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Research Article

Semi-automatic Hydraulic Hotpress Tool Design for the Production of Biodegradable Tableware from Kitchen Waste

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Abstract.

The disposal of nonbiodegradable wastes in densely populated regions of the world has become a significant challenge for waste management systems due to the use of plastic composite materials in packaging. The demand for eco-friendly bio-composite packaging materials with biodegradable properties has increased to replace the petroleum-based synthetic polymers. Meanwhile, different varieties of food waste can be utilized to obtain biodegradable tableware. This study involves the production of biodegradable tableware through the application of pressure and temperature on the fruit peel or other alternative resources as substitutes. As a result, the utilization of a hot-pressing apparatus is imperative. An assessment was made on the effectiveness of a semi-automatic hydraulic hot-pressing machine in creating biodegradable cutlery from alternative resources. This hot-pressing machine was created through a literature review, working drawings, manufacturing design, and functional testing. Through the utilization of a hydraulic mechanism, the machine can apply a pressing force of up to 5 tons and generating temperatures of up to 120°C. The contact time can be adjusted up to 60 mins with a heater cross-sectional area of 200 cm^2. In addition, this hot-pressing machine can produce tableware in accordance with exact specifications.

Keywords: biodegradable tableware, hot-pressing machine, organic waste

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1. INTRODUCTION

The development of the food and beverage industry in Indonesia is growing very fast and offers a lot of easy access to the public (Asyik et al., 2022; Irawati & Prasetyo, 2022). The most common and often consumed is fruit juice, the fruit juice product produces pulp and is simply disposed of as waste. According to the 2021 Bappenas report, Indonesia ranks third largest in the world in terms of *food loss* and *food waste* after Saudi Arabia and the United States. Between 2000 and 2019, the amount of food loss and food waste in Indonesia reached around 150 to 184 kilograms per person per year. This amount should be enough to feed 30% to 40% of Indonesia's population [3].

Based on data from the Ministry of Environment and Forestry (KLHK), 37.3% of waste in Indonesia comes from household activities and the majority of waste generated by the community is in the form of food waste including pulp from fruits and vegetables which, if not managed properly, will become waste [4]. Juice pulp waste is one type of organic waste generated from the process of making fruit juice. The increasing amount of waste today is caused by population levels and lifestyles, meaning that the more advanced and prosperous human life is, the more waste is produced. The increase in the amount of waste occurs with geometric progression. Landfill land availability is the cause of landfills having a short lifespan as they can no longer accommodate the existing waste. Low technology and weak infrastructure cause waste problems to be quite complex, especially in developing countries such as Indonesia [5], [6].

Sheet metal plates can be transformed into desired production items with the help of Press Tool, which is an equipment specifically designed for cutting and forming with emphasis[7]. The efficiency of this tool lies in its ability to produce a large quantity of products with consistent quality in a short amount of time. Incorporating the blanking process in this tool has several advantages that make it highly desirable. First, the ability to produce products in bulk quantities is one of the key advantages, especially for industries that need to manufacture products on a large scale. Furthermore, it should be noted that the blanking process is not only important for maintaining consistency and quality across batches, but it also ensures that each product is uniform, which is crucial for the overall success of the production process. The benefits of utilizing this tool extend beyond just improving the quality of mass-produced goods as it also helps in reducing the cost of production, making it an efficient and cost-effective solution for businesses that require goods produced in large quantities[8], [9].

The press tool is highly appropriate for producing a workpiece that has identical shape and size in a considerably shorter time than the sequential production of machine tool products. The collision method between the matres and the punch stamp is employed as the working principle of the press tool. The object's location lies between the punch and the matres. Usually in each process, the workpiece is clamped by a stripper that uses spring force.

The classification of press tools can be categorized into simple tools, compound tools, and progressive tools based on the work process performed on the die. The Simple Press Tool is characterized as the most basic type of press tool, where only one working process and one station are present in the tool. A press tool consists of several important components, including shank, top plate, bushing, retaining plate, punch holder, stripper plate, die, bottom plate, pillar, stopper, stripper spring, fastening

bolt, and stripper bolt. Punch and die, categorized under production auxiliary tools, are utilized for shaping or severing sheets of material through pressing [7], [9], [10].

The large projected waste generation in the future and the limited efforts to utilize household waste are the basis for researchers to propose this program. This research aims to design a simple semi-automatic hydraulic hot -pressing machine to create simple biodegradable kitchen utensils from kitchen waste.

2. METHODOLOGY & MATERIALS

2.1. Methodology

The research is conducted numerically utilizing the Finite Element Method with the aid of Solidworks 2022 software, executed on a computer with a Core i5 Cache 6M processor with specifications including a 3.60 GHz clock speed, 64-bit processing, 16 GB DDR4 RAM, and 512 GB SSD storage. The simulation utilized a system analysis method that focuses on static load analysis. This involved the application of various pressure load variations, up to 5 tons or the equivalent of 11200 psi, which were assumed to be evenly and centrally loaded.

The structural strength of the composite was tested using the Element Method for numerical analysis. The simulated loading was established to bear the closest resemblance to the real situation. Throughout the simulation procedure, the geometry data and dimensions of the composite press apply to the intended design **as shown in Figure 2**. During the process of design, the structural integrity is replicated in order to ensure compliance with the allowable stress threshold. Should this not be the case, the design will be revised and re-evaluated through the addition of supplementary supporting components and modifications to the tool's dimensions.

The design of the hot pressing mould was created by utilizing the methodology outlined in the flow chart depicted in Figure 1.

The Flowchart, which concerns Determining the Theme, can be explained as follows.

The present study explores the fabrication process of a semi-automatic press intended for household applications. A metal plate is employed in conjunction with a hydraulic pump to achieve the desired results.

- Needs Analysis

The research highlights the pressing need to tackle the issue of biomass waste in Indonesia. It is imperative to introduce a waste processing mechanism that can cater to household requirements.

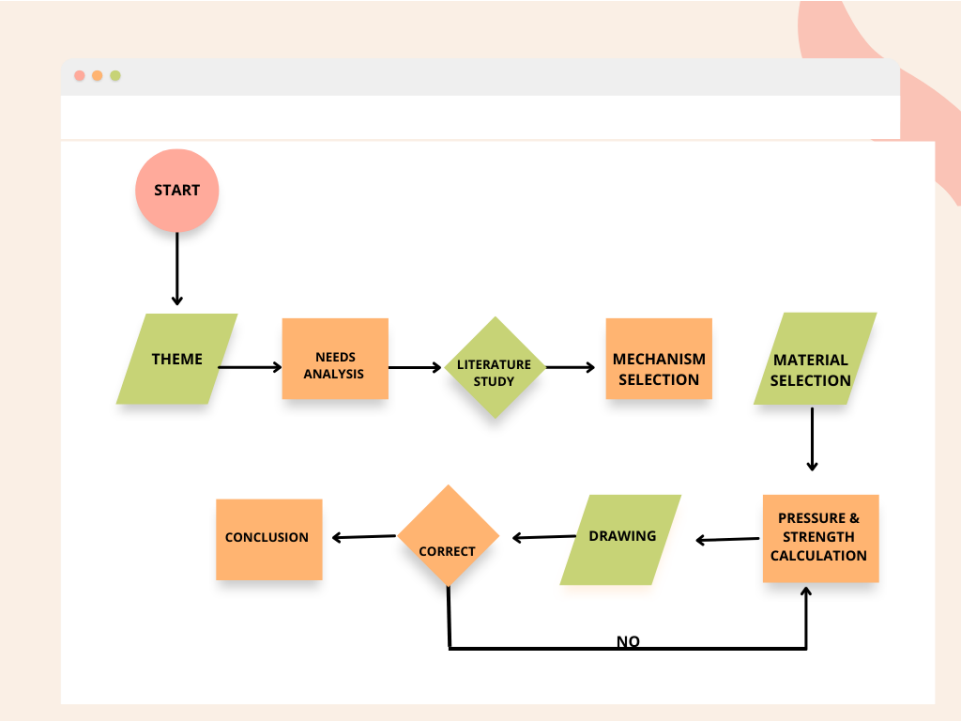

Figure 1: Research Flowchart.

- Literature Study

The analysis of literature is employed to comprehend the concepts and theories behind the functioning of compression moulding, the hydraulic mechanisms involved in the process of compression and the role of heaters during the operation.

- Mechanism Selection

The present research employs a hydraulic system comprising a hand pump that drives oil to operate a single-acting cylinder of the cylinder type. The hydraulic system is utilized owing to its reasonable cost.

- Material Selection

The material utilized in the Compression Moulding machine is durable and can withstand high pressure and heat, particularly on the base plate that is subjected to compression. Once a suitable material has been obtained, the subsequent step involves devising a design for the Compression Moulding process.

- Pressure and Strength Calculation

Within this research, a range of manual hand pumps were utilized that are priced appropriately for household use, and are capable of attaining the necessary pressure for biomass waste processing. Following the acquisition of the pressure, the subsequent process involves determining the structure's stability for safe use.

- Drawing

Upon receipt of the results from pressure and strength calculations, the subsequent step is to create working drawings as a means of conducting the fabrication process.

- Conclusion

The conclusion is derived subsequent to the execution of the design process.

2.2. Materials and Instruments

This research was conducted in the Mechanical Workshop of State Polytechnic Creative Media. The hydraulic system used in this hot press was built by using two main components: tools and materials.

The tools used in this research were:

1. PPE (Personal Protective Equipment)
2. Milling machine
3. Lathe machine
4. Drilling machine
5. Grinding machine
6. Hardness tester
7. Sawing machine
8. Universal testing machine (UTM)
9. Tool heat treatment
10. Electric welding
11. Measuring tool

Materials were used consist of:

Rex-C100 C-100 Out Relay Include Thermocouple Type-K Temperature

Relay Delay Timer Switch Board DC 12V-24V AC220

Hydraulic Jack 5 tons

10-100A Relay Board Fotek SSR

Aluminum Solder Heating Plate Split Welding Station Demolition Board

US aluminum alloy rod

Large nuts and bolts

Cable 0.5 mm

20 cm large spring

AD16 switch and LED

The initial step in the design process entails carrying out the system design process in accordance with the prescribed steps. The assessment of urgent requirements conducted during the needs analysis process encompasses aspects of production, manufacturing, ergonomics, and occupational safety. The design concept of the pressing system comprises two concepts that will be compared to ascertain the differences between the former and the latter, which are characterized by distinct criteria. The pressing system planning involves the calculation of various elements including material cutting, heating elements, guide rods, hydraulic systems, and frame calculation [7], [9].

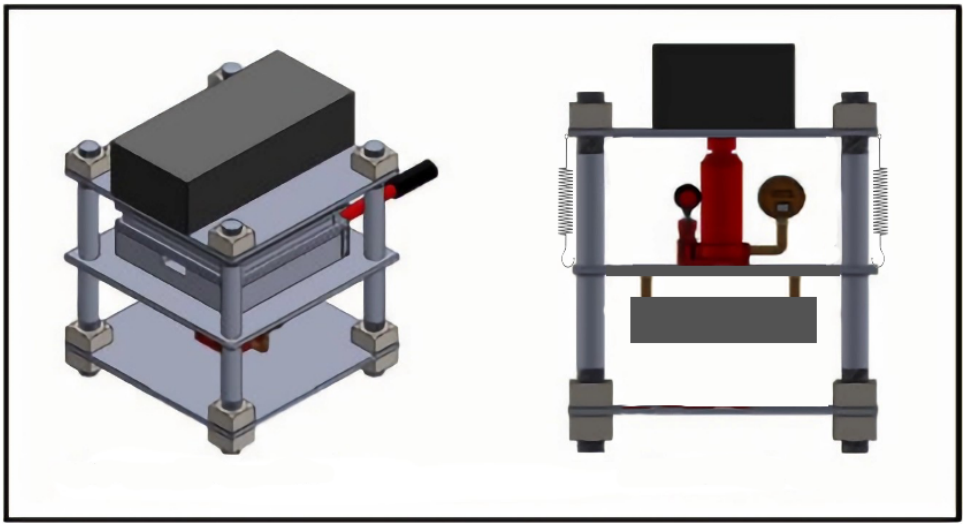

Figure 2: Concept Drawing.

3. RESULTS AND DISCUSSIONS

The literature pertaining to hot-pressing indicates that this technique is primarily employed for manufacturing laboratory samples. It is advisable to limit the maximum temperature to 210°C and to maintain the pressure below 50 tons for specimens measuring up to 300mm x 300mm on average. The contact angle increases while water absorption decreases as the temperature, pressure, and duration increase[11], [12]. The augmentation of material density results in an increase in mechanical strength and a more homogeneous surface appearance of the bio-composite. The method is suitable for producing bio-composite parts and conditioning pre-fabricated sheets. Material properties can be improved by post-operative hot-pressing at higher pressure for outdoor application. The material is recommended to be heated in a hot-press and compressed in a cold-press, as stated in papers. In order to use this process for the purpose of industrial “thermoforming” of bio-composite semi□finishings, several individual processes can obviously be linked together in a similar way [13], [14].

3.1. Results of Design Validation

In the process of designing a hydraulic hot press tool, a design is made to make it easier for researchers to make the construction of a hydraulic press. The quality of the design's feasibility can be assessed through the following evaluation formula, and the results of the assessment are as follows:

$$PPV = \frac{SR}{ST} \; x \; 100\%. \quad (1)$$

Description:

PPV = Percentage of validator assessment

SR = Total number of validator answers

ST = Total number of validator's highest score

TABLE 1: Score Interpretation Criteria.

Score (%)	Description
0-25	Not feasible
26-50	Less feasible
51-75	Feasible enough
76-100	Feasible

The design is categorized as feasible and the assembly process can be carried out if the total assessment gets a minimum category value of 51-75% (Feasible Enough). The following are the results of the assessment from the validator, see Table 2 below.

TABLE 2: Validator Assessment Results.

Asessment	**Score**				**Score**	**Max**	**Percentage**
	1	2	3	4			
Compatibility				4	16	16	100
easy to understand			2	2	14	16	87,5
Appropriate size			3	1	13	16	81,25
Neatness			1	3	15	16	93,75
Clarity			2	2	14	16	87,5
Mean							90

Based on the aforementioned validator assessment results, an average score of 90% was achieved. The design has satisfied all mandatory criteria and is eligible for the production of components in accordance with an authorized design.

3.2. Manufacturing Process

The production of this hydraulic tool component for composite materials pressing involves various machining procedures, including drilling, grinding, and welding, carried out using specialized machines.

1. Machining Process

The process of making the components of the composite material hydraulic press tool involves going through a machining process, which includes:

a. Grinding Machine

The purpose of employing this grinding machine is to sever the material for the main frame of the hydraulic press. This grinding machine is utilized for cutting angle iron, concrete iron, cleaning the frame's surface from welding splashes, and rectifying faulty welds. The grinding machine's versatility and reliability make it an essential tool for the production of high-quality hydraulic press frames. It helps to ensure that the frames are precisely cut, properly cleaned, and free from defects. This contributes to the overall quality and durability of the hydraulic press, which is essential for its safe and reliable operation.

b. Drilling Machine

The drilling machine serves the purpose of piercing holes in the hydraulic press. This drilling machine is used for activities such as making holes in the support pole frame. The drilling machine in the hydraulic press workshop played a vital role in ensuring the efficient and safe operation of the press. It was used to precisely pierce holes in the support pole frame, enabling the secure mounting of brackets, wiring, and hoses. The machine's robust construction and powerful motor withstood the rigors of the workshop environment, while its variable speed control and safety guard ensured accurate and hazard-free operation.

c. Electric Welding Machine

The purpose of utilizing this electric welding machine is to execute the assembly of components that will be affixed permanently. The electric welding machine is used to carry out activities such as joining the lower frame, upper cross frame, and attaching support poles.

3.3. Assembly Process

The assembly process is the process of combining the parts of the components that have been made into a single component so that a complete and ready-to-use tool is formed. The following assembly process is carried out:

Connection of Adjustable Support Poles with Underframe, in the installation process between the right and left support poles with the bottom frame using welding connection. This welding process is carried out on each side so that both components remain in position (Figure 3).

Figure 3: Assembly Process.

b. Connection of the upper crossbar frame with the support pole, in the process of connecting the upper crossbar frame with the support pole using welding connection. The welding process is carried out in stages to prevent distortion of the frame.

c. Installation of the lower mould support with the upper mould suppressor, this installation process is carried out by inserting the component into the support post in an upward tilted position.

d. Painting (finishing) The process of painting the frame of this hydraulic press includes sanding on all sides of the frame aimed at cleaning from welding splashes and so that the paint can adhere firmly. This painting is done manually using spray paint.

e. The heating plat is mounted on the bottom plate and it is surrounded by heating coils. These coils are used to heat the biodegradable materials and absorb the moisture present in the materials on heating. Control panel, on top of the machine, can manage the temperature and time with 500watt electricity power. The heating temperature can reach 120◦C with adjustable timer until 60 minutes.

Figure 4: Control Panel.

3.4. Analysis of Press Capacity calculation of Compression Molding Machine

Calculation of press capacity in Compression Molding is obtained from the Formula

Press capacity (kN) = $\frac{A\ ram\ area\ x\ Hydraulic\ Pressure\ [MPa]}{10}$ (2)

Description:

Press capacity: Maximum Press Capacity (kN)

A ram area : Area of the hydraulic cylinder ram (cm2)

Hydraulic pressure: (MPa)

The compression force is obtained from the calculation (1), which determines the press capacity of the equipment. The following are the results of the calculation of the hydrauolic capacity in the design is 5 tons, the maximum pressure obtained from Formula (1) on the press capacity of the equipment.

Obtained from Formula (1) on Compression Molding is

Press capacity (kN) = $\frac{A\ ram\ area\ x\ Hydraulic\ Pressure\ [MPa]}{10}$

$$49.03 = \frac{200\ x\ Hydraulic\ Pressure\ [MPa]}{10}$$

Hydraulic Pressure = 2.45 MPa

Figure 5: Semi-Automatic Hot-Press Hydraulic Machine.

4. CONCLUSION AND RECOMMENDATION

The study successfully demonstrated the effectiveness of a semi-automatic hydraulic hot-pressing machine in creating biodegradable cutlery from alternative resources. The machine was designed and manufactured based on a literature review, working drawings, and manufacturing design. It is capable of applying a pressing force of up to 5 tons and generating temperatures of up to 120° C, with a contact time adjustable up to 60 minutes and a heater cross-sectional area of 200 cm^2. The machine can produce tableware in accordance with exact specifications, making it a promising tool for the production of sustainable and eco-friendly packaging materials.

The findings of this study contribute to the growing body of knowledge on the development of biodegradable packaging materials from alternative resources. The semi-automatic hydraulic hot-pressing machine presents a viable solution for the production of biodegradable cutlery, which can help to reduce the environmental impact of non-biodegradable waste. Further research is warranted to investigate the optimal operating parameters of the hot-pressing machine for different types of alternative resources. Additionally, the machine can be modified to produce other biodegradable tableware items, such as plates and cups.

References

[1] Irawati R, Prasetyo IB. Pemanfaatan Platform E-Commerce Melalui Marketplace Sebagai Upaya Peningkatan Penjualan dan Mempertahankan Bisnis di Masa Pandemi (Studi pada UMKM Makanan dan Minuman di Malang) [PENATARAN]. Jurnal Penelitian Manajemen Terapan. 2022;6(2):114–33.

[2] Asyik NF, Patuh M, Triyonowati W. Respatia, and N. Laily, "Aplikasi Digital Pengelolaan Keuangan, Sarana Meningkatkan Penjualan UMKM Makanan Minuman di Kabupaten Gresik," *Jurnal Kreativitas dan Inovasi*, pp. 12–26, 2022.

[3] Bapennas, "Pengelolaan Limbah Makanan yang Berkelanjutan Berkontribusi pada Pembangunan Rendah Karbon di Indonesia." [Online]. Available: http://greengrowth.bappenas.go.id/pengelolaan-limbah-makanan-yang-berkelanjutan-berkontribusi-pada-pembangunan-rendah-karbon-di-indonesia/

[4] Rizaty MA. "Mayoritas Sampah Nasional dari Aktivitas Rumah Tangga pada 2020 | Databoks," Databooks.Katadata.Co.Id. Accessed: Mar. 14, 2023. [Online]. Available: https://databoks.katadata.co.id/datapublish/2021/07/29/mayoritas-sampah-nasional-dari-aktivitas-rumah-tangga-pada-2020

[5] Nurmandi A. *Manajemen perkotaan*. 2022. Accessed: Mar. 14, 2023. [Online]. Available: https://books.google.com/books?hl=en&lr=&id=nS9sEAAAQBAJ&oi=fnd&pg=PP1&dq=Teknologi+yang+rendah+dan+infrastruktur+yang+lemah+menyebabkan+masalah+limbah+cukup+kompleks,+terutama+di+negara+berkembang+seperti+Indonesia&ots=sO88VlQyhq&sig=i8S5XDyO2T3LfIRGS4ANdczkXTw

[6] Patinvoh RJ, Taherzadeh MJ. Challenges of biogas implementation in developing countries. Curr Opin Environ Sci Health. 2019;12:30–7.

[7] Rizza MA. Analisis proses blanking dengan simple press tool. Jurnal Rekayasa Mesin. 2014;5(1):85–90.

[8] Junaidi J. Pengembangan Alat Kempa Panas (Hot Press) Penekanan Dongkrak Hidrolik untuk Pembuatan Papan Komposit ukuran 25 cm x 25 cm. Jurnal Teknik Mesin. 2020;13(1):25–31.

[9] Rusmar I, Husainy H, Kasir MK, Bukhari B. "Perakitan Alat Kempa Tekan Panas Untuk Pencetakan Material Komposit Dengan Bahan Pengisi Olahan Limbah Kelapa Sawit," *Jurnal Agroindustri, Agribisnis, dan Agroteknologi*, vol. 2, no. 1, pp. 13–18, 2023.

[10] Alfirdaus AA, Ashari F, Maghfiroh AM. Perancangan Alat Press Hidrolik Material Komposit. Jurnal Teknik Industri. 2023;26(02):11–22.

[11] Chakraborty S, Sarkar U, Bera D, Ghosh CK, Roy L. Biodegradable polymers for sustainable packaging: Fabrication methods. Reference Module in Materials Science and Materials Engineering. Elsevier; 2023. https://doi.org/10.1016/B978-0-323-96020-5.00156-4.

[12] Choeybundit W, Shiekh KA, Rachtanapun P, Tongdeesoontorn W. Fabrication of edible and biodegradable cutlery from morning glory (*Ipomoea aquatic*) stem fiber-reinforced onto soy protein isolate. Heliyon. 2022 May;8(5):e09529.

[13] Friedrich D. Thermoplastic moulding of Wood-Polymer Composites (WPC): A review on physical and mechanical behaviour under hot-pressing technique. Compos Struct. 2021;262:113649.

[14] Pandey R, Singh R, Baitha P, Topno R. Design and development of eco-friendly cutlery out of paper waste through molding next generation waste management. Mater Today Proc. 2021;46:1557–61.