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FLEXURAL PROPERTIES OF SAMPLES OBTAINED FROM "LIQUID WOOD"

Abstract: The use of recycled materials has become an important point of view in many activity areas, that's why the "liquid wood" could replace plastic materials in the near future. Arbofill, Arboblend and Arboform are the three types of "liquid wood" developed by Fraunhofer Institute for Chemical Technology in Pfinztal-Germany. The main drawback of plastic materials is the existence in their composition of some carcinogens substances, non-biodegradability and the difficulty in recycling products. The "liquid wood" removes these disadvantages. More "liquid wood" has the mechanical properties even better than other plastics, good resistance to water, can be reused up to five times over, without affecting the mechanical properties of the material, as for example fire resistance and durability, etc. This paper presents analysis of flexural properties for arboblend. Also the bending deflection and angle deflection are presented. Finally the paper presents the modulus of elasticity after flexural test. The values of these modulus are better than others plastics such as PA 66 (Polyamide 66), PA11 (Polyamide 11), POM (Acetal Homopolymer), PE-HD (High Density Polyethylene), PVDF (Poly Vinylidene Fluoride), ECTFE (Etylene Copolymer Fluoride), ECTFE (Etylene Copolymer) in case of high stiffness of function parts. On the other point of view the liquid wood could replace the following plastics material: PA66SF20, PEEK GF30, PEEK CF30, PEK, PAI, PPS GF40, PEI GF30 etc. According to the analyses performed and to the conclusions drawn, the liquid wood can replace the plastic materials in many industrial applications, such as: ornaments and not just for cars, connectors, switches, electrical industry, different industry mobile accessories, computers, televisions, mobile phone housings etc.

1. Introduction

Researches made in the last years led to discovery of new methods for lignin extracting (main compound from liquid wood content) from which sulphur was removed from the final product composition. In this way, fluid wood can be used in a many applications from food industry (packaging) up to the electronics industry (housing and packaging). Replacing the plastics traditional from the market will be made gradually. From this point of view there are some studies made by big companies in the world, for instance Henkel announced that it

discovered new biodegradable additives and recently concluded a partnership with TECHNARO GmbH. Also this company recently completed a contract with Baska Company which produced, green Polyethylene used by TECHNARO GmbH in its material composition. The main advantages of materials based on lignin ("Liquid Wood") are as follow, [1]: processing with conventional machinery and equipment, high rigidity, high surface hardness, low thermal expansion, good water resistance, can be 100 percent renewable resources, without any synthetic plastics, high impact strength, processing with conventional machinery and equipment. All of these materials could be used in several activities are, such as: furniture industry: handles, fittings, front panels, chairs. Construction: slab materials, junctions, toys industry: figurines, game pieces, automotive: ornaments, switches, paneling, electrical industry: connectors, switches, housings, computers industry, TV, mobile phone housing, etc. Concerning the composition can be point out that Arboblend [1], contains different biopolymers like e.g. Polyhydroxialkanoate, Polyester, Ingeo TM, Lignin, Starch, Cellulose, organic additives, natural resins or waxes and natural reinforcing fibers, depending on the application.

2. Theory

The flexural test measures the force required to bend a beam under three point loading conditions. The data is often used to select materials for parts that will support loads without flexing. Flexural modulus is used as an indication of a material's stiffness when flexed.
The general scheme of flexural test used is shown in figure 1, [6] .

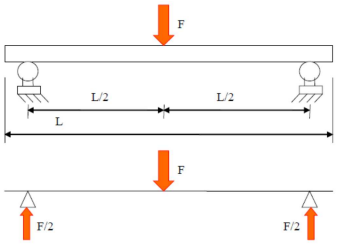

Fig. 1. The general scheme of flexural test

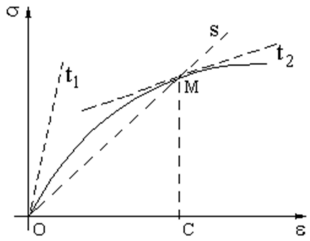

Fig. 2. Defining the modulus of elasticity

The proportionality factor is called longitudinal elastic modulus (E-Young's modulus), the main feature relating to stiffness of the material. Young's modulus is a measurement of the stiffness of an elastic and isotropic material. It is defined as the report of axial tension and axial deformation in the validity of Hooke's Law. Between two identical parts equally loading, the most will become deformed that material whose modulus of elasticity is smaller. It should be noted that only two groups of materials - steel and wood - respect practically Hooke's law, others having curvilinears diagrams $\sigma(\varepsilon)$ for its entire length, usually without discontinuities rupture.

In these cases could be defined (Figure 2) a conventional elastic modulus of the material as tangent and secant types, [3].

For the calculation of the average value of elasticity modulus E_m is used the relation (1), (SR-EN408: 2004), [5]:

$$E_m=[al_1^2(F_2-F_1)]/[16I(w_2-w_1)] \quad (1)$$

where: a is arm force [mm]; l_1 is the distance between points of forces action [mm]; $\Delta F=F_2-F_1$ represents the evolution of the linear force of deformation graph; $I=bh^3/12$ is the moment of inertia of the section [mm^4] and $\Delta w=w_2-w_1$ represents the deformation according to ΔF variation.

3. Results and discussion

The flexural tests were made on the machine WDW 50E model. The movement speed of the sleeper was 2 [mm/min] and is equivalent to the variation of beam deflection. Tests were made according ISO 178, [4], specimens having dimensions 80x10x4 [mm]. Inside the experimental research has been considered three specimens of each material. The Figure 3 presents the flexural test for Arboblend material. In this case the maximum arrow is 5.44 [mm] and deflection angle is 11^o. It is recorded a decrease of maximum arrow and deflection angle once the material hardness is increasing.

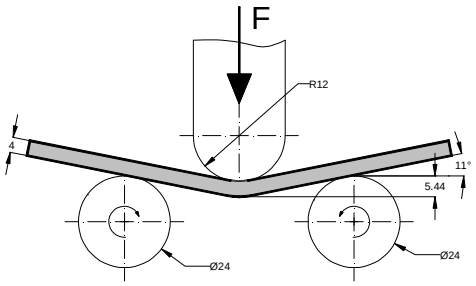

Fig.3. Flexural scheme for Arboblend

Analyzing the loads-deformations diagrams, presented in the Fig. 4, can be note that was obtained the highest values of the deformations with the lowest scattering field with the values between 7,8 to 10 [mm]. In terms of bending deflection, Fig. 5 shows the ranking of Arboblend and Arbpform materials at average maximum load values. Arboblend is situated on the first place followed by Arboform.

Modulus of elasticity can be determined after tensile testing but also after the flexural testing. In this case the Fig. 6 presents the calculation of elasticity modulus after flexural test. Three specimens were used for each material. For this material was obtained the highest values of the modulus of elasticity, so the most rigid material. The values of the elasticity modulus obtained have been compared with some values belonging to plastics [2]. Thus this material, liquid wood, can replace a few plastics materials such as: PA 66 (Polyamide): 2830MPa; PA11 (Polyamide): 3200MPa; POM (Acetal Homopolymer): 2620 MPa; PE-HD (High Density Polyethylene):1400MPa; PVDF (Poly Vinylidene Fluoride): 2000MPa; ECTFE (Etylene Copolymer): 1700MPa, in case of required is for greater stiffness of material. In the other situation when require is for low stiffness, the liquid wood can replace the following plastics: PA 66SF20 (Polyamide black with 20% aramide fiber)-4800MPa; PEEK GF 30 (Poly Ether Ether Ketone with 30% Glass Fiber)-9200MPa; PEEK CF 30 (Poly Ether Ether Ketone with 30% Carbon Fiber)-18800 MPa; PEK (Poly Ether Ketone with 10% glass fiber, 10% graphite and 10% PTFE)-11500MPa; PAI (Polyamide Imide)-5000MPa; PPS GF 40 (Poly Phenylene Sulphide with 40% glass fiber)-13000MPa; PEI GF 30 (Poly Ether Imide with 30% glass fibre)-9000MPa; PVDF CF 20 (Poly Vinylidene Fluoride with 20% glass fiber)-6000MPa.

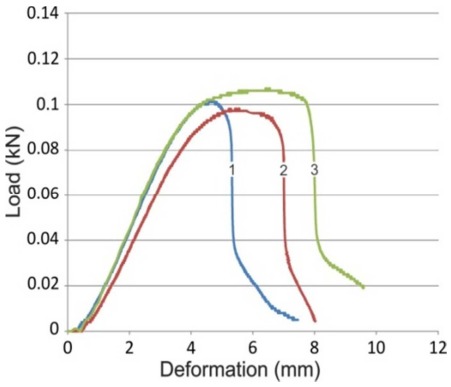

Fig. 4. Load-deformation diagram for Arboblend V2 Nature

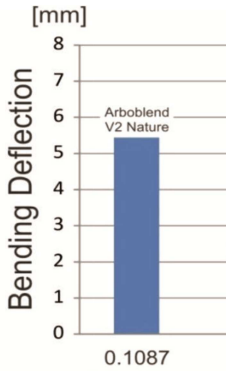

Fig.5. Bending deflection diagram

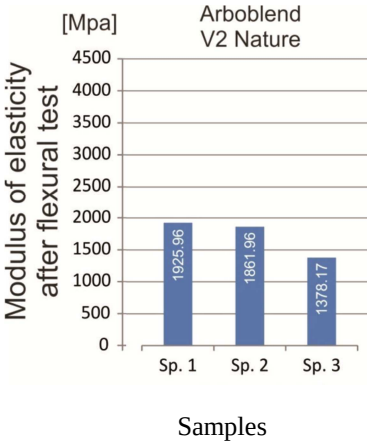

Fig.6. Modulus of elasticity after flexural test

4. Conclusions

The use of recycled materials has become an important problem in all activity fields. That's why the "liquid wood" is the material that could replace plastic materials in the near future. For this material was obtained the highest values of the deformation with the lowest scattering field and the value is between 7.8 to 10 [mm]. In terms of bending deflection at 0.1087 [kN] loading force was obtained 5.4mm. It was also determined the elasticity modulus after the flexural testing. The resulted conclusions after the calculation of elasticity modulus are confirmed by deflection angles that give the same hierarchical of material studied. Considering the results obtained this material can replace some plastics such as: Polyamide 66, Polyamide11, Acetal Homopolymer, High Density Polyethylene, Poly Vinylidene Fluoride, Etylene Copolymer in case the require if for greater stiffness of material. In the other situation when require is for low stiffness of parts the liquid wood can replace the following plastics: PA 66SF20, PEEK GF 30, PEEK CF 30, PEK, PAI, PPS GF 40, PEI GF 30, PVDF CF 20.

References

1. http://www.technaro.de/english/willkommen.htm?section=we
2. http://www.eplas.com.au/assets/125/files/msvc.pdf
3. http://www.mec.tuiasi.ro/rm/incercari/5.htm
4. Flexural Properties, ASTMD790, ISO 178.
5. Giurgiu, M., Cismaru, I., Studiu comparativ privind comportamentul la solicitari mecanice ale grinzilor din lamele incleiate din lemn de molid, pin si duglas (Comparative study on mechanical behavior of beams glued strips of spruce, pine and Douglas), online ISSN 2069-7430, Vol. 7, No. 3, www.proligno.ro, pp. 18-28, 2011.

6.http://www.mec.tuiasi.ro/diverse/Mares_Rezistenta_materialelor_Lucrari_laborator_sectia_Inginerie_si_Management.pdf.