

DEVELOPMENT OF TEAK LEAF PLATE MOLDING MACHINE FOR PRODUCING PLASTIC ALTERNATIVE PRODUCTS*

Martinus**, Agus Haryanto, Sugeng Triono, Mareli Telaumbanua

University of Lampung, Lampung, Indonesia

Abstract

Single use plastic is one of the biggest problems in the world right now. It is the main source of non-degradable material in the world. The usage of plastic and plastic derivatives in Indonesia most times cannot be avoided as long as no alternatives products are available. Only a small portion of the plastic is recycled, the rest end up in the land and in the ocean. Plastic need hundreds of year to decompose and some even can't decompose like expanded polystyrene. A new machine is in need for in producing an alternative product for plastic. This machine is designed, developed and fabricated in Indonesia. PID control system is used to control both upper and lower die. Set points for both die can be set individually. The temperature of upper and lower die varies by different leaves and how many layer of leaves. The leaf plates made by the machine then tested along with plastic plates, expanded polystyrene plates and plastic laminated paper plates. The result of this test will conclude how good the leaf plates as an alternative for other disposable plates. Teak leaf plate molding machine is built and performing quite well. The temperature from upper and lower die can be controlled precisely. The plates that produce by the machine in tensile strength test also perform quite well. Teak leaf plates tensile break average at 29.3 N, slightly lower than plastic one and higher than expanded polystyrene one.

Keywords: dish plate, disposable plate, molding machine, plastic alternative, teak leaf

1. Introduction

Plastics are one of the ecological problems in the world because it is the main source of non-degradable material in the environment. The usage of plastic and plastic derivatives in Indonesia most times cannot be avoided as long as no alternatives products are available. Disposable dishes and plastic containers are thrown into the sea. Every year 4.8-12.7 tons of

* Selection and peer-review under responsibility of the EIAETM

** Corresponding author: email: martinus@eng.unila.ac.id

new plastic waste end up in the ocean (Jambeck et al., 2015) and becoming micro plastic debris with bad impact to the marine life (Isensee and Valdes, 2015).

Only a small portion of the plastic is recycled (less than 10%) (Geyer et al., 2017), the rest end up in the land and in the ocean (Vegeter et al., 2014). Plastic need hundreds of year to decompose (Webb et al., 2013) and some even can't decompose like expanded polystyrene (Kannan et al., 2007; Kroeker et al., 2016).

A new materials and machines are need for producing an alternative product for plastic. Natural leaves with a large surface area can be used instead of plastic. This approach was developed before. One of the machines can be a teak leaf plate molding machine for producing plates made of teak leaves. Similar type of machine has developed in India (Mohanraj et al., 2017). But, in India they use different type of leaves mostly on sal and siali leaves (Gaikwad and Kalokhe, 2016). Our machine is designed, developed and fabricated in Indonesia to suite teak leaves as the main plate material. The teak leaf plates made by the machine then tested along with plastic plates, expanded polystyrene plates and plastic laminated paper plates. The result of this test will conclude how good the teak leaf plates as an alternative for other disposable plates.

2. Materials and methods

In this research we design a new machine, build it and produce a product using it. The process in building a new machine is following this steps.

On the preliminary research we choose what kind of the leaves to be used in the machines. The teak leaves then chosen as it is widely available in teak tree plantation and as production goes there will not be material shortage.

The design of the teak leaf plate molding machine should provide a good structure to withstand more than 2 Tons pressure. Control system also must be precise as leaves are very thin and prone to charred and burnt. A charred and burnt product is not desirable. Control system then develop to precisely control upper and under die temperature.

Teak leaf plate is made using hot press molding (Shamsuri, 2015), a process that use both pressure and heat to mold the leaves into plates. Materials for the machine are frame made of IWF beam, steel upper and lower die, hydraulic pressure delivery system, thermocouples, PID controller, SSR, heating elements, and power supply unit.

The plate itself then tested using a tensile strength test apparatus. This test will compare the teak leaf plates against plastic plate and expanded polystyrene plate. From this test we will know how the teak leaf plate performs against other product (other product it tries to replace). Below shown how the test is done.



Fig 1. Steps in Building the New Machine

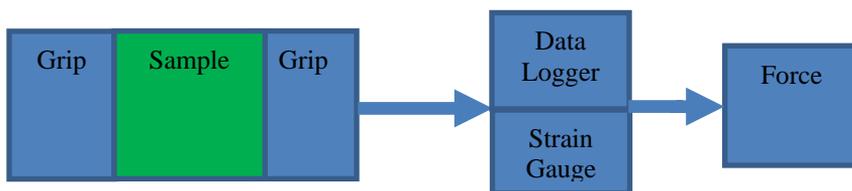


Fig. 2. Tensile strength test

3. Results and discussion

Machine is design to withstand greater pressure as preliminary research some of the frames bent under pressure. The new machine start with the new frame using IWF steel with 400 kg/mm^2 tensile strength, then the temperature control of the opposing dies, pressure delivery system and then assemble them in one final unit.

3.1. Design of the machine

The new frame design must withstand 375 kg/cm^2 of pressure. This is the maximum force that the pressure delivery system can deliver. The new frame is developed using IWF steel for the main part in pressure delivery system. The layout and photo are presented in Fig. 3 and Fig. 4.

3.2. Automatic Die Temperature Control

Temperature on upper die is a very crucial factor in forming a perfect leaf plate. Heat that transferred from the heating element to the die and finally to the leaves. Heat will dry and evaporate the leaves, dry the starch glue between the leaves. While it is heated the form of the plate will be done by pressure. Overheating on upper die resulting on charred product. Charred and burnt products are not desirable at all. Control system then needed to regulate (Martinus et al., 2018), (Telaumbanua et al., 2019) the temperature for both dies.

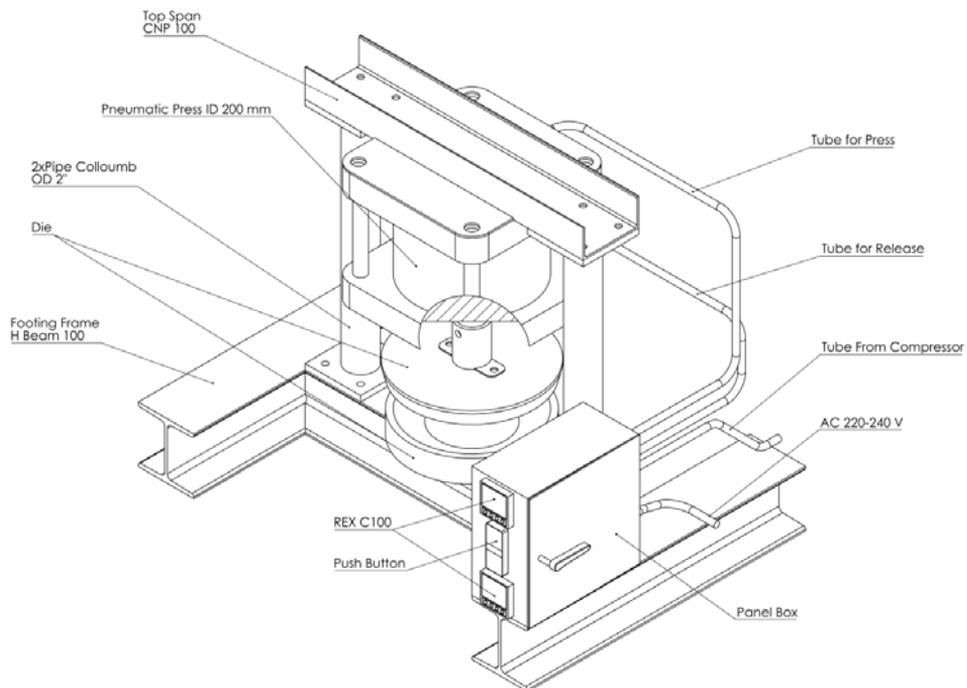


Fig. 3. Frame Design



Fig. 4. Photo of the Teak Leaf Plate Molding Machine

PID control system is used to control both upper and lower die. Set points for both die can be set individually. The temperature of upper and lower die varies by different leaves and how many layer of leaves. In Picture 4 shown how the dies temperature are controlled. The temperature control for the machine done by PID (Proportional, Integral and Derivative) analog control system (Li et al., 2006). This type of control system will assure the temperature of upper and lower dies are accurately controlled according to the set points.

Temperature curves of upper and lower dies shown in Fig.5 below.

The upper die can be maintained at 120 ± 1 Celsius at all time after 15 minutes of preheat. The lower die can be maintained at 150 ± 1 Celsius at all time after 15 minutes of preheat. These two set points are chosen best for three layer of teak leaves.

3.3. Teak Leaf Plates

The finished teak leaf plate molding machine has been tested on making teak leaf plates. The plates made then were tested for leakage, lifecycle – how long it can be stored, tensile strength of the plates, and the food capacity it can hold. In this paper shown how the tensile strength of the leaf plate produce compared to other disposable products.

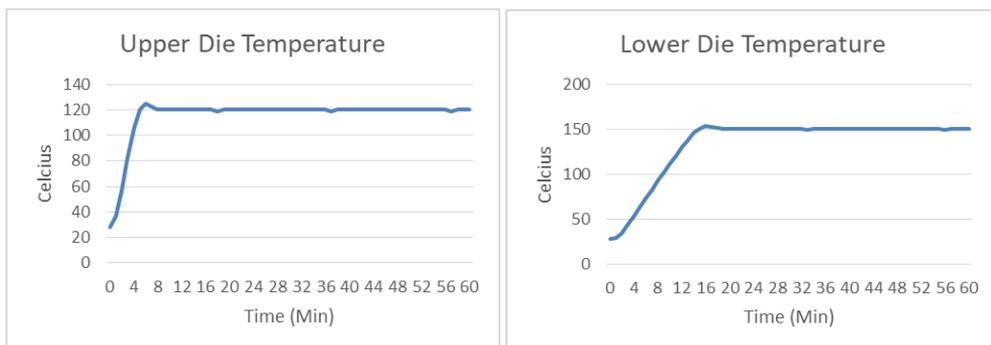


Fig. 5. Temperatures at Lower Die and Upper Die



Fig. 6. Teak Leaf Plate

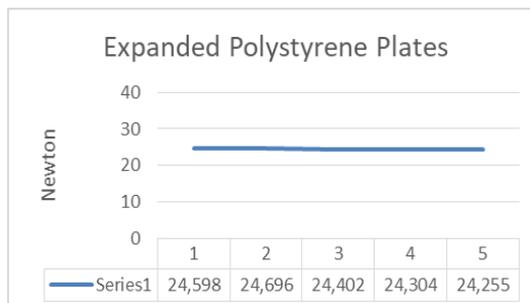
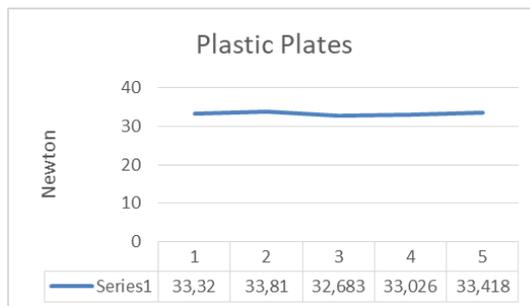
3.4. Tensile Strength of the Plates

Tensile strength test is a common test (Kora, 2019) to compare similar products. The test is done on teak leaf plates also on expanded polystyrene and plastic plates. This test will prove how the teak leaf plate performs in comparison to other product. The test was conducted using sample from each product. The size of sample test is 5cm x10cm material that cut from the leaf plate, the plastic plate and the expanded polystyrene plate. The test then repeated 5 times for each of plates.

Shown graphics below how each of plates performs under tensile strength test.

From the test we know that the teak leaf plate's strength is not consistent from one plate to another. This was caused by different age, thickness and leaf bone structure that vary from one sample to another. Test results shown below are an average force to break for each plate:

- Teak leaf plates average: 29.3 N
- Plastic plates average: 33.2 N
- Expanded polystyrene plate average: 24.5 N



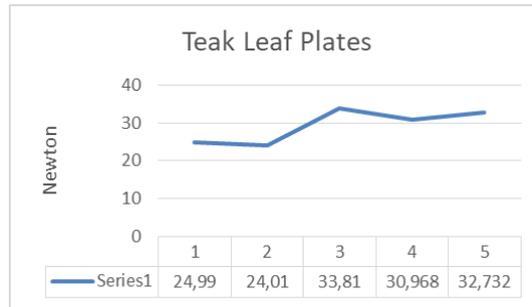


Fig. 7. Different Plates Tensile Strength Test

Even for its inconsistency the teak leaf plate performs quite well against plastic plate and expanded polystyrene plate. Teak leaf plate breaks at 29.3N slightly lower than plastic plates and higher than expanded polystyrene one. This also proves that the machine is able to produce competitive leaf plates as alternatives.

4. Conclusion

Teak leaf plate molding machine is built and performing quite well. The temperature from upper and lower die can be controlled precisely. The plates that produce by the machine in tensile strength test also perform quite well. Teak leaf plates tensile break average at 29.3 N, slightly lower than plastic one and higher than expanded polystyrene one.

Acknowledgement

The researcher would like to thank University of Lampung for financial support in this research. We would also acknowledge mechatronics lab in mechanical engineering department for its constant support.

References

- Gaikwad S., Kalokhe A., (2016), Automatic paper plate making machine, *International Journal for Research in Engineering Application & Management*, **02**, 1-5.
- Geyer R., Jambeck J.R., Law K.L., (2017), Production, use, and fate of all plastics ever made, *Science Advances*, **3**, e1700782–e1700782.
- Isensee K., Valdes L., (2015), *Marine Litter: Microplastics*, GSDR 2015 Brief, UNESCO, On line at: <https://sustainabledevelopment.un.org/content/documents/5854Marine%20Litter%20-%20Microplastics.pdf>.
- Jambeck J.R., Geyer R., Wilcox C., Siegler T.R., Perryman M., Andrady A., Narayan R., Law K.L., (2015), Plastic waste inputs from land into the ocean, *Science*, **347**, 768-771.
- Kannan P., Biernacki J.J., Visco D.P., (2007), A review of physical and kinetic models of thermal degradation of expanded polystyrene foam and their application to the lost foam casting process, *Journal of Analytical and Applied Pyrolysis*, Elsevier, **78**, 162-171.
- Kora A.J., (2019), Leaves as dining plates, food wraps and food packing material: Importance of renewable resources in Indian culture, (in en), *Bulletin of the National Research Centre*, **43**, 205.
- Kroeker S.G., Bonin S.J., DeMarco A.L., Good C.A., Siegmund G.P., (2016), Age does not affect the material properties of expanded polystyrene liners in field-used bicycle helmets, *Journal of Biomechanical Engineering*, **138**, 041005.
- Li Y., Ang K.H., Chong G.C.Y., (2006), PID control system analysis and design, *IEEE Control Systems*, **26**, 32-41.
- Martinus, Aripta T.P., Ningarta A.D., Wahyu, (2018), Making insect trap based uav (unmanned aerial vehicle), (in Indonesian), *Barometer*, Universitas Singaperbangsa Karawang, **3**, 78-82.

- Mohanraj K.S., Vijayakumar P., Senthilkumar R., A G.K., (2017), Design and analysis of semi automatic paper cum arecanut plate making machine, *International Research Journal of Engineering and Technology*, **4**, 3546-3550.
- Shamsuri A.A., (2015), Compression moulding technique for manufacturing biocomposite products, *International Journal of Applied Science and Technology*, **5** 23-26.
- Telaumbanua M., Triyono S., Haryanto A., Wisnu F.K., (2019), Controlled electrical conductivity (EC) of tofu wastewater as a hydroponic nutrition, *Procedia Environmental Science, Engineering and Management*, **6**, 453-462.
- Vegter A., Barletta M., Beck C., Borrero J., Burton H., Campbell M., Costa M., Eriksen M., Eriksson C., Estrades A., Gilardi K., Hardesty B., Ivar do Sul J., Lavers J., Lazar B., Lebreton L., Nichols W., Ribic C., Ryan P., Schuyler Q., Smith S., Takada H., Townsend K., Wabnitz C., Wilcox C., Young L., Hamann M., (2014), Global research priorities to mitigate plastic pollution impacts on marine wildlife, (in en), *Endangered Species Research*, **25**, 225247.
- Webb H.K., Arnott J., Crawford R.J., Ivanova E.P., (2013), Plastic degradation and its environmental implications with special reference to poly(ethylene terephthalate), *Polymers*, **5**, 1-18.