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FIRE PERFORMANCE, DECAY RESISTANCE AND SURFACE ROUGHNESS OF PARTICLEBOARDS MADE FROM STONE PINE (PINUS PINEA L.) CONES

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Abstract

This work explores some technological properties of three-layer particleboard produced from pine (Pinus Pinea L.) wood particles and waste cones. Four board types were made from mixtures of wood particles/stone cone (100/0, 50/50, 0/100 and 40/60%, respectively). The laying ratio (outers: core) was 40:60%. The particleboards were manufactured with a board density of 700 g/cm3, board size of 400×400×12 mm and a pressing pressure of 24-26 kPa/cm2. The limiting oxygen İndex (LOI) levels (ASTM D 2863), decay resistance (EN 113) and surface roughness (DIN 4768) of particleboards were determined. The using stone cone was found to be affecting all the properties of particleboards. The result showed that using waste cone increased the decay resistance. However, LOI values and surface roughness of the panels increased with increasing the pine cone amount of mixture.
Keywords: Particleboards, Fire performance, technological properties, decay resistance, Surface properties

ÇAM KOZLAKLARI (PINUS PINEA L.) KULLANILARAK ÜRETİLEN YONGA LEVHALARIN YANGIN PERFORMANS, ÇÜRÜKLÜK DAYANIM VE YÜZEY DÜZGÜNLÜK ÖZELLİKLERİ

Özet

Bu çalışmada fıstık çamı (Pinus Pinea L.) yongaları ve kozalak atıklarıyla üretilen 3 tabakalı yongalevhaların bazı teknolojik özellikleri araştırılmıştır. Çam Yongası ve kozalak karışım oranına göre 4 adet levha tipi üretilmiştir (%100/0, %50/50, %0/100 ve %40/60). Yongalevhaların Dış/orta tabaka kullanım oranı %40:60'dır. 400×400×12 mm boyutlarında üretilen levhaların özgül ağırlığı 700 g/cm3 olup, pres basıncı 24-26 kPa/cm2'dir. Üretim sonucunda levhaların Limit oksijen indeksi (LOI) değerleri (ASTM D 2863), çürüklük dayanımı (EN 113) ve yüzey pürüzlülükleri(DIN 4768) belirlenmiştir. Yapılan çalışma sonucunda atık çam kozalağı kullanımının yongalevhaların özelliklerini etkilediği belirlenmiştir. Kozalak kullanım oranının artmasıyla çürüklük dayanımı artmıştır. Fakat LOI ve yüzey pürüzlülüğü değerleri de karışımdaki kozalak kullanım oranının artması ile artış göstermiştir.
Anahtar Kelimeler: Yongalevha, Yangın dayanımı, Teknolojik özellikler, Çürüklük dayanımı, Yüzey özellikleri

1 Introduction

Nowadays, it has become necessary to use the products as raw materials such as particleboard, fiberboard, OSB, plywood in furniture industry because of increasing cost and competition. Particleboards (PB) are widely used one kind of wood composites that are generally made with a mixture of wood chips and synthetic resin under high temperature and pressure. Due to the growth of the particleboard industry need to large quantities of sawdust, planer shavings, mill residues, waste materials produced by other wood industries and agricultural wastes [1], [2].

In the recent times, depletion of natural resources has been a major problem due to the increase of the amount of use. The foreseen deficit in wood and wood composite industry led to many research and exert to find alternative lingocellulosic raw material sources.

Research has been performed on diversity on non-wood materials and agricultural residues by many scientists: kenaf [3], cotton carpel [4], weath straw [5], rice straw [6], reed [7], sunflower stalks [8] and bamboo [9].

Pine nuts are an important resource for the economy of the Mediterranean countries. The use of pine cones have become important because of pine nuts are precious in the international market. The total amount of pine nut production in some countries (Spain, Portugal, Italy, and Turkey) is about 4900 tons [10],[11]. In the year 2011, the pine nuts turkey production has increased from 6.266.131 kg [12]. Firstly, the cones are dried for easy separation of peanut and it is burned after separation. Buyuksari at al. [13] investigated the use of pine cone flour in particleboard production. The pine cones were soaked in hot water for four hours at 80 °C due to the high content of extractive. In this study, the soaked process was not performed owing to It would lead to extra production costs during the industrial production. If inappropriate soaked systems are also used, it is unlikely to occur in the production bottleneck.

The main goal of the study was to determine the fire performance, decay resistance and surface roughness properties such as of particleboard made from waste cone stones (Pinus pinea L.) and to determine the suitability of the use of Pinus pine cones.

2 Materials and methods

2.1 Materials

Pine (Pinus Pinea L.) wood particles were obtained from Karadeniz Technical University campus in Trabzon, Turkey. Waste pine cones were collected from Fındıklı village in Artvin, Turkey. Chemical materials were obtained from Kastamonu Integrated Wood Company in Samsun, Turkey. Urea formaldehyde (UF) adhesive with the solid content of 62% and as a hardener, Ammonium chloride (NH_4Cl) (solid content: 25%) was mixed to the adhesive. A water repellent additive such as paraffin or wax is not used in panel production.

2.2 Particleboard Manufacturing

Firstly, the nut of the cones is divided. Stone pine woods were cut 3cm in thickness. Wood materials were chipped using a HACKER chipper. Afterwards, the chips were reduced into suitable size particles using a knife ring flaker. After chipping, particles were screened on a sieve with the size of 3mm, 1.5mm, and 0.5mm by ALAGİER shaking screening machine. These particles are separated for use in surface and core layers. The boards were designed to consist of 40% particles at the surface layers and 60% at the core layer. Later, the particles were dried in an oven to a moisture content of 3% (oven temperature: 110°C). Based on the oven dry particle weight, 10% (surface layer) and 8% (core layer) UF resin was used at particleboards. 2% Ammonium chloride was applied to the UF adhesive as based on the resin weight. Board mats with dimensions of 420mm × 420mm × 12mm were hot pressed for 7 minutes to achieve a target board density of 700kg/m^3. Pressing pressure and temperature were 24-26 kp/cm^2 and 150°C, respectively. After pressing, the boards were stored in climate room for further 30 days at 25°C and 65% relative humidity (RH). Table 1 shows the raw materials formulation used for PB panels.

Table 1. Formulation of the boards.

Board Type	PB Content (by weight)	
	Wood particles (%)	Pine cone (%)
K	100	0
L	50	50
M	0	100
N	40 (Surface)	60 (Core)

2.3 Fungal decay resistance

The brown-rot fungi *Conipohara puteana* were used for testing natural decay resistance following EN 113 standard [14]. EN 113 point outs that sample dimensions are 50 mm × 25mm × 15mm. We modified the process to use 25mm × 12mm × 5mm.

Eight decay resistant specimens were cut from each board. Samples are incubated until the weight does not change before the fungus test (103 ± 2°C). Then, oven dry weights measured and to recorded as the oven dry weight after the rot. (M_0). The closed petri plates were incubated for 16 weeks, at 23°C and 60 ± 5% RH to evaluate the efficacy of the treatments. After incubation, the samples were removed from the petri plates and they have been carefully cleaned. Next, samples were dried in the oven at 103 ± 2 °C until the equilibrium and to record as oven dry weight before the rot. (M_1)

Figure 1. Fungal decay test samples

Weight loss (WL) of samples with Brown rot fungi *C. puteana* degradation was calculated with equality N1.

$$\text{WL (\%)} = \left[\frac{M_0 - M_1}{M_1}\right] \text{X } 100 \qquad (1)$$

2.4 Limited oxygen index (LOI) measurements

The LOI of the samples were determined in an Oxygen Index Tester (Dynisco Limiting Oxygen Index Chamber). LOI test is performed according ASTM D2863 [15] standard. The aim of this test is to determine the minimum amount of oxygen required to sustain combustion of the samples. Examples of flammability are controlled by giving a leading fire.

The 11 mm thick boards were cut into 15 mm wide and 100 mm long specimens for the LOI tests. Oxygen and nitrogen gas is used for combustion. Five samples were tested for each group.

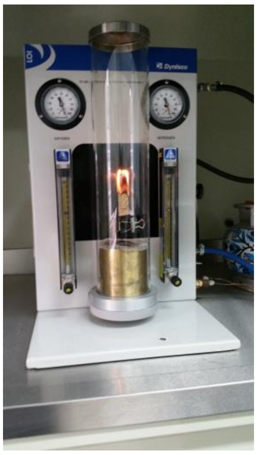

Figure 2. Determination of samples flammability

2.5 Surface roughness measurements

Mitutoyo Surftest SJ-301 device was used for the measurement of surface roughness values the boards. Cut-off length was 2.5mm, sampling length was 12.5mm and detector tip radius was 5mm in the surface roughness measurements. Surface roughness test is performed according DIN 4768 [16] standard. Ten replicates were used for each group to evaluate surface roughness (totally 150 points). Average roughness (R_a) and mean peak-to-valley height (R_z) parameters were used to determine quantitatively surface characteristics of the samples.

2.6 Statistical analysis

Duncan's mean separation test and analysis of variance with ANOVA in SPSS 13 software was used for statistical analysis of decay resistance, LOI and surface roughness properties specimens. Groups with same letters in column indicate that there is no statistical difference ($p<0.05$) between the samples according to Duncan's multiple range test. Values in parentheses are standard deviations.

3 Results and Discussion

3.1 Fungal decay resistance

The results obtained after a 16-week incubation period are presented in Table 2. There are significant effect of pine cone waste in the furnish on the sensivity of the PB samples against the *C. puteana.* The sample resistance against the brown-rot fungus significantly increased with increment of pinecones adding and the minimum weight loss occurred in the samples containing 100% pine cones. Fungal decay resistance increased with used pine cone in all board groups.

Table 2. Mean values weight loss and classes of resistance of particleboards

Board Type	Weight loss (%)
K	41.36 (0.54)^{A}
L	38.04 (0.45)^{B}
M	34,72 (0.34)^{C}
N	38.32 (0.60)^{B}

Stone pine cone contains significant amounts of extractives as compared to contents of the stone pine wood [13]. Wood extractives play a main role in the preservation of wood against fungal attack. They show a toxic effect for wood damage caused by microorganism. The amount of extractives is a more important factor in the wood microstructures in restraining fungal decay [17, 18]. Decreasing of weight loss of the particleboard panels with increasing pine cone particle can be attributed to higher contents of extractives in the cone than the wood.

According to EN 350-1 [19] standard, an average weight loss of 0 to 5% is considered as very durable, 5 to 10% is considered as durable, 10 to 20% is classified as moderately durable, 20 to 30% is considered as Slightly durable, and anything above 30% is considered as not durable. For all board types, the decay class of the particleboards was not durable.

3.2 Limited oxygen index (LOI) measurements

LOI is a parameter used to assess the flame resistance and amount of combustion of the polymeric materials same condition. Besides, these tests are used to determine the fire retardant properties of wood and wood based composites. The higher the LOI value, the more effective is the flame-retardant treatment. Higher LOI value indicates a more effective flame retardant effect [20]-[22]. Table 3 presents the LOI test results of particleboard with different loading level of pine cones. According to the results, the highest fire resistance was determined in the control group (K). LOI values decrease occurred in the increasing use of pine cones.

Table 3. Limited oxygen index (LOI) levels of particleboards

Board Type	LOI (%)
K	37 (0.25)^{A}
L	35,5 (0.30)^{B}
M	35,25 (0.10)^{B}
N	36 (0.10)^{C}

The pine cones have a high content of chemical compounds [23]. The high intensity of extractives content in the Pinus pine cones could increase flammable properties of specimens. The low bonding capacity of particles causes to increase the air void content in the particleboards. As a result of this, the flammable properties and combustion speed of samples are supposed to be affected.

3.3 Surface roughness measurements

Nowadays, wood composites mostly are used covered thin overlays such as melamine saturated papers and thin films. Surface roughness is one of the most important factors is the quality of the final product [24].

Figure 3 shows the R_a and R_z values of the samples. Panel type K made with a only particles had the smoothest surface with average values of 3.72μm, 31.67μm, respectively. This result showed that the surface smoothness of boards reduced with increased amount of pine cones.

Extractives have an important effect on adhesive bonding performance of wood. They are adversely affecting the performance of the connection between wood particles. In this case negatively affect the mechanical and physical properties [25]. Also weak adhesive bonding might cause a porus structure and roughness surface.

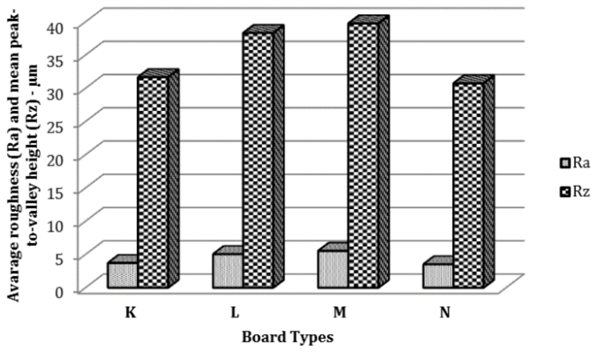

Figure 3. Surface roughness parameters of particleboards

4 Conclusions

In this work, the properties of pine particles and waste cone particleboards were investigated at four different pine cone levels. Based on the results of this study, amount of pine cones were significantly affected fungal decay resistance, fire performance, and surface quality. Pine cone usage has a positive impact decay resistance. The other hand, flame resistance and surface quality is reduced. According to the results obtained in this study pine cones has potential as a raw material for particleboard manufacturing. Especially, it could create a protective effect against biological degradation in outdoor using.

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