

The Design of Appropriate Technology of an Egg Tray Machine

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ABSTRACT

Managing fibrous waste such as paper into useful packaging materials can help reduce large amounts of paper waste. Laboratory-scale appropriate technology machines were developed to print paper pulp into egg trays by means of suction. The pulp-making process includes collecting waste paper, sorting according to paper grade, pulping, egg tray making and the final process is sun-drying. The machine consists of a mould, a slurry container and an electric mechanism to operate the machine. The machine works on the principle of suction with a pulp slurry consistency of about 5%.

Key words: egg tray, machine, appropriate technology

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I. INTRODUCTION

Humans use paper products in everyday life. Paper products and paper product derivatives throughout the world are goods that are used by humans because they are easy to process for various purposes. According to Garside (2019) the consumption of paper used by mankind in 2017 was around 419.7 million tonnes. In 2018 the use of paper products in the United States was 67.4 million tons, the American Forest & Paper Association calculated the total production of paper and paperboard in municipal solid waste. The recovery rate is around 46 million tons, the largest compared to other materials in Municipal Solid Waste (MSW) (EPA, 2018).

The use of paper in Indonesia is very high, while paper waste is not used optimally or simply thrown away, this causes the accumulation of paper waste so that efforts are made to reuse or reuse paper. Recycling is the transformation of waste into new resources that may or may not be the same as the raw materials for waste. (Kolajo et al., 2020). One type of product produced from recycled waste paper processing is egg containers. Egg containers are currently starting to have the opportunity to become a prospective business because the raw materials used are easy to obtain and market availability.

Recycling paper products is good for the environment because it reduces greenhouse gas emissions, saves forests, and protects the environment from air and water pollution that occurs in the manufacture of pure pulp. The physiochemical characteristics of paper fibers, such as durability and flexibility do not differ between recycled and pure paper pulp (Bergand and Lingqvist, 2018). Recycled paper and paper products are raw materials in the manufacture of several products such as egg packaging trays, wall panels, production of cellulose fibers and nanocrystals, production of biopolymer films and production of biofuels (Raut et al., 2012; Zihare and Blummb erga, 2017; Ozola et al. al., 2019). The paper recycling process can be grouped in the order of collection, sorting, then cleaning, making hydro pulp, refining, and finally moulding.

In the egg tray manufacturing industry in Indonesia, currently no one has used a mixture of straw and paper pulp as a moulding material. Besides that, almost the entire process of making egg trays which is done manually using paper pulp greatly inhibits the production rate so that it is not optimal, besides that as a result of manual processing, defective products are often found, where the thickness of the egg trays is uneven. The sophisticated machines used for the egg tray production process require a large investment, are complicated to operate, and are also difficult to repair and maintain. For this reason, it is necessary to design an appropriate technology machine for egg tray printing using straw as the egg tray molding material.

Utilization of making bio composite products using straw waste with lignocellulosic materials besides being able to increase the efficiency of straw utilization can also reduce the environmental burden from waste. The advantages of this bio composite product include lower production costs, abundant raw materials, flexibility in the manufacturing process and better properties such as adjustable density, low water content and good dimensional stability (Lubis et al., 2009).

Several researchers such as Onilude et al., (2012), Kolajo et al., (2020), Kolajo et al., (2021) have developed machines for egg trays and pulp processing machines. They built an egg tray machine and a pulp processing machine with the aim of helping manage waste paper into products that have more added value.

THEORETICAL CONSIDERATIONS

In theory, pulping is wood fibres released from wood to be formed into paper sheets. Pulp is a dry fibrous material made by mechanically or chemically separating fibbers from wood or fibrous plants. The pulp can expand into thick sheets. Pulp shipped and sold as pulp is called market pulp. When suspended in water, the fibbers spread and become more pliable. This pulp suspension when placed in a mould will form paper sheets (Onilude et al., 2012).

Recycling waste paper is the process of recovering waste paper and remaking it into new paper products. Paper used as a raw material for making recycled paper can be classified as pre-consumer waste and old consumer waste. Pre-consumer waste is material that is not used or discarded by paper factories before it becomes paper products that can be used by consumers. Post-consumer waste is paper material that is discarded after being used by consumers, such as used magazines, used newspapers, and used books.

Pulp molding: Pulp molding is made from recycled cardboard and old newspapers. It is used to manufacture egg trays, food and beverage serving trays, and many more trays for patterned coasters. Melded pulp is often considered a sustainable packaging material, as defined by the sustainable packaging unit, because it is produced from recycled materials, and can be recycled again after its useful life cycle.

Vacuum Filtration: Pulp presses are designed to operate on the principle of vacuum filtration whereby it sucks the filtrate side of the media and pushes the filtrate out after suctioning which is done while the machine is running. The slurry to be filtered consists of cellulose and water. The physical and chemical properties of cellulose make it develop strong bonds and allow it to maintain its shape and contour when dried. The moulds on this appropriate technology machine have been designed to produce thirty egg trays of standard size for chicken eggs and it is necessary to pay attention to manual operating methods that use the right technology to keep the egg tray easy to operate.

II. MATERIAL AND METHODS

The technology for making egg tray moulding machines used is that the mould is lowered into a slurry pulp tub where the slurry is formed in the mould with the help of a vacuum pump which sucks up fiber and water. The die is then lifted, mounted to the counter die. The suction effect of the vacuum pump is transferred to the counter-mould where the moulded product is received, while still sucking water out of the product. The product is removed from the counter-mould when the suction is blocked and taken for further drying to the desired moisture content. After that, a push is made to remove the printout that has been printed from the mould.

The parts of the egg tray moulding machine can be categorized into two groups namely mechanical parts and electrical parts. The mechanical part is the main part that forms the construction of the machine. This mechanical part consists of hollow metal (40 x 80) mm, 1.5 mm metal plate, 1 inch (25.4 mm) diameter shaft, hollow (40 x 40) mm, pneumatic, 3 phase compressor, hose, water faucet. As for the electrical part, it consists of a panel box, 3 phase ring blower rotor, 3 phase MCB, 220/240 V relay, bus bar, contactor, selector switch, indicator light, terminal block, cable duct, 220 V solenoid, MCB panel rails, cables. The fabrication work was carried out in the Applied Technology Laboratory at the Faculty of Engineering, University of Jember.

III. DESIGN DETAILS

Details of the appropriate technology machine design for egg tray printing machines can be seen in Figure 1.

Mold: This is the template, which determines the shape of the egg tray mold. This mold consists of a metal filter material molded according to the desired egg shape of the molded product, with a metal plate as a base as shown in Figure 4. In this mold, one mold functions as a suction (forming) mold and a transferring (pushing) mold.

Considering the shape of an egg which is oval in shape, therefore the largest diameter along the axis of the egg was considered in the design (40 mm) and a factor of safety of 5 mm was added to the diameter. The frustum therefore has a dimension of 20 mm (inverted base part) extending to 45mm and a space of 15 mm between the holes.

Counter mold: The essence of this mold is a place where the molded product is released from the mold so that it can be easily transferred to the drying chamber.

Slurry Vat: This serves as a container for the slurry pulp to be scored. This is the basic part of the pulp molding machine. A rectangular tub is an open container containing a liquid which is sufficiently dense under atmospheric pressure. Rectangular tub with dimensions of 70 cm x 60 cm and a depth of 30 cm. Rigid enough

to withstand stock agitation during shaping. It is also desirable that it has sufficient volume to handle a slurry with a consistency of between 5 and 10% (Onilude et al., 2012).

Lowering Mechanism: The purpose of the lowering mechanism is for the movement of the dies into the pulp vat from the dies and back. The mechanism is pneumatic actuated by three posts that extend all the way to the slurry to mold and then up again to release the mould. The hydraulic system is installed on the pipe in the middle. Two 25.4 mm diameter pipes are attached to either side of the die and are attached to the upper shaft. The top shaft is where manual pressure is applied to control the movement of the die up or down.

Electric Motor: An electric motor is used to drive the vacuum pump. This is a three phase induction motor. The compressor used to power the vacuum pump is a 7.5 hp.

Vacuum Pump: The vacuum pump used is a pump with a rotating vane, to eliminate the use of a vacuum chamber.

Making Pulp Stock: The first stage, the process of making pulp is done by collecting used paper, in this case used newspapers, and used cardboard which are then converted into pulp using Hydro-pulper. In the second stage, the pulp obtained is then mixed by adding sufficient water to obtain a suspension with the desired thickness, and in the third stage, the mixed result is poured into the pulp holding tank.

Formation and drying of Wet Products: When the vacuum pump is activated so that a vacuum is formed in the vacuum chamber. The suction mold is connected to a sub-atmospheric pressure source and lowered into suspension; deposited on the suction mold as a result of vacuum pressure.

De-watering: The suction mold is lifted from the suspension. Drying is done by allowing the liquid to flow sucked from the mold,

Wet Product Transfer: The suction mold is released from the sub-atmospheric pressure source, and pushed into the transfer mold. The suction mold remains in position when the egg tray is pressed against the transfer mold housing.

Collection and drying: A collection tray is placed under the mold to collect the printed output, after the mold is removed, the egg tray molding machine is operated in suction mode. The printed egg trays are collected on the tray, then dried in the sun.

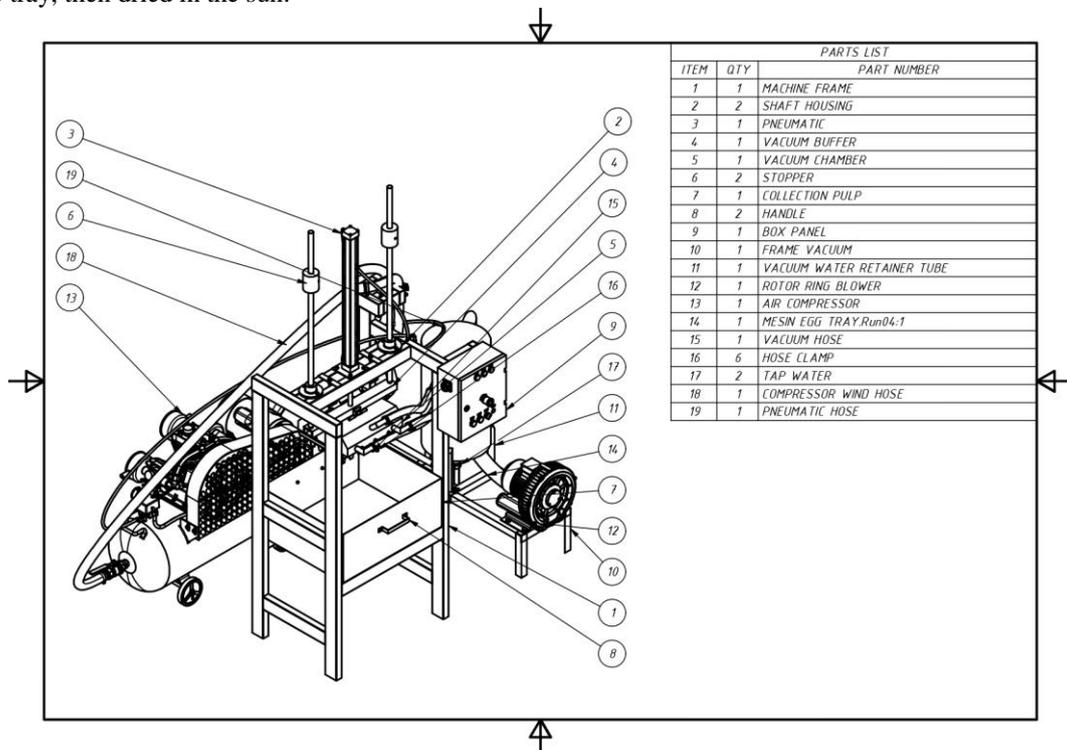


Figure 1: Desain of Egg Tray Machine

IV. RESULTS DISCUSSION

Egg Tray Machine Specifications

1. Description: Appropriate technology machine for making egg trays
2. Capacity: 120 egg trays/hr
3. Product: size 10 of 30 cavity egg trays

4. Process flow of batch production: Waste paper (manual) – hydropulping – pulp mixing – pulp feeding – pulp molding – transferring – drying in sun – collection and stacking.
5. Breakdown major equipment list: a compressor (acted as vacuum pump) 5.60 kW
6. Raw materials: waste newspapers and waste paper
7. Number of operators: 1 person

After the egg tray machine has been successfully made and tested to make egg tray, it can be seen that the machine can make egg trays well. The results of the egg tray machine fabrication are shown in Figures 2, 3, and 5, a molded product was achieved (Figure 6). The pulp mold has the same shape as the die, because the pulp mold used in the assessment is the average mold size. However, it is known that the mold process will be damaged if the pulp concentration is too dilute.

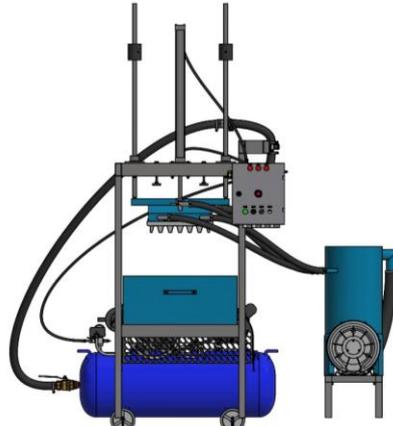


Figure 2: Egg Tray Molding Machine Design (Front View)

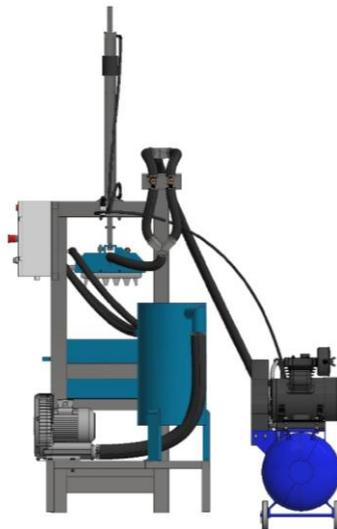


Figure 3: Egg Tray Molding Machine Design (Right View)



Figure 4: Egg Tray Mould



Figure 5: Egg Tray Moulding Machine



Figure 6: Egg Tray Moulding

V. CONCLUSION

An appropriate technology machine for making egg trays with recycled printing materials has been successfully designed and fabricated. This machine works on the principle of vacuum suction which is capable of producing 120 egg trays/hour. Even though it requires high power, it is easy to maintain. The dimensions of the resulting egg tray correspond to the dimensions of a standard egg tray.

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