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Research Article

A Design of Bamboo Plywood Pressing Machine

Le Khanh Dien[1,*], Tran Van Hung[2], Hoang Duc Lien[3], Svetlin Antonov[4]

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ABSTRACT

Bamboo is very popular in countryside of almost all Southeast countries, particularly in Vietnam. Its ability can replace some kinds of wood in decoration and household goods. Bamboo grow up rapidly and can be harvested within 3 to 5 years of planting, in the meanwhile the harvesting time of other hardwood trees must be from 8 to 10 years or longer. The inherent characteristics of bamboo is lighter than other wood materials and has a value in social and environmental benefits. Its advances in manufacturing technology have created high value products such as bamboo flooring and bamboo furniture that can substitute for wood flooring and wood furniture. Bamboo plywood presses play an important role in the production bamboo plywood in industry. The machine has the function of pressing bamboo powder and binder has been mixed from the front to the bamboo plank to meet the technical requirements. This article presents a design of bamboo polywood pressing machine that combines the heating function for the block board and keeps that temperature during the pressing process to create a suitable size bamboo plywood according to customer requirements. The simulation results show that the complete bamboo plywood-pressing machine is appropriate and authentic to the initial design. The result of the design was applied to manufacture the machine in DCSELAB workshop via a collaboration project between Langtre PhuAn company and the DCSELAB. The system is installed a resistance flat plate capacity of 1KW, and 2 resistors flat plate with capacity of 0.8KW. The first manufactured machine is now in the ininitial working session in Langtre Villige, Binhduong province. The initial experimental products were accepted by the partner compaby and we have recommended some measures to ameliorate time by time the quality as well as the productivity of the machine. There are really not yet an official statistic on the comparaison with the products of similar machine and we are attending the respond of the customers.

Key words: Bamboo polywood, Pressing machine, Bamboo powder, Functional analysis

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INTRODUCTION

BAMBOO is a sustainable and environmental friendly material that has the potential to improve the global decline of natural resources. Bamboo is very popular in countryside of almost all Southeast countries, particularly in Vietnam. Its ability can replace some kinds of wood in decoration and household goods. Bamboo grow up rapidly and can be harvested within 3 to 5 years of planting, in the meanwhile the harvesting time of other hardwood trees must be from 8 to 10 years or longer. The inherent characteristics of bamboo is lighter than other wood materials and has a value in social and environmental benefits. Its advances in manufacturing technology have created high value products such as bamboo flooring and bamboo furniture that can substitute for wood flooring and wood furniture. According to the biology studies, the bamboo has the characteristics that can replace the natural wood, but the direction of development from the stage of cultivation to the stage of finished products has not been exploited thoroughly. The closure and restrictive exploitation of forests in many countries around the world are an opportunity, but also a big challenge for businesses in developing wood alternative products of bamboo, especially in Vietnam [1].

With abundant bamboo resources, the production of bamboo plywood will become a great potential for the bamboo plywood industry in Vietnam. However, the bamboo plywood industry in Vietnam is only developing and stopping in the production of pressed bamboo. Therefore, instead of using the technology of squeezing bamboo together, we can chop and grind the bamboo tree to powder that is dried and pressed into bamboo plywood by specialized machine similar to the production artificial wood particleboard (PB). Bamboo waste such as bamboo shoots thrown away after harvesters can be used to recycle and produce bamboo boards, both for environmental protection and for economic benefit [1].

In the production process of bamboo plywood, the bamboo-pressing machine plays a very important role of the function of pressing bamboo powder plywood

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board after the the blending bamboo process and before cutting and trimming process to standard industrial dimensions. It is necessary to design carefully the bamboo polywood pressing machine because it is the main facture to decide the quality, the productivity and the saving energy of the chain of production of bamboo plywood[2]. In the word, India and Thailand have had many experiences and applications of bamboo machine[3,4].

METHODOLOGY OF RESEARCH - STRUCTURAL DESIGN FOR BAMBOO PRESSING MACHINE

Functional analysis of bamboo pressing machine is shown in **Figure 1**.

To arrange the functions of the bamboo pressing machine, we have the following diagram (**Figure 1**)[5]:
System design, structure of bamboo pressing machine (**Figure 2**)[5]:

RESULTS & DISCUSSION - DESIGN CALCULATIONS OF BAMBOO PRESSING MACHINE

In one word, the bamboo-pressing machine consists of the following modules: 1) Electric motors; 2) Gearbox; 3) PLC controllers; 4) Load cell; 5) Mixing module; 6) Feed material module; 7) Hydraulic module; 8) Pressed module (**Figure 3**).
The selected machine size 500x300x200mm is appropriate to the volume of finished product after pressing is 0.03m^{3}according to the dynamic diagram in **Figure 4**.
- The density of pressed plywood is 800kg/m^3.
- The volume of 1 mixed batch after squeezing is 800x0.03 = 24kg.
- Mixture ratio of bamboo glue: 8 ~ 12%.
- Maximum pressure on the surface p~ 26 at.
- Total pressure on the surface: P = 50x30x26/1000 = 39 tons.
- The thickness of blended pulp: h = 200mm.
- Pressing course: S = 1050mm.
- Time holding pressure: t = 15 minutes.
- Maximum press temperature: T_{max} = 180^{0}C.
- Heat resistance is applied.
- Power source: electric motor and hydraulic system.

Select the cylinder

Due to the system working with pressure (39 tons), we choose the working pressure of about 200 bar (20MPa)

The inner radius of the cylinder is given by the formula[6]:
$r_B = \sqrt{\frac{P_H}{\pi p}} = \sqrt{\frac{39x1000}{\pi x200}} = 7.88cm = 78.8mm$
P_H: nominal force of the machine. P_H = 39 tons. p: working pressure of hydraulic oil: p = 200 bar.
The inner diameter of the calculations of the cylinder: D_B = 2.r = 157.6mm. Selected D_B = 160mm.
$r_H = r_B\sqrt{\frac{[\sigma]}{[\sigma]-px\sqrt{3}}} = 80\sqrt{\frac{320}{320-20x\sqrt{3}}} = 84.7mm$
The permissible C45 steel is selected as the best material for manufacture of the cylinder of the hydraulic system with limited stress of $\sigma = 320MPa$
The outer diameter of the cylinder: $D_H = 2.r_H$ = 169.4mm, selected D_H = 170mm.
The cross-section area of the cylinder:
$F = \frac{\pi.D_B^2}{4} = \frac{3.14x160^2}{4} = 20106.2\ mm^2$
The volume of fluid oil in the cylinder: A_{max} = H.F = 100x20106.2 = 2010620 mm3 or 2.01062m^3.
$F = pA = p\frac{\pi D^2}{4} \rightarrow D = \sqrt{\frac{4F}{\pi p}} = \sqrt{\frac{4.39.1000}{\pi.200}} = 157.6mm$
D (mm): Piston diameter; p (bar): liquid pressure in the cylinder; A (mm^2): Working area of the cylinder; F (Kg): Force acting on the cylinder.
Parker hydraulic cylinders is selected with denoted code 160 MF1 MMB R N 1 4 C 1050 M 11 11

Selection of oil pump

Following to the schema of hydraulic system in **Figure 5**, the flow is calculated by the formula: Q = v*x*A
Q is the flow supplied by the pump (litre /s).
v is the flow velocity(m / s).
A is the piston bottom area [m^2].
The speed of the piston in the working direction is v_1 = S / t_1. Therefore, the supply flow rate for the cylinder in working direction is $Q_1 = v_1xA = \frac{S}{t_1}x\frac{\pi xD^2}{4} = \frac{1}{10}x\frac{3.14x1.6^2}{4} = 0.000201\ m^3/s = 12.06\ liters/minutes$.
The speed of the piston in the return direction is v_2 = S / t_2. The supply flow rate for the cylinder in the return direction is $Q_2 = v_2xA = \frac{S}{t_2}x\frac{\pi x(D_2-d_2)}{4} = \frac{1}{8}x\frac{3,14x(1,6^2-0.8^2)}{4} = 0.188\ m^3/s = 11.3\ l\ /\ min$
Hence the flow rate of the source pump must be chosen to the bigger one Q1. The selected revolution per minute of the shaft of the pump is n = 1470 rpm that is the most suitable revolutions of gear pumps. Therefore, the specific flow of the pump is: $q = \frac{Q}{n} = \frac{12.06x10^3}{1470} = 82.000\ mm^3/loop$.
Based on the following influential parameters such as pressure, flow rate, operating speed of the pump, the type of fluid, and cost of the system, the gear pump is the most reasonable choice because of its compact size, low cost and suitable pressure but small flow, easy maintenance and simple control.

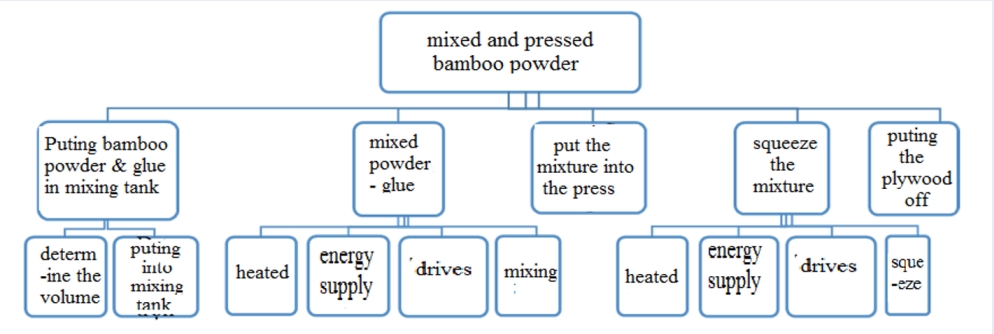

Figure 1: **Diagram of functional analysis of bamboo polywood pressing machine, mixed powder glue and squeeze the mixture by heating are very important session.**[5]

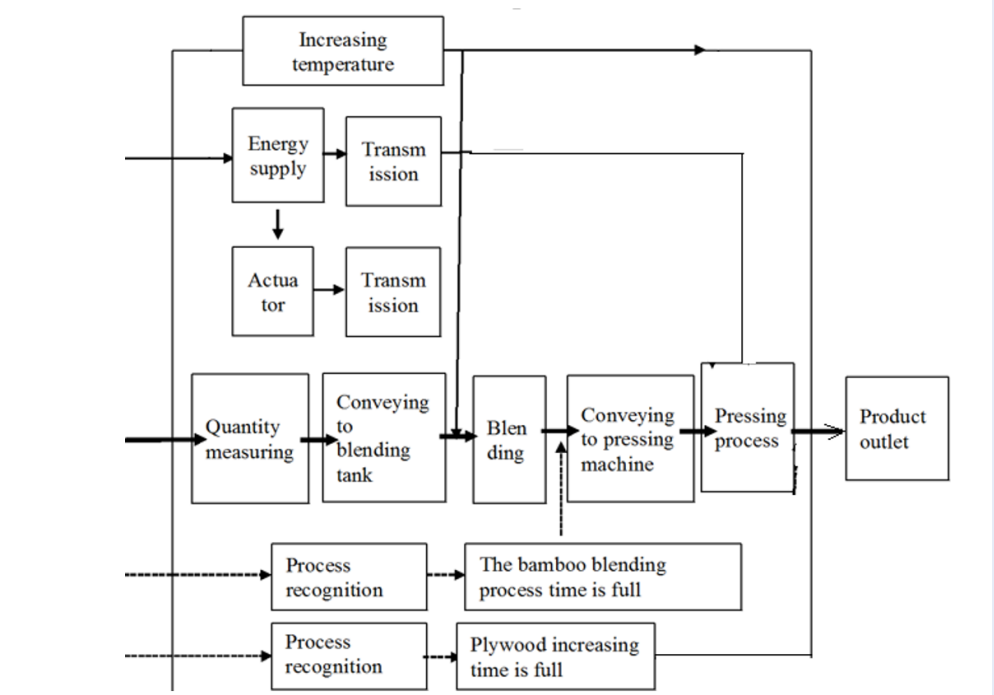

Figure 2: **Functional arrangement map of bamboo polywood pressing machine, the recognition process is controlled by sensor with high accuracy.**[5]

Gear pump has the pressure in the range of p = 100 -280 bar; suitable flow rate is Q= 100 (l/min);
Finally the gear pump HYDROMAX coded HGP-3A-8[6] is selected with specific flow: Q = 8000 mm^3/course); Maximum operating pressure P_{max} = 250 bar; Maximum rotation speed: n = 3500 rpm.

Computing the electric motor

System power: $N = \frac{PxQ}{612} = \frac{200x12,06}{612} = 3.94\ (kW)$.
Herein: Q is the flow rate of the pump; P is the system pressure.

From the above data, we have selected 4A100L4Y3 with specific parameters: 1500 rpm, power is 4 kW motor.

Testing the strength of the pressing barrel

Testing the strength of the pressing barrel with Solidworks software (**Figure 6**), the material is medium carbon steel with the following results:

Computing of heating

Parameters:

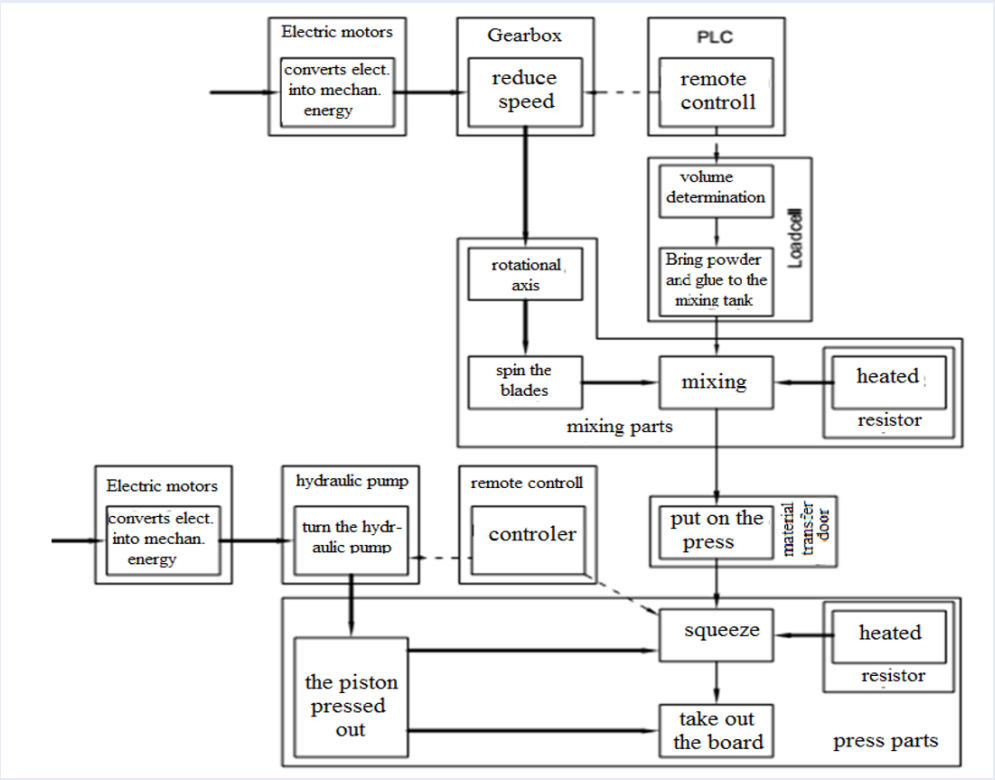

Figure 3: **Structural plan of bamboo polywood pressing machine, heating queeze is remote controlled.**

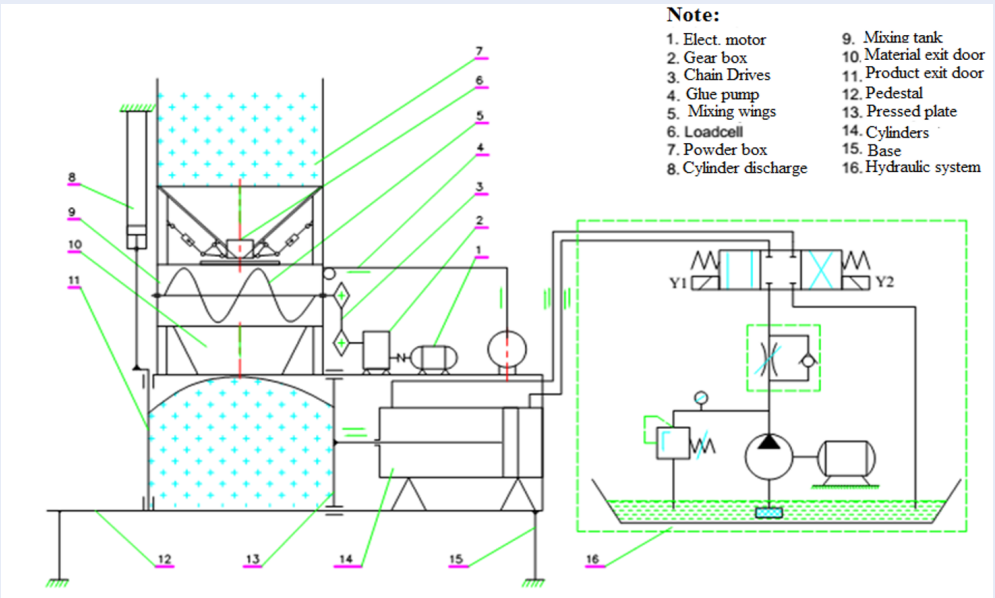

Figure 4: **Dynamic diagram of bamboo plywood pressing machine.**

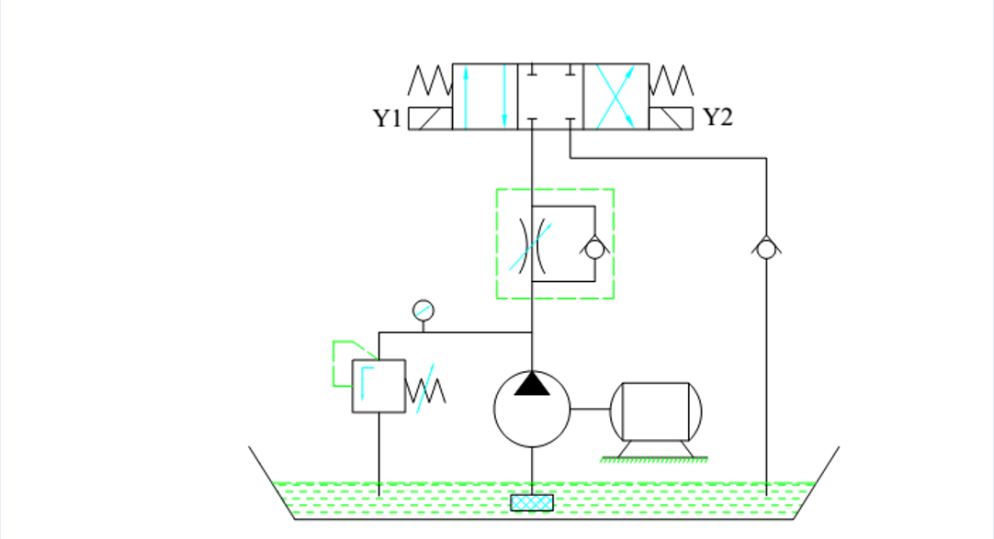

Figure 5: **Schema of hydraulic system of bamboo polywood pressing machine.**

Name	Type	Min	Max
Stress	VON: Von Mises Stress	7377.96 N/m^2 Node: 12998	1.80644e+007 N/m^2 Node: 17581

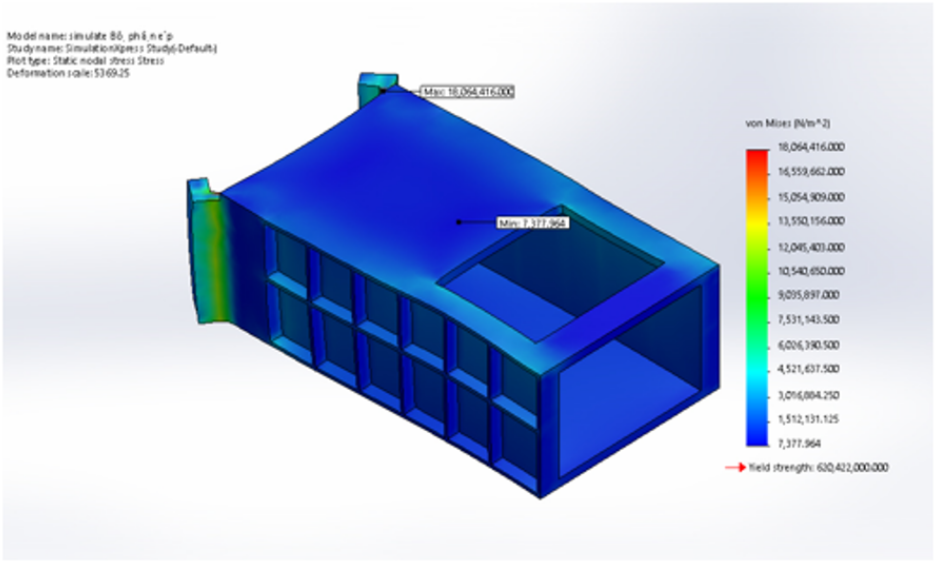

Figure 6: **Simulation result on resistance of material of the machine.**

$G = 24Kg$; $\tau = 15\,min = 900s$; $t1 = 150^0C = 423^0K$;
$t2 = 180^0C = 453^0K$; $Cp = 1.55\frac{KJ}{Kgx^0K}$;
$\bar{\triangle}t = 165^0C = 438^0K$.

$Q = GxC_px(t_2 - t_1) = 24x1.55x(453 - 233) = 1116\,kJ$

$P = \frac{Q}{\tau} = \frac{1116}{900} \approx 1,24\,kW$

$P_{tt} = \propto xFx\bar{\triangle}t = 5x0.4x438 = 876W \approx 0.88kW$

$P_{tk} = (P + P_{tt})xk = (1.24 + 0.88)x1.2 \approx 2.5\,kW$

The system is installed a resistance flat plate capacity of 1KW, denoted D 2.6 I and 2 resistors flat plate with capacity of 0.8KW, denoted D 1.6.

Total structure of the designed bamboo plywood-pressing machine is illustrated in**Figure** 7.

The schema of heating by shunt resistor is illustrated in **Figure** 8 with high power.

CONCLUSION

The bamboo plywood pressing machine is one of the important machine that decides the quality of the plywood product. The simulation results show that the complete bamboo plywood-pressing machine is appropriate and authentic to the initial design. The result of the design was applied to manufacture the machine in DCSELAB workshop via a collaboration project between Langtre PhuAn company and the DCSELAB. The first manufactured machine is now in the ininitial working session in Langtre Villige, Binhduong province. The initial experimental products were accepted by the partner compaby and we have recommended some measures to ameliorate time by time the quality as well as the productivity of the machine. There are really not yet an official statistic on the comparaison with the products of similar machine and we are attending the respond of the customers.

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AUTHOR'S CONTRIBUTION:

The authors declare that all authors discussed the results and contributed to the final manuscript.

CONFLICT OF INTEREST

There is no conflict of interest.

ABBREVIATIONS

DCSELAB: DIGITAL CONTROL & SYSTEM ENGINEERING LABORATORY

160 MF1 MMB R N 1 4 C 1050 M 11 11: denoted CODE OF Parker hydraulic cylinders

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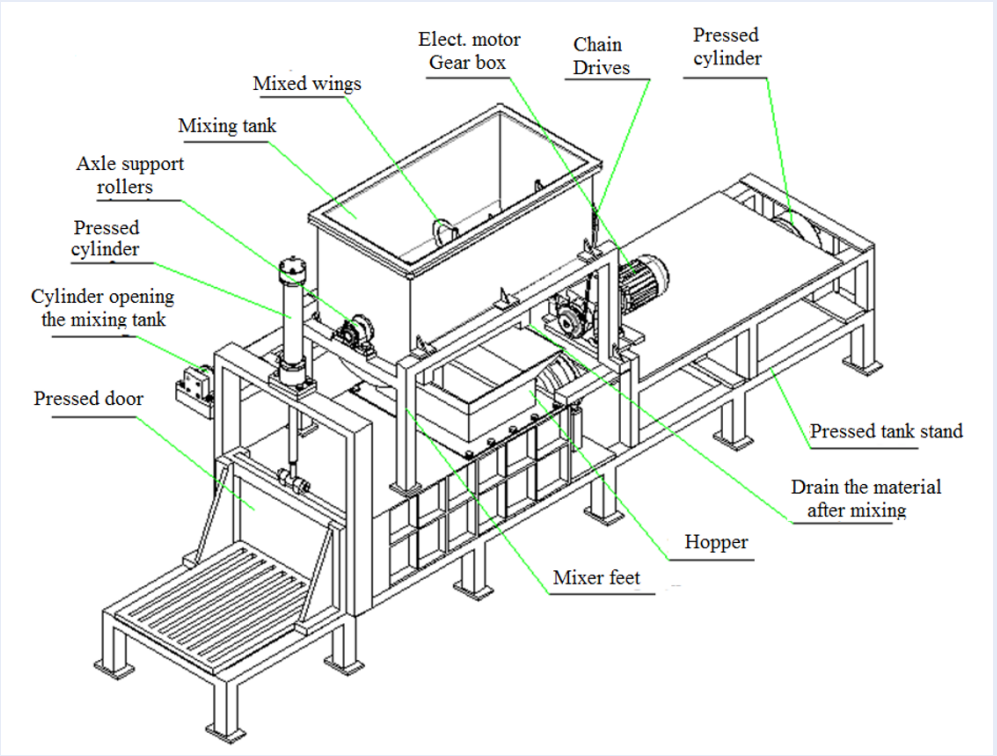

Figure 7: **Overall drawing of bamboo polywood pressing machine**.

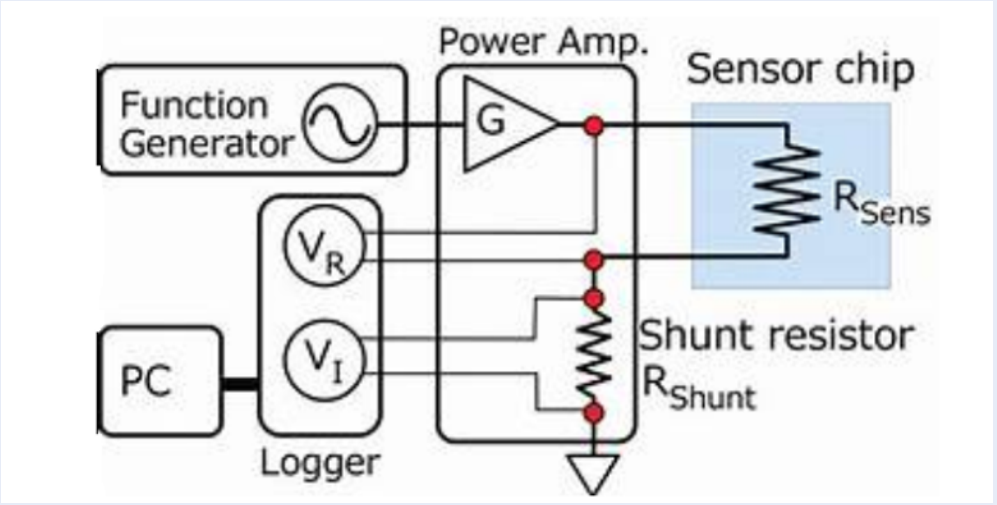

Figure 8: **Shuntresistor is controlled by computer and thermal sensor was applied for heating.**

Tạp chí Phát triển Khoa học và Công nghệ – Engineering and Technology, 2(SI1):SI143-SI150

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Bài Nghiên cứu

Thiết kế máy ép ván ép từ nguyên liệu tre

Lê Khánh Điền[1,*], Trần Văn Hưng[2], Hoàng Đức Liên[3], Svetlin Antonov[4]

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TÓM TẮT

Tre rất phổ biến ở vùng nông thôn của hầu hết các nước Đông Nam Bộ, đặc biệt là ở Việt Nam, nó có thể thay thế một số loại gỗ trong trang trí và đồ gia dụng. Tre mọc lên nhanh chóng và có thể thu hoạch trong vòng 3 đến 5 năm sau khi trồng, trong khi thời gian thu hoạch của các cây gỗ cứng khác phải từ 8 đến 10 năm hoặc lâu hơn. Các đặc tính vốn có của tre nhẹ hơn các vật liệu gỗ khác và có giá trị về lợi ích xã hội và môi trường. Những tiến bộ trong công nghệ sản xuất đã tạo ra các sản phẩm có giá trị cao như sàn tre và đồ nội thất tre có thể thay thế cho sàn gỗ và đồ gỗ. Máp ép ván bột tre có một vai trò quan trọng trong kỹ nghệ sản xuất ván ép bộ tre. Máy có nhiệm vụ ép bột tre và tấm phủ mặt đạt được yêu cầu kỹ thuật. Bài báo giới thiệu một phương thức thiết kế máy ép kết hợp với gia nhiệt và giữ nhiệt trong giai đoạn ép để tạo đúng kích thước ván ép tre theo yêu cầu của khách hàng. Kết quả mô phỏng cho thấy máy ép ván ép tre hoàn chỉnh là phù hợp và xác thực với thiết kế ban đầu. Kết quả của thiết kế đã được áp dụng để chế tạo máy thông qua dự án hợp tác Làng tre Phu An. Hệ thống được lắp đặt một tấm phẳng có điện trở công suất 1KW và 2 tấm phẳng có công suất 0,8KW. Các sản phẩm thử nghiệm ban đầu được chấp nhận bởi đối tác và chúng tôi đã đề xuất một số biện pháp để cải thiện chất lượng cũng như năng suất của máy.

Từ khóa:

Từ khoá: Gỗ tre, Máy ép, Bột gỗ tre, Phân tích chức năng

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