, short fibers and fines. The materials are blended with hot water for about 20 min until they become pulp.



In case of recycled materials, such as cardboards, newspapers, magazines, recycled papers, and other paper-based products, the pulp goes through a set of vibrating screens that remove impurities like plastics and metals. The custom designed die, which is the negative of the geometry to be formed, is attached to the moulding machine. The combination of dies attached to the moulding machine is called the moulding pattern. The die is immersed in the stock pond and through vacuum suction the pulp is deposited on the outer surface of the die. The pulp accumulates to a desired thickness and the mechanically bound water is removed via a vacuum-assisted process.The deposition of the wet-pulp on the forming tool is a form of wet pressing. Cellulose fibers in the wet-pulp are entangled in a way that they make the entire structure porous. During pressing, two types of stress are generated: stress due to the fiber structure, which provides resistance to the flow of water in the web, and stress due to the hydraulic pressure. Campbell was the first to apply this concept to paper forming, thereby verifying and quantifying the behaviour of the wet web during the formation of paper. Stress applied during pressing gets counterbalanced by the two stresses and the hydraulic pressure squeezes the water outwards. Wet pressing process is influenced by the compressibility of the fibre network. Several researchers have studied the deformation of wet webs using a platen press. In these studies, the paper web was compressed in-between a smooth solid material and a rough porous material. The expelled water was taken up by the porous material and transferred outwards by the drainage channels. In the platen press arrangement, water flows through the fibre network and experiences viscous forces. The interaction results in a non-uniform and uneven compaction of the wet web in the thickness direction. This phenomenon is termed as stratification. During compression, water is not only squeezed out of the fiber network but also through the fiber walls. Vomhoff and Norman indicated that the pressure should be directed towards the fiber and must be uniform throughout to avoid uneven surfaces. The agglomeration of pulp fibers in the passageways of the forming tool could obstruct the water flow. To prevent the problem, the tool must be cleaned at each production cycle.





1.2 Drying process

Once the product is formed, it is then removed from the forming tool and transferred for the subsequent drying process.

Two fundamental methods of drying can be identified: plain and precision molding. The forming process is the same for both methods. For plain molding oven drying is preferred, while in precision molding heat is applied between the matching mold surfaces. Plain molding involves drying of the formed products in a heated oven.Products of plain molding fall in the thick wall and the transfer molded categories. Production systems for such products are usually designed for large volume production with high levels of automation. The amount produced is typically greater than 20 tons per day (>18 metric tons per day), and it depends on the molding patterns and speed of the molding machine. Secondary treatments, such as printing, coating etc., are sometimes given. Colored molded packaging are obtained by using a dyed pulp. Decorative finishes can be realized by spray gun.The drying process in the precision molding process is performed by applying heat in between the surfaces of a matching mold. This manufacturing process is also referred to as compression molding or thermoforming process. During the drying process, the part is pressed, making the products denser, smoother, and more precise than their free-dried counterparts. The pressing also increases the bonding between the fibers, thus improving the mechanical properties. Virtually any plain-molded product can be made in this manner, but the product cost and electrical energy input would increase. This is the reason why the production is tailored for high quality and more valuable products but in smaller volumes.

Molded Fiber Products Used For Packaging

Made from 100% post-industrial recyclable materials, moulded fiber/ moulded pulp is a cost effective and environmentally friendly packaging solution that reduces packing labour and requires less storage space while providing superior protection at every stage of the supply chain. Products that can be made from moulded fiber are :

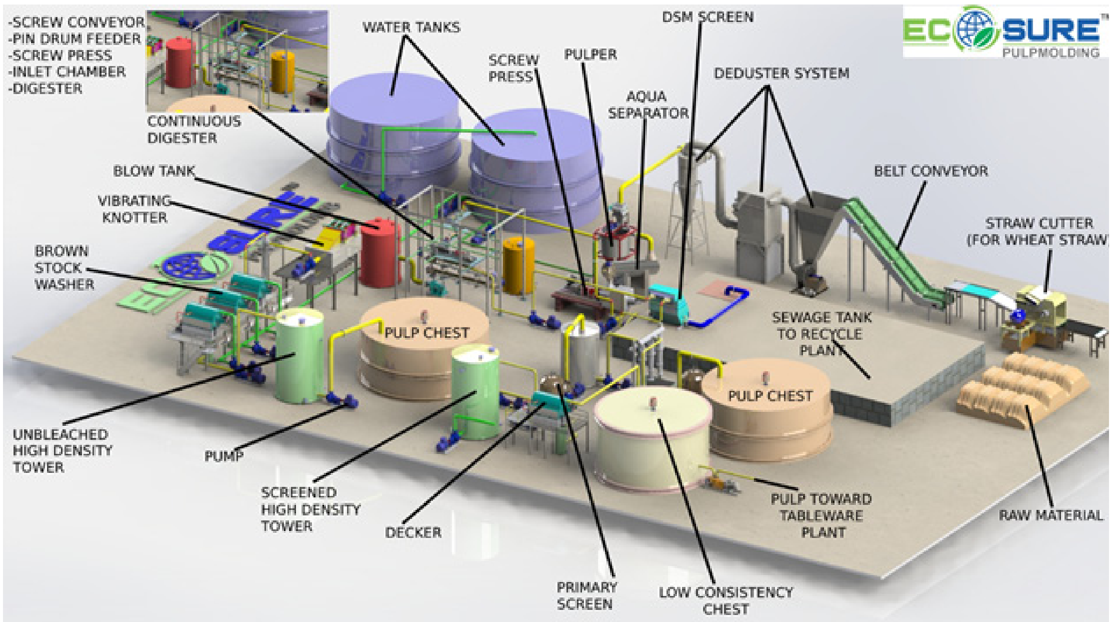
- Fruits and vegetable packaging
- Beverage and glass packaging
- Industrial packaging
- Electronic packaging
- Hardware and Metals packaging
- Medical Disposable packaging
- Cosmetics packaging
- Clothing and Apparels packaging

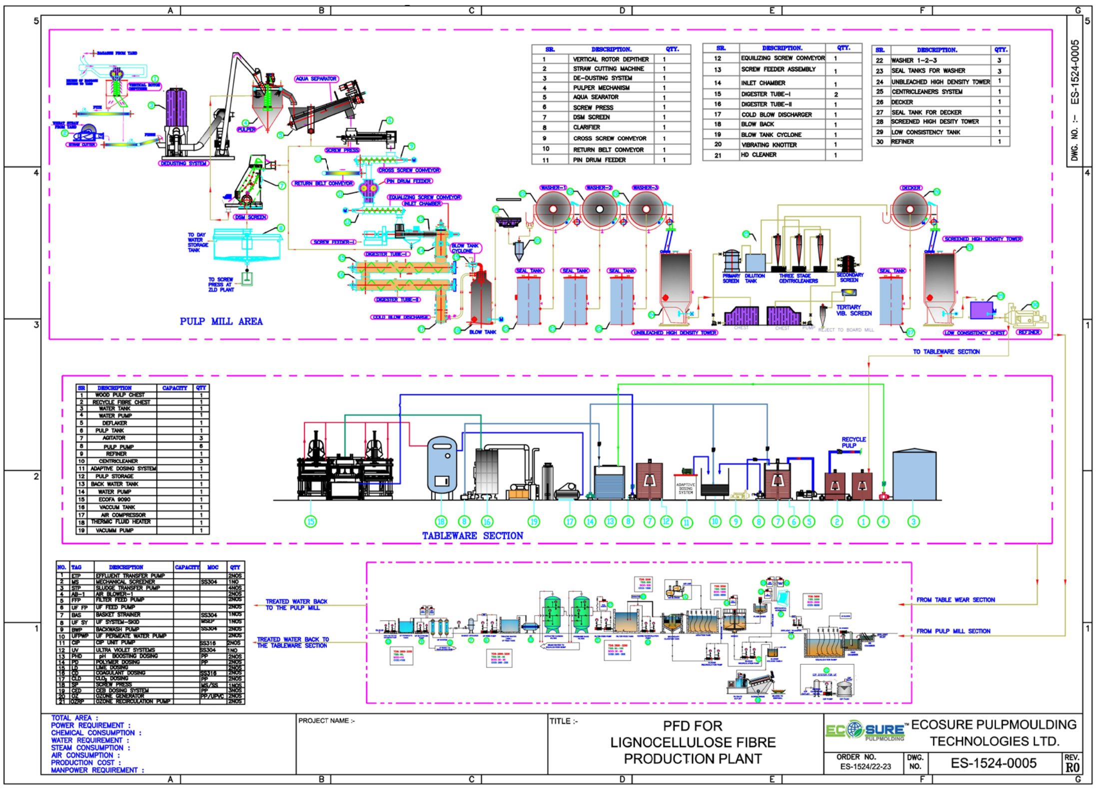
Advantages of Moulded Fiber Pulp Packaging

- Renewable and natural resources made from agro waste material.
- 100% Biodegradable and compostable.
- Microwave safe
- Freezer friendly
- Water and oil resistence
- Hygiene and food grade
- Heat resistence and steady to hold
- Recyclable
- No plastic coating

Technology & Applications in many Sectors :

Process flow to Convert Agro-waste into Molded Fiber Pulp suitable for Molded Fiber Pulp Packaging





Conclusion:- In general, societies shift toward green/ sustainable living style, which is a major driving force to witness the significant research and development and industrial efforts on molded fiber technologies. This work gives overview of the plastic waste challenges and molded pulp products as alternatives to these non-degradable, non-sustainable oil-based traditional plastic packaging products. The main concepts involved in the molded pulp packaging industry, from the general manufacturing process to current and emerging areas of molded pulp technology, were reviewed.

Molded fiber technologies/ products and their industrial exploitation are rapidly evolving, both scientific knowledge and engineering design/practices, from the environmental advantages to cost-effectiveness, are critical in unlocking the true potential of molded fiber products for various packaging applications. The following are some examples of these topics that could be tackled:

(1) The driving force of molded fiber technologies/ products is largely driven by their green/ sustainable advantages. Therefore, the choices of raw fiber sources, the technologies on fiber preparations (enzymatic, mechanical, chemical, energy consumption, waste generated, post consumption treatment, etc.), will have to be carefully evaluated and optimized because they will certainly determine the environmental impact of the final molded fiber products and their overall manufacturing processes.

(2) Fundamental research will be required to impart desirable features to cellulosic/ lignocellulosic fibers for specific MFPs. For example, in many applications, such as food packaging, a high transparency, yet with high barrier properties on these molded pulp products are required. Further research in resolving these challenges but also with cost-effective solutions, will be desirable.

(3) Market do exist for different MFPs, some are in large volume/ low value, while others are in small volume/ high value. Large volume/ low value molded pulp products, such as coffee/drink carrier trays, picnic plates, are already common in the market; however, small volume/high value for niche applications, for example, packaging of medicine/pills, cosmetics, are yet to be developed, which certainly require more research and development efforts.

(4) Process development and optimization, especially for the dewatering and drying technologies are highly needed. For instance, exploiting some more efficient additives to increase dewatering efficiency, and understanding the mechanism of the novel impulse drying process so that the drying and energy efficiency of the precision molded products can be significantly boosted.

(5) In order to completely understand the environmental sustainability of molded products, further specific studies on their life cycle should be carried out based on LCA method, in particular for those key stages of pulp preparation and product production (such as the drying process) that are the most contributing life-cycle stages.

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