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ENHANCING THE QUILITY OF DIFFERENT TYPES OF PRESSED WOODS MADE FROM AGRICULTURAL WASTES

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ABSTRACT: The main goal of the present research is to investigate the possibility of recycling agricultural residues for producing different types of pressed wood. All experimental work was conducted using a mixture of wood saw dust + linen sass + corn stalks with equal percentages, to produce samples of different types of pressed wood. The main experiments were carried out to control and study the effect of some different operating parameters (pressing pressure (1, 3, 5, 7 MPa), pressing time (5, 10, 15, 20 min.) and resin type (Urea formaldehydes and Speria formaldehyde) affecting the pressed wood production processes. The produced pressed wood was evaluated taking into consideration physical properties (Density, thickness swelling and water absorption), mechanical properties (Modulus of elasticity, modulus of rupture, and internal bond strength) and final product quality. The obtained data reveal that the produced pressed wood quality were meeting the required physical and mechanical properties as stated in the standard quality guidelines under conditions of 5 MPa pressing pressure and 15 min.. pressing time with the use of urea formaldehyde resin. The findings also illustrated that by controlling both pressing pressure and pressing time, a mixture of wood saw dust + linen sass + corn stalks with equal percentages could be used to produce different types of pressed wood (Particleboards, PB; Medium density fiberboards, MDF and High density fiberboards, HDF).

Key words: Pressed wood, pressing time, pressure, water absorption, modulus of elasticity, modulus of rupture, internal bond strength.

INTRODUCTION

The huge amount of agricultural wastes in Egypt are considered one of the most critical problems, which face the Egyptian farmers. Accumulation of these residues results not only in deterioration of the environment but also in a loss of potentially valuable material. The environmental problems of incineration primarily involve air-quality issues and the disposal of the potentially toxicity ash. Burning some agriculture residues always releases carbon dioxide and thus enhances the planet's greenhouse effect. Small farmers in the pilot sites can increase their returns by recycling field crop residues by converting them into valuable products. Therefore, their returns can be increased by converting crop residues into compressed wood. Wood particles are bonded using synthetic adhesives and pressed into boards at high temperature and high pressure. The pressing operation provides increased density and strength. Pressed wood is cheaper, denser and uniform than conventional wood. Pressed wood has found typical applications as flooring, wall and ceiling panels, office dividers, furniture, cabinets, counter tops, and desktops **(Rowell, 1992)**.

There is increased interest in use of agricultural residues for composite panel manufacture, **Scurlock *et al.* (2000)** identified crop residues as the largest source of natural fiber and cellulose fiber bio composites, which have minimal costs and will greatly improve production chains and manufacturing of pressed wood. **Beakers and Bergsma (2004)** stated that the advantage of engineered bamboo products is the ability to create standard sections for

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members and connections, and to reduce the variability within a single member. Bamboo in its natural form is a light material that is comparable in strength to steel in tension and concrete in compression, yet acceptance is limited by the variance in cross-section and mechanical properties. **Yasin *et al.* (2010)** stated that there are a new environmentally friendly technology is being developed to convert agricultural residues like straw into quality value-added composite products using conventional formaldehyde-based resins. The implementation of the new technology will promote efficient use of agriculture byproduct as a sustainable resource for commercial production of commodity products like particleboards and help in reducing the amounts of agricultural wastes and eliminating the pollution caused by the burning of such straw. **Kargarfard and Latibari (2011)** studied the performance of corn and cotton stalks for medium density fiberboard production. The results indicated that corn and cotton stalks could be utilized as supplementary raw materials for MDF production in fiber deficient regions. **Guler (2015)** investigated the possibility of using agricultural residues (licorice root, hazelnut and peanut husks, corn and cotton stalks) to manufacture three-layer particleboards. All the produced panels tested for mechanical properties complied with the minimum requirements in the standards for the general grade particleboards. His results showed that it was possible to produce composite panel utilizing agricultural residues on lab scale.

There are many factors affecting on compressed wood production, **Nemli (2002)** stated that increasing press temperature, press time and pressure improved the technological properties of particleboard. **Goroyias and Hale (2002)** found that heat treatment of wood strands to greater than 235°C prior to pressing imparted a noticeable increase in their resistance to moisture, but also decreased strength and stiffness. **Unsal *et al.* (2003)** studied the effect of the heat treatment process on the physical and mechanical properties of eucalyptus wood. They concluded that density, swelling and hardness values decreased with an increasing duration of heat treatment and temperature. **Kadja *et al.* (2011)** used bone adhesive for producing particleboards from stems of cotton. The optimum pressure, temperature and the optimum pressing time and density used were respectively 140°C, 10-15 min. and about 0.6-0,671 g/cm^3. The optimum value of bone adhesive used in particleboards was 10 %. The results revealed that the density of particleboards obtained from cotton plant at 140°C have neither notable influence on their mechanical properties, nor evolve in the same way as the constant mechanics of the particleboards. **Attia *et al*. (2017)** conducted various experiments to study some different operating parameters (pressing temperature, sample thickness and resin ratio) affecting the pressing process for producing pressed wood from agricultural residues. Her experimental results reveal that modulus of rupture (28.1, 39.8 MPa), modulus of elasticity (4530, 5030.2 MPa) and thickness swelling (6.3 and 3.9%) of the produced pressed wood from rice straw and wood sawdust respectively were in the suitable region under conditions of 180°C pressing temperature and 8% resin ratio with acceptable sample thickness of 12 mm.

The above literature review cleared that such studies had to be carried out to solve the problem of converting the agricultural straw materials into high quality pressed wood through sound technical processes as this problem represents the basic challenge for the board producers. Therefore, the main objective of the present investigation was to try producing high quality of different types of pressed wood like (PB -MDF-HDF) by recycling farm crop residues. To achieve this objective, the following sub main objectives were taken into consideration:

- Recycling of agricultural residues to produce different types of pressed wood (particleboards (PB), medium density fiberboards (MDF) and high-density fiberboards (HDF).
- Controlling and adjusting pressing temperature, pressing pressure, pressing time and resin type to enhance the produced pressed wood quality.
- Compare the produced pressed wood with the standard quality guidelines using the standard engineering measurements.

MATERIALS AND METHODS

The main experiments were carried out through the year of 2020 at a private workshop in Zagazig city, Sharkia Governorate for recycling agricultural residues to produce different types of pressed wood.

Materials

Agricultural Residues

Different types of agricultural residues wood saw dust were used as a raw material for producing different types of pressed wood.

Agricultural residues were collected from the field, cleaned from dust and chopped by using hammer mill. Wood saw dust was obtained from local carpentry workshop in Zagazig city, Sharkia Governorate.

winandy and krzsik (2007) showed that the moisture content of the used raw materials were decreased by drying them in a technical oven at 70ºC until reaching 5 =% moisture content to make the samples (d.b.).

Resins and Hardener

Two different types of resins were used (Urea formaldehydes and Speria formaldehydes). Both types of resins were obtained from Mansoura for resins and chemicals industries to be mixed with the used raw materials for producing pressed wood. The standard properties of the used resins are given in Table1. Ammonium chloride was used as a hardener. 1% from 33% of ammonium chloride was added to the resins as a hardener.

The Hydraulic Press

The hydraulic press was used to press the raw materials to produce pressed wood (Fig.1).

The hydraulic press consists of the following main parts:

- Main frame with 230 cm length, 225 cm width and 48 cm thickness.
- Piston with 21 cm diameter and 40 cm length.
- Control panel, which contains two contactors (relay and over load).
- Oil pump with a disposal of 11 L/min.
- Pressure gauge that gave a pressure of 250 bar.

The hydraulic press was powered by an electric motor of 7.35 kW (10 hp).

The Thermal Moulding (The Forming Pattern)

The agricultural residues were placed in the thermal moulding during the pressing operation and pressed by the hydraulic press (Fig.1).

The thermal moulding consists of the following main parts:

- Thermal moulding contained one solid sheet with thickness of 1mm and dimensions of 30×30 cm.
- Two solid plates with dimensions of 20×25 cm and thickness of 7 cm, each plate was provided with heater of 800 watt.
- Two hollow plates with a frame of 2.5 cm with dimensions of 25×30 cm, one of them with 2.5 cm depth, the other with 5 cm.

The thermal moulding was attached with thermometer that used to measure and control temperature.

Universal Testing Machine

The universal testing machine (Fig.2) is used for bending, compression and tension tests of the pressed wood samples. Instron testing machine (Model 1122; Instron Corporation, Canton, MA) with capacity of 5000 KN and loading rate of 5 mm/min was used to perform tests. A hydraulic loading system with a piston activated by a hydraulic pressure in a cylinder is used.

Data Logger

Data logger contains two units; load cell and strain gauge (Tokyo Sokki Kenkyuio) was used to record the load and percentage of deflection.

Methods

Experiments were conducted to study the possibility of using agricultural residues as a raw material for producing different types of pressed wood.

Table 1. Standard properties of the used resins

Properties of resin	Value	
	Urea formaldehydes	Speria formaldehydes
Density at 20 ^{0}C, gm/cm^3	1.29	1.22
PH	8	8
Viscosity at 20 ^{0}C, cps	224	200
Solid content, %	65	60
Free formaldehyde, %	0.3	0.3
20% NH_4Cl content,	4	4
Storage time, day	20	18

Table 2. Chemical characteristics of the used raw materials

Agricultural residues	Chemical characteristics			
	Hemi Cellulose (%)	Cellulose (%)	Lignin (%)	Ash (%)
Linen sass`	6.2	71.5	9.4	10.5
Corn stalks	30	37	18	3.95
Wood saw dust	30	50	20	5.5

Fig. 1. The hydraulic press and the thermal moulding

Fig.2. The universal testing machine

Based on the preliminary experiments, a mixture of wood saw dust + linen sass + corn stalks with equal percentages could be used during conducting the main experiments to produce different types of pressed wood .Table2 showed the chemical characteristics of the used raw materials. While the agriculture residues was contained more cellulose and lignin that produced more hardener product . A mixture of wood saw dust + linen sass + corn stalks with equal percentages produced High Density Fiberboard (HDF). By synthetic lumber, the same ingredients were also obtained Particle boards (PB) and Medium Density Fiberboard (MDF).

Sample Preparation

The above mentioned agricultural residues mixture was agglutinated by mixing them with additives before the pressing process to be easier to stick and to be more hardener during pressing pressure to obtain best results , while the sample wasn't mix well the resin escaped from the sample and gave undesirable results, plus the resin blended for a long time made the components of the sample homogenous to one another, as opposed to unblending for 15 min. made them homogenous for less time , and more than 15 min. made the resin solidify before pressing pressure . The mixing operation was carried out using a small local vertical mixer. The mixer was fed manually with raw material while the additives were sprayed for five minutes. The mixer rotates at 250 rpm for a period of 15 min. to make suitable mixture to accomplish the mixing operation **(El-Nasr company for particle Board and Resins, 2009).**

Experimental Conditions

To fulfill the objective of this research work, some operating parameters were taken into consideration:

- Four different pressing pressures of 1, 3, 5 and 7 MPa.
- Four different pressing times of 5, 10, 15 and 20 min.
- Two different types of resins (Urea formaldehydes and Speria formaldehydes) with a percentage of 10% by weight from the pressed solid content.

All experiments were conducted using a mixture of wood saw dust + linen sass + corn stalks with equal percentages, to produce samples of different types of pressed wood, as achieved from the preliminary experiments. The pressing temperature was kept constant at 150ºC under all experimental conditions in an attempt to produce 12 mm of the produced pressed wood samples.

Measurements and Determinations

Both physical and mechanical properties as well as final product quality were taken into consideration to evaluate the produced pressed wood:

Physical properties

Physical properties were determined in terms of pressed wood density, thickness swelling and water absorption**.**

Pressed wood density

The density of the pressed wood sample was estimated from the following equation **(BSI, 1993):**

$$\rho = \frac{m}{V} \longrightarrow \quad (1)$$

Where:

ρ – Pressed wood density, kg/m^3,

m – Sample mass, kg,

V – Sample volume, m^3.

Thickness swelling

Thickness swelling (TS %) was important in ascertaining dimensional changes. Samples with dimensions of 50 x 50 mm and 12 mm thickness were prepared for evaluation of the thickness swelling. Samples were oven-dried at 70^{o}C to provide a uniform initial condition. The thickness was measured with a micrometer. The test samples were immersed in a water bath at room temperature for 2 hours, and then taken out and thickness is measured. The results of thickness swelling after 2 hours were determined from the following formula **(Unsal *et al.*, 2009):**

$$TS = \frac{TS_2 - TS_1}{TS_1} \times 100 \longrightarrow \quad (2)$$

Where:

TS_2 - Thickness swelling after 2 hours immersion in water, mm.

TS_1- Oven-dry thickness before immersion in water, mm.

Water absorption

Water absorption (WA%) is used to determine the amount of water absorbed by a pressed wood sample. Samples with dimensions of 50 x 50 mm and 12 mm thickness were prepared for evaluation of the water absorption. Samples were oven-dried at 70^{o}C to provide a uniform initial condition. The thickness was measured with a micrometer and weight was recorded. The test samples were immersed in a water bath at room temperature for 2 hours, then taken out and weighed. The results of water absorption after 2 hours were determined from the following formula **(Unsal *et al.*, 2009):**

$$WA = \frac{W_2 - W_1}{W_1} \times 100 \longrightarrow \quad (3)$$

Where:

W_2 – Weight (d.b.) after immersion in water for 2 hours, g,

W_1- Oven-dry weight before immersion in water, g.

Mechanical properties

Random samples of the produced pressed wood were analyzed in the Faculty of Engineering, Zagazig University to obtain mechanical properties. Random samples were selected that showed apparently produce results that prepared for analysis on test machines. The pressed wood samples with 20 cm width, 25 cm length and thickness of 12 mm was cut into equal slices. One sample was divided into 5 slices one part was measured for mechanical properties and the other for physical properties to know the validity of the samples to obtain compressed wood after measuring compered the standard guidelines. Each slide has dimensions of 20 cm length; 5 cm width and thickness of 12 mm. Mechanical properties were tested through the following indicators:

- Static bending strength including modulus of rupture (MOR) and modulus of elasticity (MOE).
- Tension test to calculate internal bond strength (IP)

Static bending strength tests

The static bending tests were conducted using the Universal Testing Machine. The specimens were prepared and tested according to the American Standard for Testing and Materials (ASTM D-1037standard). The dimensions of the specimens were 20 x 5 cm. The specimen was supported on a span of 15 cm and the force was applied at the mid-span using a loading head. The test was stopped when the samples started to break. Then, modulus of rupture (MOR) and modulus of elasticity (MOE) were calculated from load deflection curves.

Modulus of rupture (MOR) was calculated according to **BSI (1993):**

$$MOR = \frac{3P_b L}{2bh^2} \longrightarrow \quad (4)$$

Where: P_b- the load at the proportional limit, N,

Modulus of elasticity (MOE) was calculated according to **(BSI, 1993):**

$$MOE = \frac{P_{bp} L^3}{4b h^3 Y_p} \longrightarrow$$

(5)

Where:

P_{bp} - the maximum load, N

L - span, mm,

b - width of the specimen, mm,

h - thickness of the specimen, mm.

Y_p - the deflection corresponding to P_{bp}, mm.

Tension test (internal bond strength)

The tension test is the most commonly used method to evaluate the mechanical properties of compressed wood. It is the maximum stress sustained by a specimen from a test with tension forces applied. The pieces of 5 ×5 cm were used for internal bond strength measurement. Internal bond strength (IP) was calculated according to **(BSI, 1993):**

$$IP = \frac{P_s}{bL} \longrightarrow \quad (6)$$

Where:

P_s - The rupture load, N,

L - The length of the specimen, mm.

Final pressed wood quality

Final pressed wood quality (particleboard, medium density fiberboard and high density fiberboard) was measured in terms of physical and mechanical properties and compared with the similar pressed wood quality guidelines.

RESULTS AND DISCUSSIONS

The discussion will cover the obtained results under the following heads:

Physical Properties of the Produced Pressed Wood

Physical properties of the produced pressed wood in terms of density and water absorption are affected greatly by the pressing pressure, pressing time and type of resin.

Density of the produced pressed wood

Representative values of pressed wood density versus pressing pressure are given for the four pressing times with the two used resins in Fig. 3.

Referring to pressing pressure, results indicated that by increasing pressing pressure from 1 to 5 MPa, pressed wood density increased. While increasing it more than 5 up to 7 MPa decreased density. The recorded density values at a constant pressing time of 15 min. were 650, 850, 1100 and 900 MPa, under pressing pressures of 1, 3, 5 and 7 MPa, respectively at which urea formaldehyde resin was used. However, with the use of speria formaldehyde, the recorded density values were 450, 650, 850 and 780 MPa under the above mentioned pressing pressures. The increase in pressed wood density by increasing pressing pressure from 1 to 5 MPa is due to resin and additive weights added to the effect of pressure increase. This is in agreement with **Bowyer *et al.* (2003)** who stated that density of pressed wood is higher than the original material components, due to resin weight, additive weight and pressure during manufacturing. The decrease in pressed wood density by increasing pressing pressure more than 5 MPa is attributed to the mass losses in the compressed sample due to the increase in formaldehyde emissions. This result agreed with **Unsal *et al.* (2009)** who stated that increasing pressure and temperature increased specimen mass losses.

Relating to pressing time, results indicated that by increasing pressing time from 5 to 15 mint, pressed wood density increased. While, increasing it more than 15 up to 20 min., decreased density. The optimum pressing time is

15 min. at which density value was 1100 kg/m^3 at pressing pressure of 5 MPa with the use of urea formaldehyde resin. While, this value was 850 kg/m^3 at the same pressure with the use of speria formaldehyde resin. The decrease in pressed wood density by increasing pressing time more than 15 up to 20 min. is due to subjecting the sample to pressure and heat for a long time that tends to increase formaldehyde emissions outside the sample resulting in mass losses and reduction in density. This is in agreement with **Unsal *et al.* (2003)** who found that density and swelling values decreased with an increasing duration of heat treatment and temperature.

As to resin type, results showed that urea formaldehyde resin gave the best results compared to speria formaldehyde resin according to the standard guidelines. The composition of the urea formaldehyde allowed it to penetrated the sample more smoothly than the speria formaldehyde when it was pressed , the best resin was pressed at 15 min. afterwards, the increased pressure of the sample caused the resin to escape from the inside of the sample , and the time increased by the constant pressure gave unsatisfactory results as the glue escaped from the inside of the sample, whether the urea formaldehyde or speria formaldehyde. Urea formaldehyde resin recorded a density value of 1100 kg/m^3, at pressing pressure of 5 MPa and pressing time of 15 min. in Fig3 . While, speria formaldehyde resin recorded a density values of 850 kg/m^3 under the same previous conditions. The obtained results is in agreement with **Pizzi (2003)**.

Although similar manufacturing processes are used in making pressed wood, different types of produced pressed wood were obtained depending on pressing pressure and pressing time values. Depending on **Reddy and Yang (2007)** who reported that boards with density lower than 450 kg/m^3 are low density particleboards, between 450 and 800 kg/m^3 are medium density fiberboards and greater than 800 up to 1450 kg/m^3 are high density fiberboards. The above mentioned results showed that the used mixture under conditions of 5 MPa pressing pressure and 10 min. pressing time had a density of 650 kg/cm^3, which corresponding to low density particleboards (PB). However, under conditions of 5 MPa pressing pressure and 20 mint pressing time had a density of 850 kg/cm^3, which corresponding to medium density fiberboard (MDF). The same mixture under conditions of 5 MPa pressing pressure and 15 min pressing time had a density of 1100 kg/cm^3, which corresponding to high density fiberboard (HDF).

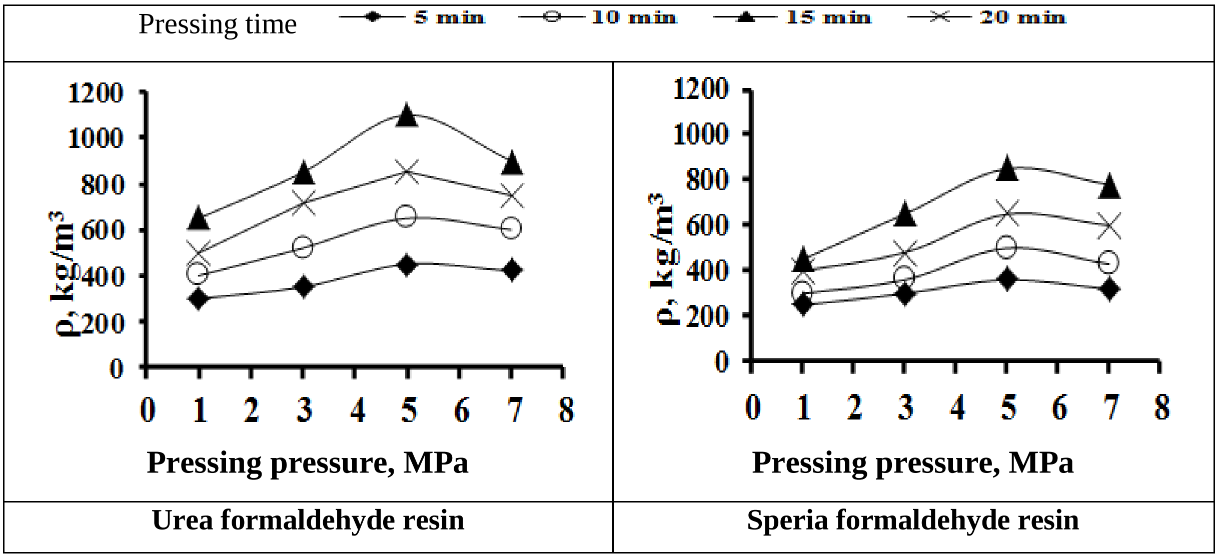

Fig. 3. Effect of pressing pressure and pressing time on pressed wood density (ρ) using two different types of resins

Thickness swelling of the produced compressed wood

Fig.4.illustrated the effects of pressing pressure, pressing time and resin type on thickness swelling of the produced pressed wood.

Considering pressing pressure, results indicated that by increasing pressing pressure from 1 to 5 MPa, thickness swelling decreased. While increasing it more than 5 up to 7 MPa increased swelling. The recorded thickness swelling values were 10, 7, 5 and 6% at a constant pressing time of 15 min. under pressing pressures of 1, 3, 5 and 7 MPa, respectively at which urea formaldehyde resin was used. However, with the use of speria formaldehyde, the recorded swelling values were 12.5, 8, 6 and 7% under the same previous conditions.

Regarding pressing time, results indicated that by increasing pressing time from 5 to 15 min., thickness swelling decreased. While, increasing it more than 15 up to 20 min. increased thickness swelling. The optimum pressing time is 15 min. at which thickness swelling value was 5% at pressing pressure of 5 MPa with the use of urea formaldehyde resin. While, this value was 6 % at the same pressure with the use of speria formaldehyde resin.

Referring to resin type, results showed the best result according to the standard guidelines were obtained with the use of urea formaldehyde resin compared to speria formaldehyde resin. The composition of the urea formaldehyde allowed it to penetrated the sample more smoothly than the speria formaldehyde. Urea formaldehyde density at 20 ºC, gm./cm3 was 1.29 compared to speria formaldehyde density at 20 ºC, gm./cm3 was 1.20.When it was pressed the best resin was pressed at 15 min. afterwards, the increased pressure of the sample caused the resin to escape from the inside of the sample , and the time increased by the constant pressure gave unsatisfactory results as the resin escaped from the inside of the sample, whether the urea formaldehyde or speria formaldehyde.

Urea formaldehyde resin recorded a thickness swelling value of 5 % at pressing pressure of 5 MPa and pressing time of 15 min. While, speria formaldehyde resin recorded 6% under the same previous conditions. As mentioned above, the obtained results are in agreement with **Pizzi (2003)**.

Water absorption of the produced pressed wood

The effects of pressing pressure, pressing time and resin type on water absorption of the produced pressed wood are shown in Fig.5.

Considering pressing pressure, results indicated that by increasing pressing pressure from 1 to 5 MPa, water absorption decreased. While increasing it more than 5 up to 7 MPa increased water absorption. The recorded water absorption values were 23, 13, 7 and 8% at a

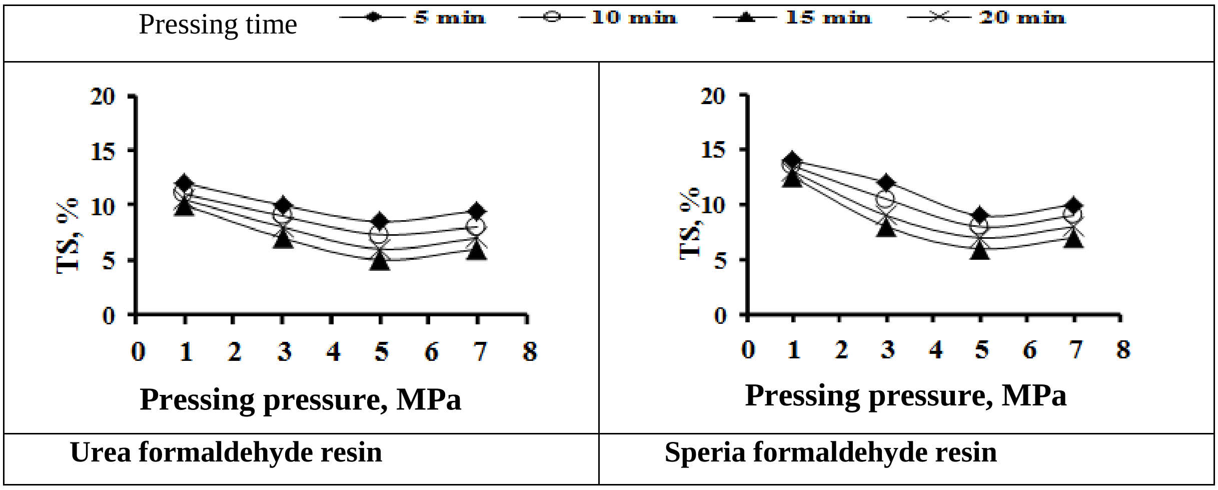

Fig.4. Effect of pressing pressure and pressing time on thickness swelling (TS) using two different types of resins

constant pressing time of 15 min under pressing pressures of 1, 3, 5 and 7 MPa, respectively at which urea formaldehyde resin was used. However, with the use of speria formaldehyde, the recorded water absorption values were 27, 16, 9 and 11% under the same previous conditions.

Relating to pressing time, results indicated that by increasing pressing time from 5 to 15 min., water absorption decreased. While, increasing it more than 15 up to 20 min. increased water absorption. Water absorption increased with increasing pressure and time due to the resin escaped from the sample, the escaped of the resin made malfunction inside the sample, when the sample was submerged in the water it caused to collapse. The optimum pressing time is 15 min. at which thickness swelling value was 7 % at pressing pressure of 5 MPa with the use of urea formaldehyde resin. While, this value was 9 % at the same pressure with the use of speria formaldehyde resin in Fig. 5.

As to resin type, results showed that the use of urea formaldehyde resin compared to speria formaldehyde resin gave the best values according to the standard guidelines. The composition of the urea formaldehyde allowed it to penetrated the sample more smoothly than the speria formaldehyde when it was pressed , the best resin was pressed at 15 min. afterwards, the increased pressure of the sample caused the resin to escape from the inside of the sample , and the time increased by the constant pressure gave unsatisfactory results as the glue escaped from the inside of the sample, whether the urea formaldehyde or speria formaldehyde.Urea formaldehyde resin recorded a thickness swelling value of 7% at pressing pressure of 5 MPa and pressing time of 15 min. While, speria formaldehyde resin recorded 9% under the same previous conditions. As mentioned above, the obtained results agreed with **Pizzi (2003)**.

Effect of some Operating Parameters on the Mechanical Properties of the Produced Pressed Wood

The mechanical properties of the produced pressed wood will be discussed in terms of modulus of rupture (MOR), modulus of elasticity (MOE) and internal bond strength (IP) as a function of change in pressing pressure, pressing time and type of resin.

Modulus of rupture of the produced pressed wood

Representative values of modulus of rupture versus pressing pressure are given for the four pressing times with the two resin types in Fig.6.

Concerning pressing pressure, results showed that modulus of rupture increased by increasing pressure from 1 to 5 MPa, but by increasing it more than 5 up to 7 MPa, modulus of rupture decreased. The recorded modulus of rupture values at a constant pressing time of 15 min. were 30, 39, 46 and 42 MPa, under pressures of 1, 3, 5 and 7 MPa, respectively at which urea formaldehyde resin was used. However, with the use of speria formaldehyde, the recorded values were 27, 35, 44 and 41 MPa under the same previous conditions.

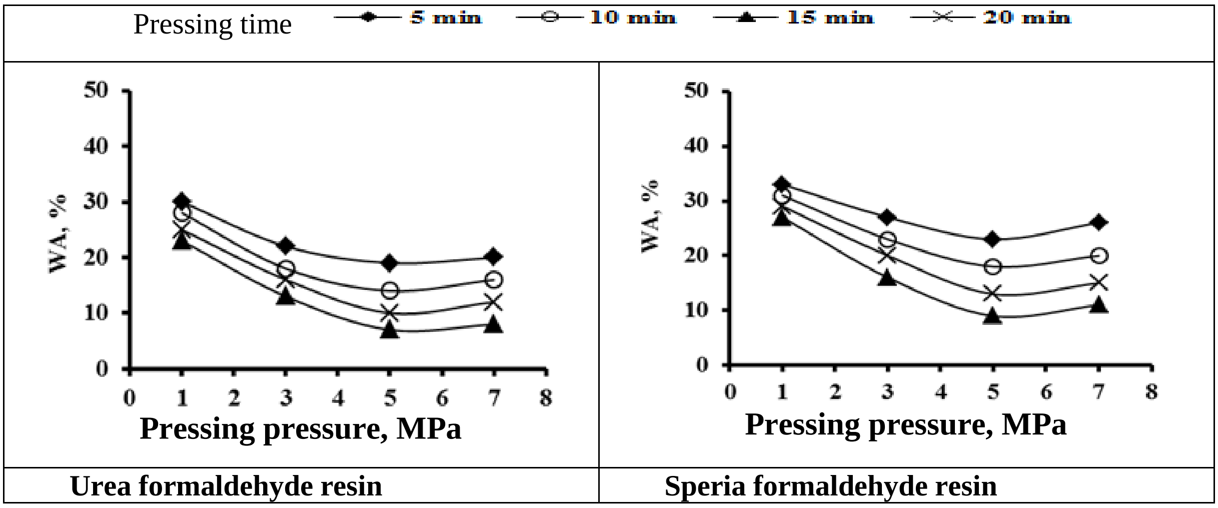

Fig. 5. Effect of pressing pressure and pressing time on water absorption (WA) using two different types of resins

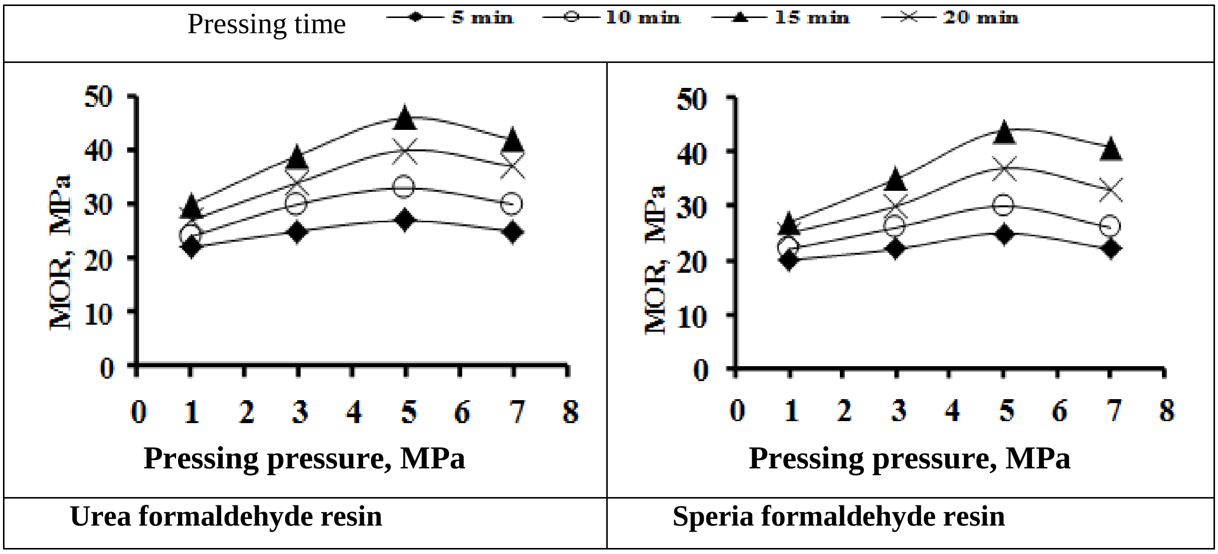

Fig.6. Effect of pressing pressure and pressing time on modulus of rupture (MOR) using two different types of resins

Regarding pressing time, results indicated that by increasing pressing time from 5 to 15 min., modulus of rupture increased. While, increasing it more than 15 up to 20 min. decreased modulus of rupture. The best pressing time is 15 min. Modulus of rupture increased with increased pressure and time due to the resistance of the sample to rupture and collapses as the resin flowed out of the sample, after increased pressure more than 15 up to 20 min. modulus of rupture decreased. At which modulus of rupture values was 46 MPa, respectively at pressure of 5 MPa with using urea formaldehyde resin in Fig.6. While, this value was 44 MPa, at the same pressure using speria formaldehyde resin under

the same previous conditions. As to resin type, results show that urea formaldehyde resin recorded good results compared to speria formaldehyde resin according to the standard guide liness. The composition of the urea formaldehyde allowed it to penetrated the sample more smoothly than the speria formaldehyde when it was pressed , the best resin was pressed at 15 min. afterwards, the increased pressure of the sample caused the resin to escape from the inside of the sample , and the time increased by the constant pressure gave unsatisfactory results as the glue escaped from the inside of the sample, whether the urea formaldehyde or speria formaldehyde. Urea formaldehyde resin recorded modulus of rupture value of 46 MPa at pressing pressure of 5 MPa and pressing time of 15 min. While, speria formaldehyde resin recorded modulus of rupture value of 44 MPa under the same conditions in Fig.6.

Modulus of elasticity of the produced pressed wood

Fig.7showed the effects of pressing pressure, pressing time and resin type on modulus of elasticity of the produced pressed wood.

Regarding pressing pressure, results showed that modulus of elasticity increased by increasing pressing pressure from 1 to 5 MPa, but increasing pressure more than 5 up to 7 MPa, modulus of elasticity decreased. With increased time, the sample collapsed due to the escape of the resin. The recorded modulus of elasticity values at a constant pressing time of 15 min. were 2900, 3800, 4800 and 4200 MPa in Fig.7., under pressing pressures of 1, 3, 5 and 7 MPa, respectively at which urea formaldehyde resin was used. However, with the use of speria formaldehyde, the recorded modulus of elasticity values were 2800, 3500, 4500 and 4000 MPa under the above mentioned conditions.

With regard to pressing time, results indicated that by increasing pressing time from 5 to 15 min., modulus of elasticity increased. While increasing pressing time more than 15 up to 20 min. decreased modulus of elasticity. With increased pressure and increased time, the sample collapsed due to the escape of the resin. The best pressing time is 15 min. at which modulus of elasticity value was 4800 MPa at pressing pressure of 5 MPa with the use of urea formaldehyde resin. While, this value was 4500 MPa at the same pressure with the use of speria formaldehyde resin.

Referring to resin type, results showed that urea formaldehyde resin gave the best values compared to speria formaldehyde resin according to the standard guidelines. The composition of the urea formaldehyde allowed it to penetrated the sample more smoothly than the speria formaldehyde when it was pressed , the best resin was pressed at 15 min. afterwards, the increased pressure of the sample caused the resin to escape from the inside of the sample , and the time increased by the constant pressure gave unsatisfactory results as the glue escaped from the inside of the sample, whether the urea formaldehyde or speria formaldehyde. Urea formaldehyde resin recorded modulus of elasticity value of 4800 MPa at pressing pressure of 5 MPa and pressing time of 15 min. While, speria formaldehyde resin recorded modulus of elasticity value of 4500 MPa under the same conditions.

Internal bond strength of the produced pressed wood

Fig.8 showed the effects of pressing pressure, pressing time and resin type on internal bond strength of the produced pressed wood.

Regarding pressing pressure, results showed that internal bond strength increased by increasing pressing pressure from 1 to 5 MPa, but increasing pressure more than 5 up to 7 MPa, internal bond strength decreased. As the pressure increased, the internal bond of the sample increased due to the resistance to high pressure, and the internal bond strength continues to hold together as the pressure increased and time increased to obtain the maximum internal bond cohesion of the sample even after the resin escaped. The recorded internal bond strength values at a constant pressing time of 15 min. were 0.36, 0.42, 0.48 and 0.44 MPa, under pressing pressures of 1, 3, 5 and 7 MPa, respectively at which urea formaldehyde resin was used. However, with the use of speria formaldehyde, the recorded values were 0.35, 0.40, 0.45 and 0.43 MPa under the above mentioned conditions.

With regard to pressing time, results indicated that by increasing pressing time from 5 to 15 min., internal bond strength increased. While increasing pressing time more than 15 up to 20 min. decreased internal bond strength. As the time increased, the internal bond of the sample increased due to the resistance to high pressure and time, and the internal bond strength continues to hold together as the pressure increased and time increased to obtain the maximum internal bond cohesion of the sample even after the resin escaped. The optimum pressing time is 15 min. at which internal bond strength value was 0.48 MPa at pressing pressure of 5 MPa with the use of urea formaldehyde resin. While, this value was 0.45 MPa under the same pressure with the use of speria formaldehyde resin in Fig.8.

Urea formaldehyde resin recorded internal bond strength value of 0.48 MPa at pressing pressure of 5 MPa and pressing time of 15 min. While, speria formaldehyde resin recorded value of 0.45 MPa under the same conditions.

Final Pressed Wood Quality

Table3 illustrated the comparison between the different produced pressed wood with the standard quality guidelines of each type.

Results in the table showed that the produced low density particleboards (PB), medium density fiberboard (MDF) and high density fiberboard (HDF) under conditions of 5 MPa pressing pressure and of between 5 to 20 min. pressing time with the use of urea formaldehyde resin, met the minimum requirement of the standard quality guidelines TS-EN 312.

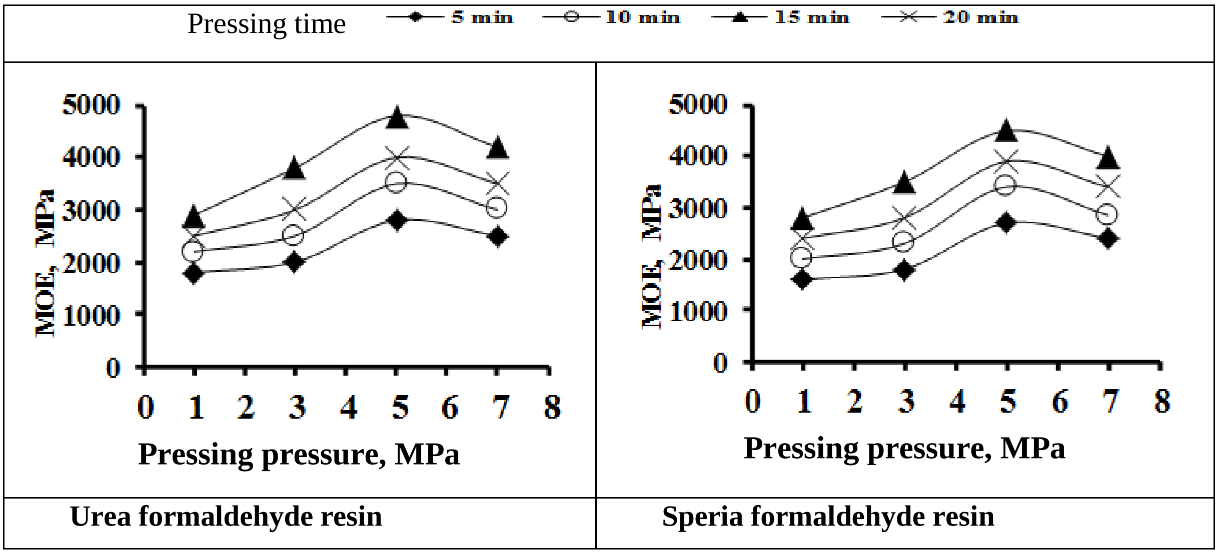

Fig.7. Effect of pressing pressure and pressing time modulus of elasticity (MOE) using two different types of resins

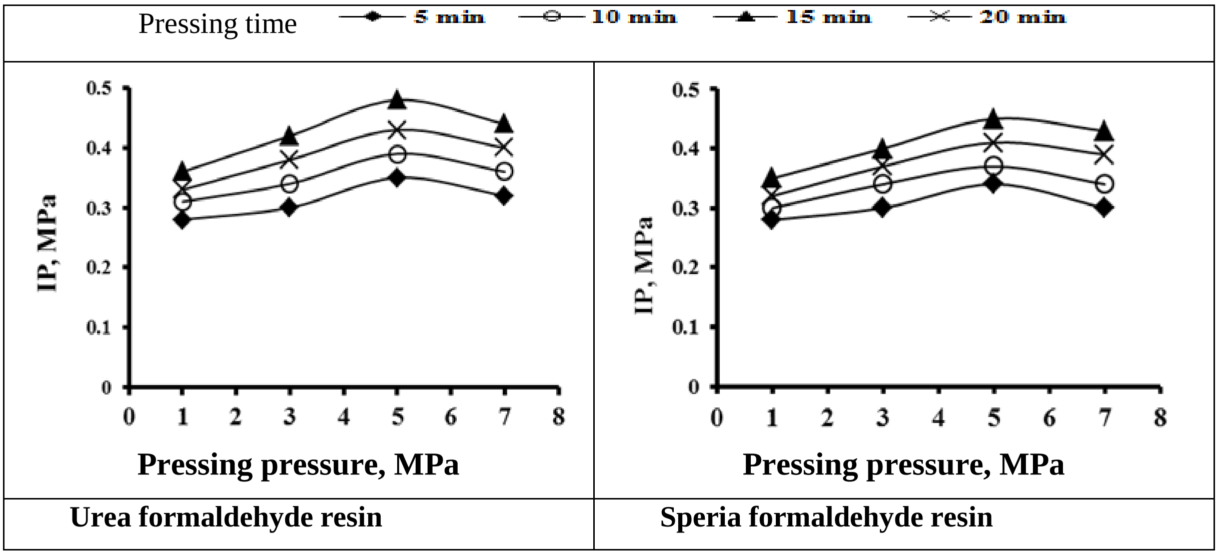

Fig.8. Effect of pressing pressure and pressing time on internal bond strength (IP) using two different types of resins

Table 3. Comparison between the produced pressed wood and the standard quality guidelines

Properties	Particleboards (PB)		Medium density fiberboard (MDF)		High density fiberboard (HDF)`	
	The used mixture	standard quality guidelines	The used mixture	standard quality guidelines	The used mixture	standard quality guidelines
MOR, Mpa	33	20 - 30	40	30 - 40	46	40 – 50
MOE, MPa	3500	2000 - 3000	4000	3000 - 4000	4800	4000 – 5000
WA, %	14	15 - 20	10	10 - 15	7	5 – 10
TS, %	7.3	8 – 10	6	6 - 8	5	4 – 6
Density, kg/m^3	650	350-550	850	550-850	1100	850-1450

Conclusion

Based on the obtained results, it could be concluded to the following:

- It is important to conserve the natural wood resources by recycling agricultural residues for producing pressed wood.
- Controlling pressing pressure, pressing temperature as well as pressing time is of great importance during the manufacturing processes of pressed wood production.
- A mixture of wood saw dust + linen sass + corn stalks with equal percentages could be used to produce different types of pressed wood (Particleboards, PB; Medium density fiberboards, MDF and High density fiberboards, HDF).
- The different types of the produced pressed wood quality were meeting the required physical and mechanical properties as stated in the standard quality guidelines under the following recommended conditions:
  - Pressing pressure of 5 MPa.
  - Pressing time of 15 min.
  - Using urea formaldehyde resin.

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تحســـين جــودة أنـــواع مختلفة من الأخشاب المضغوطة المصنعة من المخلفات الزراعيـــة

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يعتبر تراكم المخلفات الزراعية من أهم المشاكل الحيوية التي تمثل خطرا على البيئة ويعتبر إعادة تدوير هذه المخلفات واستخدامها في انتاج أخشاب مضغوطة كبديل عن الأخشاب الطبيعية أحد الحلول للتخلص منها بطريقة آمنة. لهذا فقد كان الهدف من هذه الدراسة هو إعادة تدوير المخلفات الزراعية لإنتاج أنواع مختلفة من الأخشاب المضغوطة عالية الجودة وذلك باستخدام مكبس حرارى و قالب تشكيل (اسطمبة) مزود بنظام حرارى. تم اجراء التجارب العملية باستخدام مخلوط من المخلفات الزراعية (نشارة الخشب + ساس الكتان + حطب الذرة بنسب متساوية) حيث تم ضغط هذا المخلوط على أربعه ضغوط مختلفة (1، 3 ، 5 ،7 ميجا بسكال) مع أربعه أزمنة كبس مختلفة (5 ، 10 ، 15 و 20 دقيقة) باستخدام نوعين مختلفين من الغراء (يوريا فورمالدهيد وسبيريا فورمالدهيد) وذلك لإنتاج أخشاب مضغوطة ذات سمك 12 مم مع تثبيت درجة الحرارة عند 150 م°. هذا وقد تم تقييم الأخشاب الناتجة من خلال قياس بعض الخواص الفيزيائية (الكثافة - سمك الانتفاخ- امتصاص الماء) وبعض الخصائص الميكانيكية (معامل المرونة - معامل التمزق - قوة الرابطة الداخلية) كما تم مقارنة الأخشاب الناتجة بالمواصفات القياسية للأخشاب المضغوطة المتداولة في السوق المحلية. هذا وقد أسفرت النتائج عما يلي: أظهرت النتائج أن استخدام مخلوط (نشارة الخشب + ساس الكتان + حطب الذرة) بنسب متساوية يمكن بواسطته انتاج ثلاث أنواع مختلفة من الأخشاب المضغوطة (أخشاب منخفضة الكثافة PB - أخشاب متوسطة الكثافة MDF - أخشاب عالية الكثافة HDF). أظهرت النتائج ايضا أن القيم المثلى لكل من الخواص الفيزيائية والخواص الميكانيكية للأخشاب المضغوطة المنتجة تم الحصول عليها عند ظروف التشغيل الآتية: ضغط الكبس 5 ميجا باسكال، زمن الكبس 15 دقيقة، استخدام غراء اليوريا فورمالدهيد، تم مقارنة مواصفات الأخشاب المضغوطة المنتجة من مخلوط (نشارة الخشب + ساس الكتان + حطب الذرة) بالمواصفات القياسية للأخشاب المضغوطة فوجد أنها متقاربة منها وبذلك فهى تعد صالحة للاستخدامات المختلفة.

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