Universidad Continental

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Mecánica

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Design of A Processing Machine for Hybrid Composites Based on Coconut and Maguey Fibers for the Production of Chipboard in the Junin-Peru Region

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Para optar el Título Profesional de
Ingeniero Mecánico

Huancayo, 2022

TSP - JULIAN DAGA RUBISNOL FELIX

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2022 5th International Conference on Robotics, Control and Automation Engineering (RCAE) | 978-1-6654-5941-9/22/$31.00 ©2022 IEEE | DOI: 10.1109/RCAE56054.2022.9995743

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Abstract— **In the present investigation of the design of a processing machine for hybrid compounds based on coconut and maguey fibers, using the non-experimental quantitative method, under the German VDI 2221 and 2225 methodology, using mathematical models of machine elements and mechanical design and selection. of electronic components, where the main objective was the design of the hybrid compound processing machine, which consists of four processes: material transport, crushing process, mixing and compacting process, to obtain boards agglomerated, with the purpose of reusing usable solid waste and transforming it into fibers, in order to avoid the use of wood and to reduce the logging that occurs in the central jungle of Peru, for which it is essential to know the mechanical characteristics of coconut and maguey fiber, coconut fiber has a tensile strength of 220 Mpa and fiber Maguey has a tensile strength of 305 Mpa, likewise the automated control is programmed in PLC S7 1200 and TIA Portal v15 for reading analog inputs and outputs, visualization and control are developed through the HMI that is accessible to data control.**

Keywords—Design, hybrid composites, agglomerates, automation.

I. Introduction

To know the seriousness of deforestation at a global level, the Food and Agriculture Organization of the United Nations (FAO) reported that currently 178 million hectares were lost, likewise the leading countries are Brazil, Indonesia, Colombia and in seventh place Peru [1]. The factors which affect deforestation are mainly due to the extraction of wood, the driving force is mainly technological and economic [2], because the deforestation carbon storage increases at the same time climate change in the world [3]. Likewise, in Latin America it constitutes about 20 % of the world's forests with a deforestation rate above the world average [4]. In Peru, on the Amazonian borders, according to the Peruvian Institute of Natural Resources (IRENA), it states that annually more than 2 million hectares are lost due to deforestation due to illegal logging, with direct costs of US$ 558 to 639 million per year [5]. On the other hand, the furniture industries require cedar wood, screws and pink nohena from the central jungle of Peru, for this reason the increase in demand for wood directly affects the tropical forests of the Junín Region [6].

According to the Ministry of the Environment of Peru, Junín Region had forest losses from 2001 to 2020 of 185,967 hectares, with 2020 being the year with the highest loss of forest with 20,766 hectares, mostly concentrated in the provinces. of Satipo and Chanchamayo [7], On the other hand in the Junín Region there is a large amount of wood manufacturing (ISIC 20) reaching 327 large companies, medium and micro throughout the region [8].

Faced with this situation, it is proposed to develop the design of an automatic machine that can replace wood with organic waste such as coconut fiber and maguey fiber for the creation of chipboard, for that it is necessary to know the mechanical, morphological, and thermal characteristics of the fibers to study such is the case of coconut fiber and maguey fiber and the production of these fibers in the Junín Region (see Table I and II).

TABLE I. Mechanical Properties of Coconut Fiber [10]

Mechanical properties	Coconut fiber			
	Density	***tensile strength***	***modulus of elasticity***	***Elongation***
Unit of measurement	(Kg/cm3)	(MPa)	(Gpa)	(%)
Worth	1.25	220	6,00	15,00-20,00

Agricultural production in 2018 of coconut at the national level was 2,383 metric tons, the regions that produce this product are the Amazonas region with 52 metric tons, Huánuco region produces 128 metric tons, Loreto region produces 872 metric tons, and Junín region 69 metric tons [9], which generates wasted solid waste such as shell of the coconut.

Likewise, the production of maguey in Junín Region, province of Jauja - Sincos where its main activity is the planting of maguey, in 2019 they made 12 thousand maguey seedlings to produce distillate, nectar, jams and among other products. [11], once the internal substance of the maguey is extracted, the leaves are wasted, generating solid waste.

TABLE II. MECHANICAL PROPERTIES OF MAGUEY FIBER [12]

Mechanical properties	**Maguey fiber**		
	Density	***tensile strength***	***modulus of elasticity***
Unit of measurement	(Kg/cm3)	(MPa)	(Gpa)
Worth	1.30	305	7.50

Faced with these problems of illegal logging in the Junín region and the waste of coconut shells and maguey leaves, it is proposed to take advantage of these residues and transform them into fibers that can be agglomerated by means of additives, to obtain a new chipboard material using natural fibers that can benefit wood manufacturing centers and benefit society.

II. MATERIALS AND METHODS

The design methodology used and adapted in the research is the German standard VDI 2221 [13]. For the design of the hybrid compound processing machine, we apply each module of this standard and in the solution concept phase and economic evaluation we will complement it with the VDI 2225 standard, which consists of determining the optimal solution with a minimum cost [14].

Likewise, the research developed is of the technological type since it focuses on the investigation of knowledge to build or obtain an invention with some process or machinery, to obtain an economic benefit to satisfy some needs [15].

The prototype of the hybrid compound processing machine will consist of 4 processes. In the first process is the transport of the raw material, a 2 m conveyor belt inclined at 30° with respect to the ground level will be included, it will be activated manually and automatically by means of an electric motor. In addition, a band deviation sensor was included to control the material. In the second process, the crusher has fins, a rotation monitor was included to deactivate the process when the motor stops rotating. On the third level there is a roller grinder powered by an electric motor and filtered through a sieve. In the last level there is the dryer by means of resistances and the pressing of the agglomerate. A temperature sensor, limit switches and hydraulic actuators were added. To power the actuators, a 2 HP pump and a pressure sensor will be used to stop the process if there are faults, as can be seen in the following figure.

Fig. 1 shows the prototype of the hybrid compound processing machine, which has 4 processes. For the crushing process it has a capacity of $49466.6\ cm^3$, this based on the volume of the coconut and maguey fiber where 20 % of the maguey fiber and 80 % of the coconut tow will enter, the ratio of the percentages are due to the production of each of these fibers, the grinding process has a dual system; crushed by blades and crushed by hammers, it has 78 blades and 78 separators, as well as 60 hammers, this system will have a minimum speed of 15.8 m/s, likewise with a maximum speed of 41.28 m/s and will have a force of impact of 8,242 N, the material for the hammers to be designed will be an ASTM A36 steel.

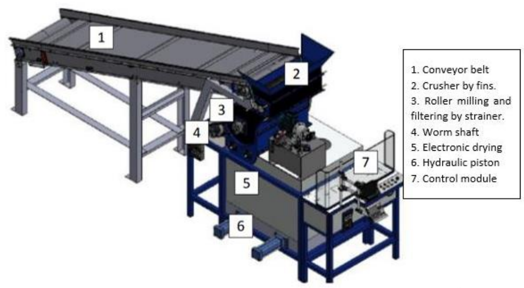

Fig. 1. Prototype of the hybrid compound processing machine.

To determine the impact force, the mass of the hammer, maximum speed, loading speed and time were considered.

$$F_{impact} = \frac{m_{hammer}(v_{max} - v_{load})}{\Delta t} \quad (1)$$

Then, all the distributed loads that the shafts will support, torque and maximum bending moment are evaluated through the analysis of Von Mises and ED-ASME elliptic to determine the diameter of the shaft [16].

$$d = \left\{\frac{16n}{\pi S_y}\left[4(K_f.M)^2 + 3(K_{fs}.T)^2\right]^{1/2}\right\}^{1/3} \quad (2)$$

The mixing process requires knowing the volume that enters, the density of the material and the length of the axis, which can be seen in the following formula.

$$w_o = \frac{V*d*g}{L} \quad (3)$$

Likewise, the diameter for the endless screw or helical screw is 21 mm, which is incorporated into the overall length, to consider the pitch as half the diameter.

$$S = \frac{D}{2} \quad (4)$$

The power required for the endless screw considers the speed and volumetric theoretical performance in one hour from the density of the fibers studied [17].

$$Q_m = 15\pi D^2 S.w.(p_{coconut} + p_{maguey}) \quad (5)$$

For the design of the mixing process, it will be through the helical screw, for which it is necessary to have these three powers to take into account the weight, and the drag force of the natural fibers and resins, in the calculations carried out, it was obtained the diameter for the axis of the screw of 21 mm, the pitch of the propeller of 10.5 mm and the necessary power to be able to exert movement in the helicoidal screw.

The third process is that of compaction by means of a hydraulic system, the movement carried out in the compaction process is obtained hydraulically, by means of the hydraulic fluid, a tank and an electric motor, this will transmit a power transformed into pressure, this through the cylinders hydraulics, For the selection of the hydraulic cylinder it is necessary to know the pressure that will be exerted on the plate, which we will call working pressure and also a safety factor.

$$P_{t.work} = 49.35\ atm \quad (6)$$

For the design of the hydraulic cylinder, a DIN ST37 steel will be assigned, the calculation of the thickness of the cylinder wall is based on the internal diameter, the elastic limit of the chosen material, the working pressure, and the safety factor.

$$t_{cylinder} = \frac{D_{int}}{\frac{200\frac{Sy}{F.S}-2}{1.11P}} \quad (7)$$

III. Results

A. Design and Simulation of the Grinding Process

Fig. 2 shows the design of the crushing process. It is based on a dual blade crushing and hammer crushing system. The blade crushing system has two 47-tooth spur gears with a ratio of 1:1, made of steel. AISI 1020, 78 blades and spacers, two 25 mm hexagonal shafts.

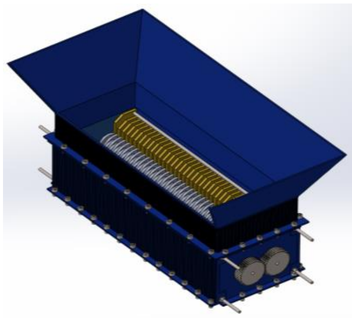

Fig. 2. Grinding process using blades.

The simulation obtained the tangency load of 26.64 N, likewise the analysis by Lewis resulted in 2.11 MPa and in the simulation a close value of 2.093 MPa was obtained, the material used in the simulation and the safety factor obtained were validated.

In Fig. 3, the simulation of the blades was carried out, to validate the tool steel material, for an impact force of 75 N and a rotational speed of 600 rpm, where the main concentrations of efforts can be observed are the tips. of the blades.

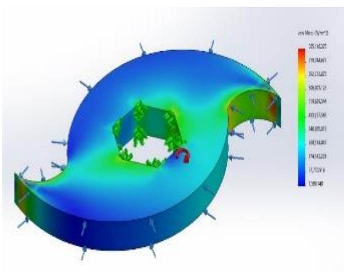

Fig. 3. Blade simulation.

Fig. 4 shows the hammer crushing system with 4 AISI 1020 steel cross discs, 4 AISI 1050 steel shafts for the hammers and 60 crushing hammers.

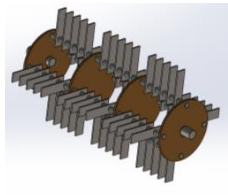

Fig. 4. Crushing process using hammers.

Fig. 5 shows the simulation and validation of the hammers, the A36 steel material was assigned, for an impact force of 8,242 N, the assigned material was validated where the hammers did not present problems for the force of impact. impact.

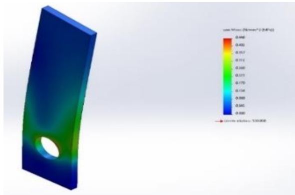

Fig. 5. Simulation of impact hammers.

B. Design and Simulation of the Mixing Process

The design of the mixing process is based on the endless screw or helical screw which allows the transport of solid materials, such is the case of the mixture between coconut fiber and maguey fiber.

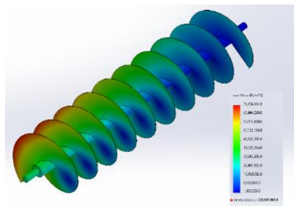

Fig. 6. Simulation of the helical screw.

In Fig. 6, the simulation was carried out and the assigned material was validated where the load carried out in the propeller can be observed, where it has a torque of 90.25 Nm, a distributed load of 1546.134 Nm and a maximum force in the axis of 84.61 N.

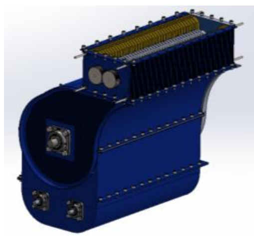

Fig. 7. Grinding and mixing processes.

C. Control and Automation of the Plant

To have an automated control of the entire process and take preventive and safety measures through the locks and sensors implemented at each level, a PLC S7 1200 (CPU 1214C

AC/DC/Rly) and an HMI were used to visualize the entire system (KTP1000 Basic color PN).

A.1. Programming in TIA Portal v15

Fig. 8 shows the corresponding programming in the TIA portal environment, normalization and scaling blocks were used for reading the analog inputs and outputs. In the first segments there is the start and emergency stop of the machine. In addition to the ignition of each of the components: motors, sensors, pump, actuators, etc. There is also the configuration of the frequency inverter for its direct implementation. Finally, to have a safe control, there are interlocks of monitoring, temperature and pressure sensors to deactivate the system if any failures occur.

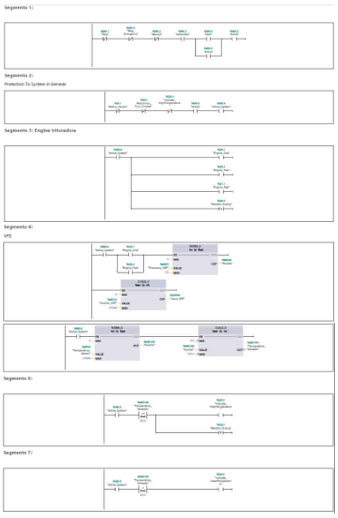

Fig. 8. Programming in TIA portal V15.

Fig. 9 shows each of the variables declared for the inputs, memories, and analog/digital outputs of the programming environment. Which will also serve to be able to encompass the HMI.

Start	Bool	%M0.0
Stop	Bool	%M0.1
Manual	Bool	%M0.2
Automatic	Bool	%M0.3
Stop_Emergency	Bool	%M0.4
Active	Bool	%M0.5
Watchman_Turn_Crusher	Bool	%I0.0
Engine_One	Bool	%Q0.1
Detour_Sensor	Bool	%I0.1
Engine_Two	Bool	%Q0.2
Resistor_Drying	Bool	%Q0.3
Temperature_Sensor	Word	%IW64
Auxiliar	Real	%MD100
Temperature_Sensado	Real	%MD104
Indicate_HighTemperature	Bool	%Q0.4
Indicate_LowwTemperature	Bool	%Q0.5
Presion_Sensor	Word	%IW66
Auxiliar_Presion	Real	%MD106
Presion_Sensado	Real	%MD200
VDF	Bool	%Q0.6
Hydraulic_Engine	Bool	%Q0.7
Sensor_Initial	Bool	%I0.2
Sensor_Final	Bool	%I0.3
Active_System	Bool	%M0.6
Frecuency_VDF	Word	%MW5
Escalas	Real	%MD56
Auxiliar_VDF	Real	%MD10
Input_VDF	Word	%QW96
Pump	Bool	%Q1.0
Material_Sensor	Bool	%I0.4
Engine_Faja	Bool	%Q1.1

Fig. 9. PLC signal conditioning.

A.2. Visualization and control via HMI

In the first place, the start-up panel window is shown, each of the pushbuttons for turning on the system and controlling it automatically/manually, start/stop and an emergency stop are displayed (see figure 10).

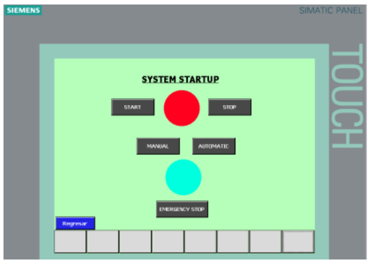

Fig. 10. Command control.

Within the general process, there is the operation of the entire process: transport of material by means of the conveyor belt, electric motors, pressure and temperature sensors, rotation monitor and deviation sensor, hydraulic actuators, a dryer by means of resistance and a bomb. Indicators of each component and frequency of the variator were also placed at each level. All this to have greater control of the system (see Fig. 11).

Fig. 11. System in operation.

Finally, to have a correct reading of the analog sensors, a tab was placed where each of the signals received by the sensors is shown (see figure 12). If you want to display each of the signal's scales to °C or bar. You can go to the overview window to see each of those indicators.

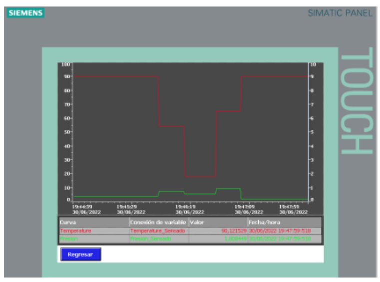

Fig. 12. Graphics Environment.

IV. Discussion

In the study carried out by López R. and Mesías J. [18] they propose the use of African palm with biodegradable adhesives for the manufacture of chipboard, under the ASTM D 1037-12 standard, they obtained results where the board presented better mechanical properties It was the one that contained particles with sieve # 16 and a mass ratio of 30%, it had a modulus of rupture of 6.70 MPa and a modulus of traction of 1.35 Mpa. On the other hand, López N., and Verdusco H. [19], propose to take advantage of the solid waste produced by the coconut shell, by means of a coconut pulverizing crushing machine, where they mention that the coconut fiber is used in the creation of threads, nets, stuffed chairs, or mattresses, likewise for the crushing they used fixed and mobile blades adjustable through screws with springs and their capacity is 30 kg/h. It is important to mention the type of press that should be used in the design, whether vertical or horizontal, according to HSM Maquinarias with its 8 TE vertical compactor, it has a pressing force of 80 KN, with a power of 4 kW, with the following filling measures 690 mm x 645 mm x 730 mm, with a cycle of 21 seconds [20].

Additional information about hybrid compound processing machine is shown in Table III.

TABLE III. COMPARISON TABLE

Comparison Table	
Hybrid Compound Processing Machine	***Discussion***
Maguey Fiber and Coconut Fiber	African palm cuesco with biodegradable adhesive
The machine has 4 processes	Compacting machine
Mall Granulometry N°5	Particles with sieve #16, with a mass ratio of 30%
It has two crushing processes, by blades and hammers	Triroured by blades
Compacted board 2Mpa	Board compacting 1.67 Mpa
Hopper capacity 49466.6 cm^3 according to grinding of 7.2 Kg/min	Triration capacity of 120 Kg/h

V. CONCLUSION

It was determined that the machine must have four processes, to obtain a granulometry of mesh No. 5, where it will start with the crushing of 2 phases through blades and then hammers, and then go through the second phase of mixing. homogeneous raw materials with their respective proportion of 80 % natural fibers and 20 % additives and for this it is necessary to use 2 endless shafts which will help to mix and to transfer the material to the compacting process and finally the material will be compressed. material using a hydraulic press.

Each component of the three proposed processes was designed and selected through interactions, adding their respective materials considering the acquisition of each material and elements in the local market and finally each element was validated using static and dynamic modeling using the SolidWorks design- Simulation.

In addition, it was determined that for the grinding process it is necessary to have 2 phases, which specifically will start grinding using mobile and fixed double-axis blades whose material is AISI D2 tool steel and finally grinding using mobile hammers which will reduce up to a granulometry No. 5.

The production capacity was determined based on the design of the hopper where it obtained 49466.6 cm^3 of volume for each filling of the hopper equivalent to a crushing production of 6 coconut/min and based on the grinding it is obtained of 7.2 Kg/min.

REFERENCES

[1] C. Morland, F. Schier, N. Janzen, and H. Weimar, "Supply and demand functions for global wood markets: Specification and plausibility testing of econometric models within the global forest sector," For. Policy Econ., vol. 92, pp. 92–105, 2018, doi: 10.1016/j.forpol.2018.04.003.

[2] R. A. Samndong, G. Bush, A. Vatn, and M. Chapman, "Institutional analysis of causes of deforestation in REDD+ pilot sites in the Equateur province: Implication for REDD+ in the Democratic Republic of Congo," Land use policy, vol. 76, no. February, pp. 664–674, 2018, doi: 10.1016/j.landusepol.2018.02.048

[3] S. Desbureaux and R. Damania, "Rain, forests and farmers: Evidence of drought induced deforestation in Madagascar and its consequences for biodiversity conservation," Biol. Conserv., vol. 221, no. October 2017, pp. 357–364, 2018, doi: 10.1016/j.biocon.2018.03.005.

[4] M. G. Ceddia, U. Gunter, and P. Pazienza, "Indigenous peoples' land rights and agricultural expansion in Latin America: A dynamic panel data approach," For. Policy Econ., vol. 109, no. August, p. 102001, 2019, doi: 10.1016/j.forpol.2019.102001.

[5] R. Quispe, "Facultad de Ciencias Empresariales," Normas Tribut., p. 84, 2017, [Online]. Available: http://repositorio.unap.edu.pe/bitstream/handle/UNAP/1891/Casas_Ochochoque_Joel_Rainier.pdf?sequence=1&isAllowed=y.

[6] D. Villar, "Rendimiento de madera en la producción de muebles y artesanía en el Valle de Mantaro," p. 93, 2011, [Online]. Available: http://repositorio.uncp.edu.pe/bitstream/handle/UNCP/2607/Villar Arteaga.pdf?sequence=1&isAllowed=y.

[7] G. B. Ministerio del Ambiente, "Bosque y Pérdida de Bosque Bosque Amazónico (2020) Pérdida de Bosque (2001-2020)," pp. 1–5, 2021, [Online]. Available: https://geobosques.minam.gob.pe/geobosque/view/perdida.php.

[8] M. de la Producción, "Análisis Regional de empresas industriales-Región Junín," Produce-DVMYPE, pp. 1–13, 2014, [Online]. Available: http://www2.produce.gob.pe/RepositorioAPS/2/jer/PRODUCTIVIDAD_COMPETITIVIDAD/Informes/analisis_lalibertad.pdf.

[9] E. Albujar, "Producción Agrícola Nacional," 2018.

[10] D. B. Cajas Arguero. "Diseño de un triturador pulverizador de estopa de coco para la producción de sustrato granulado".

[11] R. Agronoticias, "Sembrarán 12 mil plantones de maguey para producir destilado en Jauja," pp. 5–7, 2021, [Online]. Available: https://agronoticias.pe/ferias-y-eventos/sembraran-12-mil-plantones-de-maguey-para-producir-destilado-en-jauja/.

[12] F. Florez Leon and Y. Limpe Zevallos, "Influencia de la fibra de maguey (Furcraea andina) en las propiedades mecánicas de la mampostería de adobe tradicional, Cusco – 2018," Univ. Nac. San Antonio Abad del Cusco, 2019, [Online]. Available: http://repositorio.unsaac.edu.pe/handle/20.500.12918/3670.

[13] B. Barriga, "Métodos de diseño en ingeniería mecánica," p. 19, 2016.

[14] D. I. De Gijón, "Sistema de mecanizado portátil para armarios eléctricos - Anexo III – VDI 2225," 2018.

[15] J. Cegarra Sánchez, Metodologia de la investigación científica y tecnológica. 2004.

[16] R. Budynas and K. Nisbett, Diseño en Ingeniería Mecánica de Shigley. 2554.

[17] A. M. Goméz De la Torre Maldonado and J. Mitau Caride, "'Diseño y Simulación de una mezcladora (80 kg/semana) y dosificadora (1 kg) de polvos finos (café, cacao, azúcar, leche, etc.), y construcción de un modelo'" pp. 5–9, 2006.

[18] R. A. López Zapata and J. C. Mesías Narváez, Elaboración y caracterización de tableros de partículas a partir del cuesco de la palma Africanacon adhesivos biodegradable. Quito, 2020.

[19] N. López Luiz et al., "Máquina trituradora pulverizadora de fibra de coco seco," 8o Congr. Iberoam. Ing. Mec., no. 18, p. 8, 2007, [Online]. Available: http://www.pucp.edu.pe/congreso/cibim8/pdf/16/16-23.pdf.

[20] HSM, "Hsm-prensa-compactadora-horizontal-8-te.pdf." [Online]. Available: https://maquinaria10.com/recursos/pdfs/hsm-prensa-compactadora-horizontal-8-te.pdf