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Development and Performance of A Hot-Press Machine for Particle-Board Production

[1*]Hassan-Ajao Oluwatoyin Q., [2]Moradeyo Oyinkansola A., and [3]Omoniyi Temidayo E.

[1]*Wood Products Engineering Department, Faculty of Technology, University of Ibadan, Ibadan Nigeria;*
gudirat.toyinajao@gmail.com
[2]*Wood Products Engineering Department, Faculty of Technology, University of Ibadan, Ibadan Nigeria;*
moradeyooyinkan@gmail.com
[2]*Wood Products Engineering Department, Faculty of Technology, University of Ibadan, Ibadan Nigeria;*
temidayoomoniyi@gmail.com

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Corresponding Author:
qudirat.toyinajao@gmail.com;
+2347032933802

ABSTRACT

Waste management in wood and agricultural processing industries conserves resources, energy, and money. Hot-press machines can help small-scale producers afford essential materials like lamination, composites, and woodworking, but current models struggle with tracking process parameters, frequent maintenance, and productivity loss. This research focuses on the development of a hot-press machine for the production of particle boards. The part design for the machine includes the frame's upper and lower platens, hydraulic jack base, mix-unit, control box, mould and mould-plate. Design done per ASTM standards. The fabrication process was done at the Works and Maintenance Metal Workshop, University of Ibadan. Agricultural residue Z.mays-cob was sourced and milled at Bodija International Market Ibadan. Z.mays-cob was further air dried and sieved, retention on sieve number 2.00mm was used for the particle board (composite) production. Production of the particle boards was done using (60:40; 70:30 and 80:20)% of Z.mays-cob particle and Urea-Formaldehyde as the composite-mix ratio. The boards were pressed at a temperature range of 90-120^{0}C, with a pressing duration of 1440 minutes. Density, water absorption, and thickness-swelling were determined at 2 and 24 hours, respectively. Also, internal bonding was determined. Density was found increasing in boards with higher percentages of Urea-Formaldehyde with higher pressing temperature. Boards with higher Urea-Formaldehyde contents demonstrate better physical qualities. Internal bonding strength increases with optimum temperature of 120°C. The hot-press machine developed with a cost of $193 and was able to produce particle board suitable for interior usage from agricultural residue

INTRODUCTION

Appropriate residue management is essential to lowering the waste disposal issue in the agricultural processing industries (Gupta *et al.* 2022). Rousta *et al.* (2016) stated the procedures and actions involved in handling waste, from collection to disposal or recycling involve the three "R"s (Reduce, Reuse, Recycle). The "R"s of good trash management procedures are limiting the negative impacts of waste on the environment and human health, reducing waste generation, and using garbage as a valuable resource whenever possible. De Ferran *et al.* (2020) revealed the reusing and recycling of some Agricultural residue materials instead of throwing them away to cut down on the quantity of waste menace in the environment. This method conserves natural resources, saves energy and money, and reduces the quantity of garbage that ends up in landfills or incinerators. Making composites is one way to recycle and utilise wood and agricultural residue (Ramesh *et al.* 2021; Sharma *et al.* 2024). Any material composed of two or more constituent materials having dissimilar chemical or physical properties is called a composite (Omoniyi *et al.* 2013; Oyewo *et al.* 2023). When these components are combined, a new material is produced that has enhanced qualities not possible with any of the constituent materials alone. Bhong *et al.* (2023) identified numerous industries, including aircraft, automotive, construction, sports equipment, and medical devices, that use composite materials. Engineered wood, one of the most popular kinds of composites, is created by combining waste wood with a resin matrix to create ply and boards using hot press compacting equipment (Khan *et al.* 2022, Yang *et al.* 2023).

Hot press machines have become necessary equipment in the manufacture of many materials, especially for the lamination, composites, and woodworking sectors (Datta *et al.*, 2018; Kowaluk 2012). The development of a locally made hot press machine not only lowers the capital costs for manufacturers but also encourages the growth of local companies. Small-scale producers, however, cannot afford to make or import these machines since they are generally quite expensive (Oyelaran-Oyeyinka 2004). In solving these problems, a viable approach for developing a hot press machine by utilising materials that are readily available and easily accessible. The availability of hot press allows small-scale business owners to have access to quality equipment at a lower cost, which tends to ultimately promote economic development in society. This machine should address the shortcomings of current hot presses, such as the inability to track and record critical process parameters for study and optimisation, and the inability to precisely explore bonding parameters for various wood materials and adhesives (inaccurate temperature control). A more capable and affordable hot press machine that can reliably yield high-quality goods is required (Sarin *et al.* 2003). Current hot press machines in the market are either overpriced or devoid of the characteristics required to satisfy the particular needs of particular businesses (Akinola, 2014). Furthermore, certain machines might need a lot of maintenance and raise safety issues, which could result in frequent downtime and lost productivity (Jeffrey *et al*. 2023). Thus, it is possible to develop a hot press machine that can meet the unique demands of multiple industries, including composites, woodworking, plastics, and textiles, while also being safe, effective, and reasonably priced. Therefore, this research aims to develop a user-friendly hot press machine capable of compressing agricultural residue under controlled temperature and pressure conditions, producing high-quality composite boards.

METHODOLOGY

The hot press main components include the machine frame, upper platen, lower platen, heating element, thermostat, sensor, contactor, control box, hydraulic jack, hydraulic jack base, pressure gauge, mixing unit and mould.

2.1 Parts Design and Materials Selection

The choice of materials for the design is influenced by a number of factors, including the materials' appropriateness, strength, affordability, and local availability. Table 1 presents the components of the machine as presented in Figure 1(a-d).

Machine Design

The heating element, a device that converts electrical energy into heat flow/energy is proportional to the product of thermal conductivity, cross-section area and the temperature gradient.

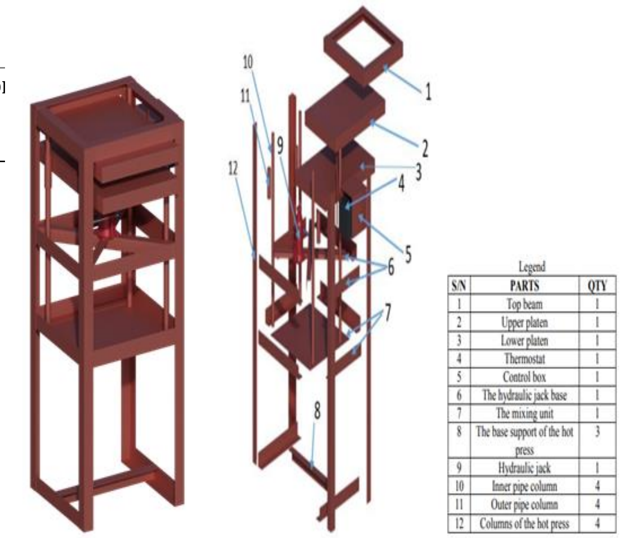
Table 1: Component of the Composite Hot-Press

S/n	Component	QTY	Dimensio (kg/m^3)			
1	Upper Platen (pipe 3mm)	4	7900			
2	Upper Platen plate(3mm)	2	7900			
3	Lower Platen plate(3mm)	4	7900			
4	Lower Platen plate(3mm)	2	7900			
5	Lower Platen bracing (flat bar 5mm)	2	7900			
6	Inner pipe column (pipe 3mm)	4	7900			
7	Outer pipe column	4	7900	0.12	0.48	4.8
8	Columns (50mm angle iron) (1200mm)	4	7900	7.71	30.84	302.54
9	Beams (50mm angle iron) (500mm)	4	7900			
10	Base of the hydraulic jack	1	7900			
11	Control box cover	1	7900			
12	Mixing unit (angle bar)	4	7900			
13	Mixing unit plate	1	7900			
14	Mixing Unit bracing(flat bar 5mm)	2	7900	0.71	1.42	14.2
15	Thermostat	1	-	-	-	-
16	Sensor	1	-	-	0.2	20
17	Heating element	2	-		4.4	88
18	Hydraulic Jack	1	-		44	440
19	Mould	1	-		1.69	16.9
20	Base support for columns	3	7900	0.96	2.89	28.9
TOTAL						1140.57

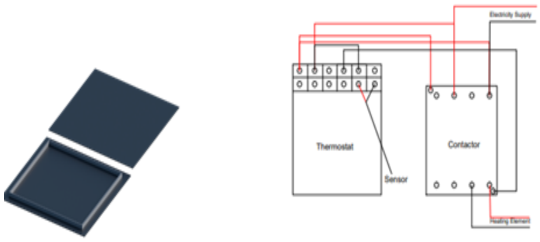
$$Q = kA\frac{dT}{dx} \quad \ldots \quad (1)$$

(Khurmi and Gupta 2019)

where: Q is the conduction heat flow, k is the thermal conductivity of the medium, A is the cross-section area of the medium, ΔT is *the temperature gradient*



(a) 3D model of the hot press machine (b) exploded view of the hot press machine



(c) mould (d) Sketch of the electrical unit

Figure 1(a-d): Hot press machine parts

Heater size is denoted by the heat required as the product of the mass of the material's moisture, its specific heat capacity and the temperature gradient inversely proportional to the heating time.

$$Q = \frac{mc\Delta T}{t} \quad \ldots \quad (2)$$

Where: Q is the required capacity of the heaters, m is the mass of the heating block, c is the specific heat capacity of the material of the heating block, ΔT is the difference temperature between the initial temperature and desired temperature, t is the desired heating time Temperature 90, 105 and

T120^{o}C was utilised for the production of the particle boards set on the hot press machine, for the duration of 5mins while pressure was kept constant at 1.4MPa. (Scatolino *et al.* 2013).

Frame

Load Design on the Hot Press machine frame (Live load + Dead load/Self-load) …. (3)

Live load =

weight of mould for a (150 x 150 x 12) mm (LxBxT) + weight of standard 5ton hydraulic jack

= 16.9N + 44N = 60.9N

Self-Weight = *Weight of Upper Platen(pipe 3mm) + Weight of Upper Platen(plate 3mm) + Weight of Lower Platen(pipe 3mm) + Weight of Lower Platen(plate 3mm) + Weight of Lower Platen bracing(flat bar 5mm) +Weight of Inner pipe column(pipe 3mm) + Weight of Outer pipe column + Weight of Columns(50mm angle iron)(1200mm) + Weight of Beams(50mm angle iron)(500mm) + Weight of Base of the hydraulic jack + Weight of Control box cover + Weight of Mixing unit(angle bar, plate) + Weight of Mixing Unit Bracing(flat bar 5mm) + Weight of Thermocouple/Thermostat + Weight of heating element + Weight of Base support for columns = **1140.57N***

Total load = Live load + Dead load = 60.9N + 1140.57N = 1201.47N

$$P_{rankine} = \frac{\delta_c \times A}{1 + a(\frac{L_e}{r_g})^2} \quad (4)$$

(Khurmi and Gupta 2019)

Where, δ, density of mild steel,=320MN/m^2, A= area, a = young modulus, for mild steel, L_e= Effective Length, r_g = *Radius of gyration,* $= \sqrt{\frac{I}{A}}$

I = moment of inertia, $\frac{bd^3}{12}$ (5)

using, Cross section of angle frame = 50 x 50mm

I = moment of inertia = $\frac{(50 \times 50)^3}{12}$ = 5.208 x 10^{5}mm^4, Area = 0.5 x 50 x 50 = 1250mm^2

Therefore, $= \sqrt{\frac{I}{A}} = \sqrt{\frac{5.208 \times 10^5}{1250}} = \sqrt{416.64}$

= 20.412 mm

Where, L = length of frame = 1200mm, L_e = 0.5L (for one end pinned and one end fixed)= effective length of frame 600mm

Then, $= \frac{600}{20.412}$ = 29.39

Using Rankine's formulae, $P_{rankine} = \frac{\delta_c \times A}{1 + a(\frac{L_e}{r_g})^2}$

Where, $= 320MN/m^2$ *, a = for mild steel*

Therefore, $P_{rankine} = \frac{320 \times 0.00125 \times 10^6}{1 + (\frac{1}{7500})(29.39)^2} = 358689.83N$

$$P_{rankine} = 4 \times P_{permissible\ load} \quad (6)$$

Factor of Safety used = 4

$P_{permissible} = \frac{358689.83}{4}$ = 89672.46N

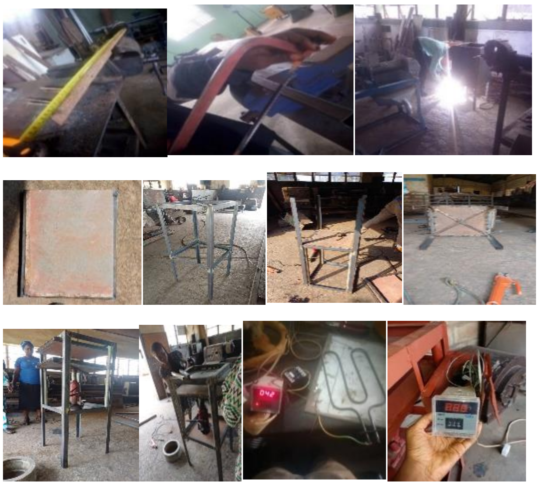
$P_{permissible} > total\ load\ on\ frame$,

That is, 89,672,46N > 3,297.67N

Since $P_{permissible}$ is not greater than the total expected on the frame, hence the design is safe.

Process of Machine Fabrication

The steel materials used for the fabrication were procured locally at the parts market Agodi Ibadan, while the electrical components were bought from Ogunpa market Ibadan. The fabrication and Assembly were done at the welding unit of the maintenance workshop University of Ibadan, Ibadan. The fabrication process commenced with the measuring of parts using measuring tape as shown in Plate 1a, cutting into required sizes using the grinding machine, and occasionally hack saw with blade as shown in Plate 1b. The mild steel were arranged and welded together as shown in Plate 1c. The legs were made from mild steel of dimension 50 x 50 mm. It was welded at right angle to each other so as to allow for rigidity and easy attachment of the frame as shown in Plate 1e. The parts were assembled as shown in Plate 1h - i and the machine frame was sand, grinded and painted.



(a) Marking out (b) Cutting (c) Welding process (d) Upper and lower platen (e) Frame fabrication (f) base fabrication (g) flat bar supporting base (h) fabrication process (i) Testing the machine (j) Electrical parts heating element, thermostat and contactor (k) Thermostat

Plate 1 (a - k): Fabrication process of the machine

Cost of Fabrication

Table 2 presents the bill of engineering measurement and evaluation for the hot press machine fabrication cost N270,300:00 ($193) at the rate of (N1400 to $1). Regular maintenance practices

are necessary to ensure proper working of the machine and to make the machine safe for use.

Table 2: Bill of Engineering Measurement and Evaluation for the Hot press Machine

S/N	Materials	Specifications	Quantity	Price (₦)
1	50 mm x 50 mm angle iron	13,716 mm	2 ½ pcs	29,000
2	3mm mild steel plate	1219.2 x 609.6mm	½ pc	17,500
3	Electrodes	200 mm long	1//2 carton	6000
4	Cutting disc	-	2	3000
5	Grinding disc	-	1	4000
6	Paint	Red paint	½ bucket	6000
7	Pipe (Galvanized iron)	33.78mm	1pc	5500
8	Pipe (Galvanized iron)	25.4mm	1pc	4500
9	Thermostat	AC 250V	1pc	15000
10	Thermocouple	-	1pc	3000
11	Contactor	-	1pc	6000
12	Heating element	Nickel-chromium	2	25000
13	Top bond	2 kg	2	7300
15	Miscellaneous	-	-	10000
	Total			**₦175,800**

Machine Evaluation

The hot press machine was test run for pressing process. Plate 2 depicts measuring process of the materials (*Z.mays* (corn) cob particles and Urea-formaldehyde) prior to the mixing stage. The materials were mixed according to their experimental design 80:20, 70:30, and 60:40 (Z.*mays*-cob particles : Urea-Formaldehyde); respectively., and the mixing was done manually.

Machining Job

S/N	Materials	Specification	Time(min)	Cost(#)
1	50 x 50mm angle iron	Cutting	45	6,000
2	33.78 mm mild steel pipe	Cutting	45	4,000
3	3mm gauge mild steel plate	Cutting	30	4,500
4	25.4 mm mild steel rod	Cutting	45	3,000
	Total			**17,500**

It was ensured that the mixture was done evenly before the mixture was poured into the mould. The composite mixture was cold pressed, to ensure that the mixture was evenly spread in the mould, before hot pressing. The operating process of pressing was depicted in Plate 3a and Plate 3b presents the particle board produced. Three replications of particle boards 12 mm thick were produced from each of the experimental groups.

(a) Weighing of the *Zmay*-cob (b) Weighing of the Urea-Formaldehyde (c) material mixture

Time and Cost of Machine Production

S/N	Materials	Time Spent (hr)	Labour Cost (#)	Equipment Cost (#)	Total (#)
1	Marking out	2	2,000		2,000
2	Welding	14	5,000	5,000	14,000
3	Machine assembly	5	10,000		15,000
4	Painting	1	2,000	4,000	6,000
5	Fabrication payment				40,000
Total					**77,000**
Grand Total					**N270,300:00**

Plate 2: Material weighing and mixing process

Plate 3: Production process of particle board from *Z.mays*-cob, (b) Particle boards produced from *Z.mays*-cob

The density of the composite board as presented in Figure 2 were 58.14±0.2; 55.63±0.2; and 52.82±01 kg/m^3 for 80:20, 70:30, and 60:40 (Z.*mays*-cob-particles:Urea-Formaldehyde); respectively. It was observed that as temperature increases and increase in Z.*mays*-cob-particles contents there was a progressive increase in the density of particle board produced, this observation agrees with the documented report of Alicho *et al.* 2024 where it was stated that an increase in particle size of corn-cob led to rise in the density of corn-cob particleboards.

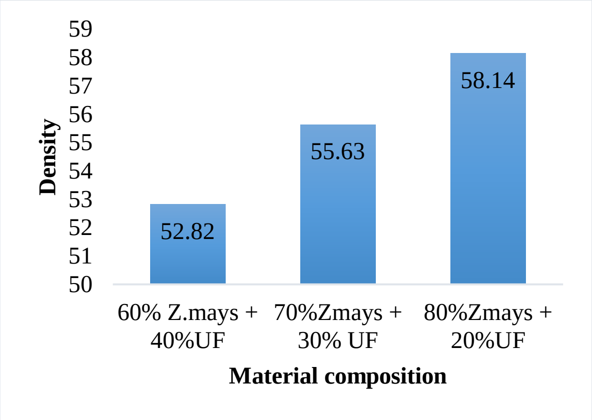


Figure 2: Densities of particle board samples

It was observed that as temperature increases and increases in Z.*mays*-cob-particles contents, there is a progressive increase in the density of particle board produced. This observation acclaims the documented report of Alicho *et al.*, 2024 where it was stated that an increase in particle size of corn-cob leads to a rise in the density of corn-cob particleboards.

The samples from each group were immersed in water for 2 hours and 24 hours for water absorption and thickness swelling test is presented in Plate 5.

(a) soaking process (b) water absorption (c) Thickness swelling

P late 5: Water absorption and thickness swelling test

Figure 3 presents water absorption (%) of the particle boards recorded at 2 hours, were 110±0.4; 142±1.3; and 168±2.2% for 60:40, 70:30, and 80:20 (Z.*mays*-cob-particles:Urea-Formaldehyde), respectively. At 24 hours, 160.96±4.4, 215.54±3.5; and 235.52±2.3% for 60:40, 70:30, and 80:20 (Z.*mays*-cob-particles:Urea-Formaldehyde), respectively. This corroborates the findings of Scatolino *et al.* (2013), an increase was noticed in water absorption of 2hrs values in samples with higher *Z.mays*-cob percentage with lower urea-formaldehyde content particle boards samples.

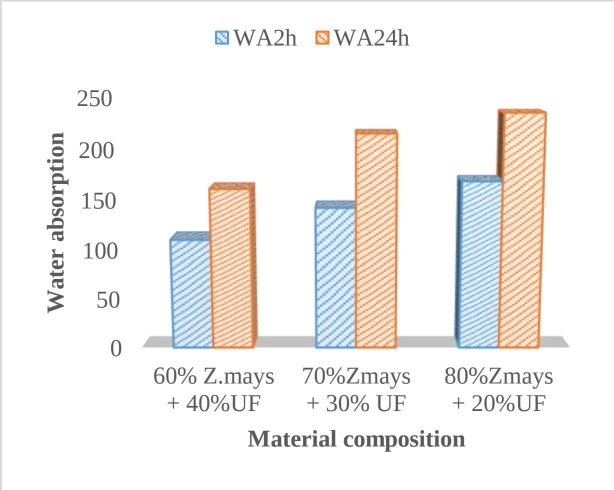


Figure 3: Water absorption of particle board samples

Figure 4 depicts the thickness swelling (%) of the particle boards recorded at 2 hours, which were 4.14±0.2; 5.47±0.5; and 6.73±0.3% for 60:40, 70:30, and 80:20 (Z.*mays*-cob-particles:Urea-Formaldehyde), respectively. At 24 hours, 6.18±0.7, 7.55±0.4; and 10.85±0.4% for 60:40, 70:30, and 80:20 (Z.*mays*-cob-particles:Urea-Formaldehyde), respectively. This corroborates the findings of Scatolino*et al.* (2013), an increase was observed in thickness swelling of 2hrs values with samples having higher *Z.mays*-cob particle percentage with lower urea-formaldehyde content particle boards samples.

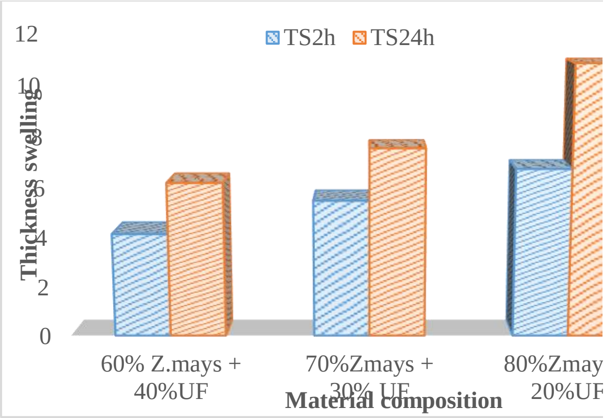


Figure 4: Thickness swelling of particle board samples

Figure 5 presents the results of the internal bonding of the particleboard material depending on the composition and processing conditions. The average lower internal bonding strength was obtained from the samples of 80:20 material composition pressed at 90^{0}C. The highest strength was obtained from the particle board samples of 60:40 materials composition from the highest pressing temperature of 120^{0}C. The highest internal bonding strength was obtained from the samples with more adhesive content and from the highest temperature press group, hence heat application enhances the internal bonding of the particle board.

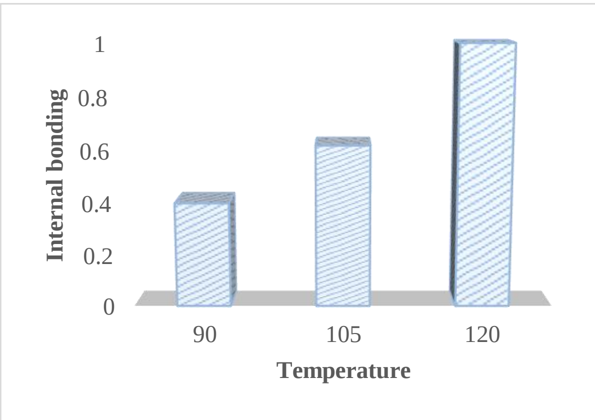


Figure 5: Relationship between temperature and internal bonding

CONCLUSION

A hot press machine of 3 tons was developed from locally sourced materials, hence the cost of developing the machine locally was N270,300:00 ($193). The 3-ton capacity hot press machine is capable of pressing and compacting various composite materials, making it ideal for research and small-scale industry. The study shows that agricultural residue biomass can be prepared, processed and recycled for engineered board production by ensuring sustainable development, economic growth, social inclusion and environmental protection.

REFERENCES

Akinola, O. (2014) Design and Fabrication of an Automated Hydraulically –Operated Laboratory Hot Press For Composites Boards Production. *Unpublished B.Sc. Project Submitted to the Department of Agricultural and Environmental Engineering, Faculty of Technology, University of Ibadan.* 53-74

Alicho, J., Mtunzi, F. F., Maia-Obi, L. P., Okoli, B. J., Qurix, B. W., & Modise, J. S. (2024). Effect of Surface Treatments on Zea mays Husk and the Behaviour of Husk/Low-Density Polyethylene Composites. *Sustainability*, *16*(13), 5782.

Bhong, M., Khan, T. K., Devade, K., Krishna, B. V., Sura, S., Eftikhaar, H. K., and Gupta, N. (2023). Review of composite materials and applications. *Materials Today: Proceedings*.

Datta, P., Mohi, G. K., and Chander, J. (2018). Durable Laminate Plywood Wood Hydraulic Cold Press Machine for Woodworking Customs Data My-50t. *Journal of Laboratory Physicians*, *10*(1), 6.

De Ferran, F., Robinot, E., and Ertz, M. (2020). What makes people more willing to dispose of their goods rather than throwing them away?. *Resources, Conservation and Recycling*, *156*, 104682.

Gupta, J., Kumari, M., Mishra, A., Akram, M., and Thakur, I. S. (2022). Agro-forestry waste management-A review. *Chemosphere*, *287*, 132321.

Jeffrey Ken B Balangao, Mikee P Tuyor, Arjel Salcedo, Consorcio S Namoco, Liezl M Jabile. (2023) Design and Development of A Manually-Operated Hydraulic Hot-Pressing Machine for Agricultural Wastes-Based Particleboard Application. Science International (Lahore) , 2022, 34 (6), pp.545-548. ffhal-03929032f

Khan, Y., Manrai, K., Sharma, A. K., Pathak, V. K., and Sharma, S. S. (2022). Optimization of sustainable alternatives of composite wooden board materials: A comparative study. *Materials Today: Proceedings*, *62*, 1677-1680.

Khurmi, R. S., and Gupta, J. K. (2019). *A Textbook of Machine Design (LPSPE)*. S. Chand publishing.

Kowaluk, G. (2012). Machining processes for wood-based composite materials. In *Machining Technology for Composite Materials* (pp. 412-425). Woodhead Publishing.

Omoniyi, T. E., Akinyemi, B. A., and Olayiwola, H. O. (2013). Design and production specifications of machine for wood cement composite boards production. *Civil and Environmental Research*, *3*(13), 137-144.

Oyelaran-Oyeyinka, B. (2004). Networking technical change and industrialization: The case of small and medium firms in Nigeria. *ATPS special paper series*, *20*.

Oyewo, A. T., Oluwole, O. O., Ajide, O. O., Omoniyi, T. E., and Murid, H. (2023). Banana pseudo stem fiber, hybrid composites and applications: A review. *Hybrid Advances*, 100101.

Ramesh, M., Rajeshkumar, L., Balaji, D., and Bhuvaneswari, V. (2021). Green composite using agricultural waste reinforcement. *Green composites*, 21-34.

Rousta, K., Bolton, K., and Dahlén, L. (2016). A procedure to transform recycling behavior for source separation of household waste. *Recycling*, *1*(1), 147-165.

Sarin, V., Pal, U., and Gopalan, S. (2003). *Development of hot pressing as a low cost processing technique for fuel cell fabrication* (No. ORNL/sub/94-SS112/04). EERE Publication and Product Library, Washington, DC (United States).,

Scatolino, M. V., Silva, D. W., Mendes, R. F., and Mendes, L. M. (2013). Use of maize cob for production of particleboard. Ciência e Agrotecnologia, 37, 330-337.

Sharma, S., Pappu, A., and Asolekar, S. R. (2024). Sustainable recycling of paddy straw through development of short-fiber-reinforced composites: exploring gainful utilization of agricultural waste. *Clean Technologies and Environmental Policy*, *26*(1), 109-127.

Yang, Y., Zhang, L., Zhang, J., Ren, Y., Huo, H., Zhang, X., and Zhang, Z. (2023). Reengineering waste boxwood powder into light and high-strength biodegradable composites to replace petroleum-based synthetic materials. *ACS Applied Materials & Interfaces*, *15*(3), 4505-4515.

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Table 1: Component of the Composite Hot-Press

S/n	Component	QTY	Dimension (kg/m^3)	Mass (kg) per each component	Mass (kg) of component	Weight (N)
1	Upper Platen (pipe 3mm)	4	7900	2.003(width) and 2.997(length)	5	49.05
2	Upper Platen plate(3mm)	2	7900	5.55	11.1	108.891
3	Lower Platen plate(3mm)	4	7900	1.957&2.997	4.95	48.60
4	Lower Platen plate(3mm)	2	7900	5.505	11.01	108.00
5	Lower Platen bracing(flat bar 5mm)	2	7900	0.72	1.44	14.4
6	Inner pipe column(pipe 3mm)	4	7900	1.15	4.6	45.126
7	Outer pipe column	4	7900	0.12	0.48	4.8
8	Columns (50mm angle iron) (1200mm)	4	7900	7.71	30.84	302.54
9	Beams (50mm angle iron) (500mm)	4	7900	0.79	3.16	30.99
10	Base of the hydraulic jack	1	7900	-	7.75	77.5
11	Control box cover	1	7900	2.35	2.35	2.35
12	Mixing unit (angle bar)	4	7900	1.21	4.82	48.2
13	Mixing unit plate	1	7900	-	3.95	39.5
14	Mixing Unit bracing(flat bar 5mm)	2	7900	0.71	1.42	14.2
15	Thermostat	1	-	-	-	-
16	Sensor	1	-	-	0.2	20
17	Heating element	2	-	-	4.4	88
18	Hydraulic Jack	1	-	-	44	440
19	Mould	1	-	-	1.69	16.9
20	Base support for columns	3	7900	0.96	2.89	28.9
	TOTAL					**1140.57**

Table 2: Bill of Engineering Measurement and Evaluation for the Hot press Machine

s/n	Materials	Specifications	Quantity	Price (₦)
1	50 mm x 50 mm angle iron	13,716 mm	2 ½ pcs	29,000
2	3mm mild steel plate	1219.2 x 609.6mm	½ pc	17,500

3	Electrodes	200 mm long	1//2 carton	6000
4	Cutting disc	-	2	3000
5	Grinding disc	-	1	4000
6	Paint	Red paint	½ bucket	6000
7	Pipe (Galvanized iron)	33.78mm	1pc	5500
8	Pipe (Galvanized iron)	25.4mm	1pc	4500
9	Thermostat	AC 250V	1pc	15000
10	Thermocouple	-	1pc	3000
11	Contactor	-	1pc	6000
12	Heating element	Nickel-chromium	2	25000
13	Top bond	2 kg	2	7300
15	Miscellaneous	-	-	10000
	Total			**₦175,800**

Machining Job

S/N	Materials	Specification	Time(min)	Cost(#)
1	50 x 50mm angle iron	Cutting	45	6,000
2	33.78 mm mild steel pipe	Cutting	45	4,000
3	3mm gauge mild steel plate	Cutting	30	4,500
4	25.4 mm mild steel rod	Cutting	45	3,000
	Total			**17,500**

Time and Cost of Machine Production

S/N	Materials	Time Spent (hr)	Labour Cost (#)	Equipment Cost (#)	Total (#)
1	Marking out	2	2,000		2,000
2	Welding	14	5,000	5,000	14,000
3	Machine assembly	5	10,000		15,000
4	Painting	1	2,000	4,000	6,000
5	Fabrication payment				40,000
		Total			**77,000**
		Grand Total			**₦270,300:00**