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INVESTIGATION OF PROPERTIES OF THERMOPLASTIC COMPOSITE LAYERS SUPPORTED BY ORGANIC AND INORGANIC MATERIALS

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Abstract: *In this study, laboratory type composite production device unit has been used. Acrylonitrile butadiene styrene (ABS) that is used often in packaging sector was used as matrix material in this study. Additive materials were glass bead, peapod and oak. Specimens were taken from the plates which were produced with and without additives. Tensile and hardness tests were performed on these specimens. As a result, influence of the additives, mixed in the same ratio in matrix material, on mechanical, thermal and physical properties of the plates were examined.*

Keywords: *Thermoform process, mold, composite, tensile test, organic additive.*

INTRODUCTION

Plastic materials are widely used in our daily life [Suhas Kulkarni, 2017]. The most popular usage area is food and packaing sector. There are lots of studies on packaging materials, used in food industry [Lineesh Punathil, Tanmay Basak,2016]. These works mostly focus on material's strength, formability, heat and moisture permeability, migration and biodegradability [AshaYabannavar, Richard Bartha,1993; Lisa E. Freed and oth. 1994]. There are a lot of plastic raw materials used in food packaging [Onur Ozcalik, FundaTihminlioglu, 2013, Yih-Ming Weng, Joseph H. Hotchkiss, 1993]. PE, PS, PP and ABS are commonly used polymers in this sector. ABS material is easily used in thermoforming processes due to its good thermal cahareteristics [H. C. Lau,S. N. Bhattacharya,G. J. Field, 2000 , Je Kyun Lee,Chris E. Scott,Terry L. Virkler 2002]. It is often used in forming process of packages because of it's controllable melting point. Plates, used in thermoforming process, are generally produced with extruders. In this manufacturing method, great amount of material is required and it is expensive.

Recent studies focus on influence of organic and inorganic additive materials on packaging materials' properties. Silicates, glass beads, herb fibers and various wood products are used as additive materials [Alireza Ashori, 2008, Ghaus M. Rizvi, Hamid Semeralul, 2008]. Mechanical, physical and thermal properties of composite materials composed with these additive materials are investigated.

In this study, a laboratory type thermoforming unit was designed and manufactured. One of the purposes was bringing this thermoforming unit to the laboratory. Besides, thermoforming parameters for Acrylonitrile Butadiene Styrene (ABS), used frequently in packaging sector, were determined experimentally. Forming temperatures, heater temperatures and heating time were the controlled parameters. A drying process was performed to dehumidify the additive materials. Then, mechanical, thermal and physical properties of manufactured composite plates were examined.

EXPOSITION

Materials and Methods

In this study, ABS plastic specimens from Terluran HI-10 grade were used. Mechanical properties for ABS are given in table 1.

Table 1. Some properties for Terluran HI-10

Rheological properties	**Standart**	**Value**
Melt Volume Rate 220°C/10 kg	ISO 1133	5.5 cm^3/10 min
Mechanical properties	**Standart**	**Value**
Izod notched impact strength 23°C	ISO 180A	36 kJ/m^2
Izod notched impact strength -30°C	ISO 180A	14 kJ/m^2
Charpy notched impact strength 23°C	ISO 179	35 kJ/m^2
Charpy notched impact strength -30°C	ISO 179	13 kJ/m^2
Charpy unnotched 23°C	ISO 179	No break
Charpy unnotched -30°C	ISO 179	140 kJ/m^2
Tensile stress at yield 23°C	ISO 527	38 MPa
Tensile strain at yield 23°C	ISO 527	2.8 (%)
Tensile modulus	ISO 527	1900 MPa
Nominal strain at break 23°C	ISO 527	9 (%)
Flexural strength	ISO 178	56 MPa
Hardness, ball indentation	ISO 2039-1	74 MPa
Thermal peoperties	**Standart**	**Value**
Vicat sortening temperature VST/B/50 (50°C/h, 50 N)	ISO 306	90 ^{0}C
Vicat sortening temperature VST/A/50 (50°C/h, 10 N)	ISO 306	103 ^{0}C
Coefficient of linear thermal expansion	ISO 11359	80-110 10^{-6}/°C
Thermal conductivity	DIN 52612-1	0.17 W/m.K

Peapod, oak flour and glass bead were used as additive materials. These materials were dried for 48 hours in a drying oven at 80^{o}C. Dried peapods and oak flours were shredded with 4 cutting blade shredder separately. Part dimensions were in the range between 0,1 mm and 4 mm. Density of the glass beads was 2,45 g/cm^3.

Specially designed moulds were used in the process. Plastic granules were placed in the moulds with and without additive materials. Electrical resistances were designed to be able to heat 150 mm x 150 mm plates. Plastic composite moulds are shown in figure 1.

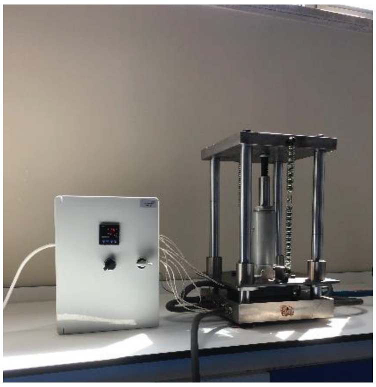

Figure 1. Plastic composite moulds

ABS plates, 1mm thick, were manufactured using both male and female moulds. Thicknesses of determinated points on plates were measured with vernier caliper with resolution of 0,01 mm. For each composite material three specimens were manufactured and their average hardness, tensile strength and thermal distribution were examined.

Temperature distribution of moulds was determined with thermal camera (Testo) and shown in figure 2. Forming temperature was determined experimentally. Heater temperature was adjusted to 197 ^{o}C and the selected/working pressure was 100 Pa. Estimated duration for heating was 5 minutes.

Manufacturing process and temperature distribution of moulds (temperature-distence) for specimen is shown in figure2.

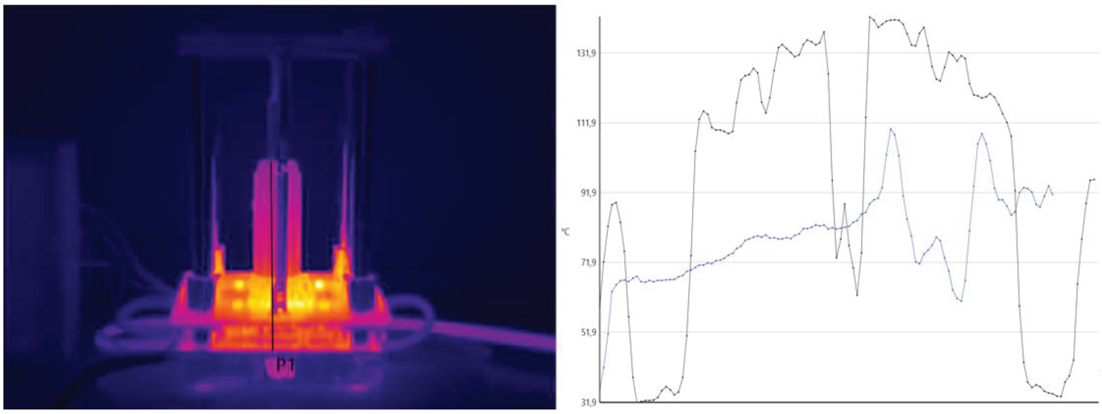

Fig. 2. Processing of experimental samples and temperature distribution of moulds

During the manufacturing process, additive materials' weight ratio in composite material was selected as 10%. These additive materials were mixed up with ABS and blended about 2 minutes and then placed in the female mould. Before the mix up, peapod fibers and oak flour fibers were dehumidified for 24 hours at 90 ^{o}C. Specimens were processed for 5 minutes at 197^{o}C and 0,1 Pa. Manufactured plates are shown in figure 3.

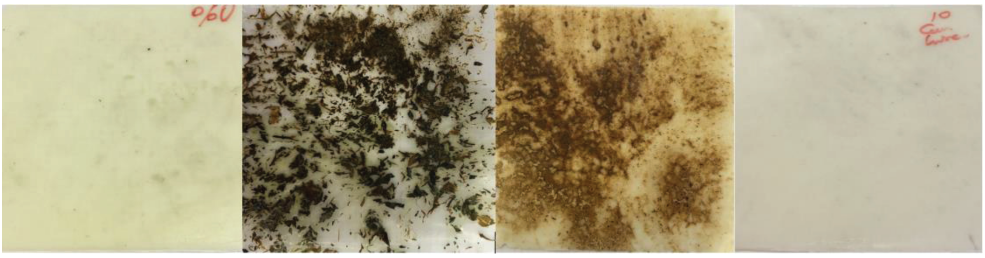

Fig. 3.Experimental sheet samples

Tensile test specimens were extracted from manufactured plates and tensile tests were performed at 5mm/min crosshead speed with universal tensile testing set-up which has 50 kN load cell. Pre-load is selected as 16 N. Tensile test specimens were manufactured according to ASTM D 638 standards.

The hardness test was taken from 10 different points over the tensile specimens. The device used in the hardness test is given in figure 4.

Fig. 4. Hardness tester

Results and Discussion

Average hardness measurements were done on 10 different points. Hardness values are presented in table 2 and figure 5.

Table 2. Hardness value of test sampels

Hardness Values (Shore D)			
PURE ABS	**10% PEAPOD**	**10% OAK FLOUR**	**10% GLASS BEAD**
65	64,5	59	70
65,5	63,5	58,5	68
63,5	62	78	69
65	68	76	71
66,5	54,5	65	67
61,5	60	57	69,5
62,5	63,5	57,5	67,4
63,5	57,2	62	68,2
67,5	59,3	64	71
68	56	58,2	69,4
64,85	**60,85**	**63,52**	**69,05**

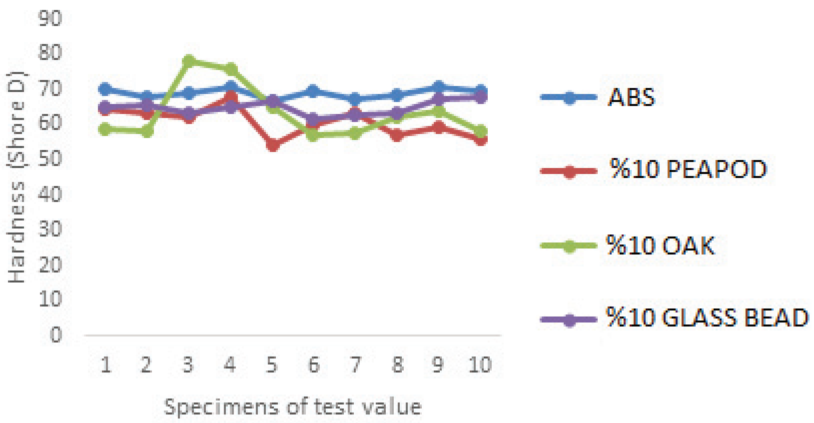

Fig. 5. Hardness value of test sampels

Stress-Strain diagram for the specimens are presented in figure 5. Stress-Strain diagrams show that test specimens without additive materials is a result of the weak interface bonds between matrix material and additive materials. It could be seen from the specimens' appearance after tests that rupture occurs in places where additive materials' weight ratio is greater.

The hardness test demonstrates that the hardest composite material is ABS with glass beads, i.e. the material with lower strength. That behaviour of ABS with glass beads is defined by the high hardness of glass beads and by their brittle structure.

The interface bonds between ABS and peapod and oak flour, used as additive materials, are weak because of morphological factors. That determines the low strenght values of ABS with peapod and oak flour, as it is evident from figure 6.

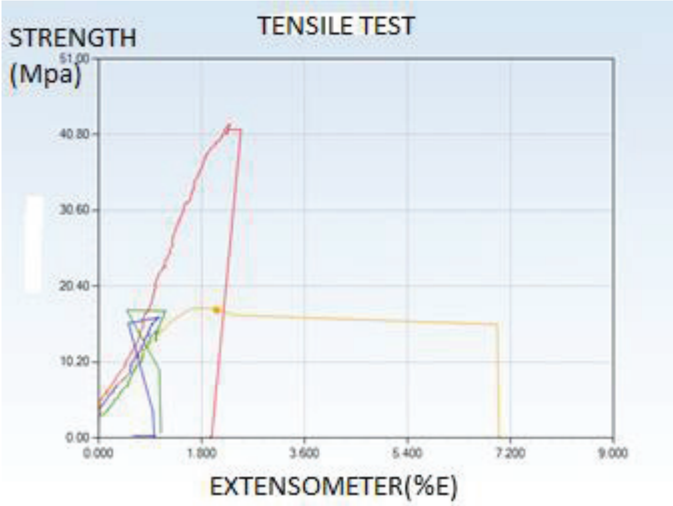

Fig. 6. Tensile strength of test specimens

CONCLUSION

1. Glass beads, peapod and oak flours, used as additive materials in ABS production have negative influence on the strenght – these additive materials reduce the strenght of ABS more than twice.
2. The hardness of the produced composite materials is higher than that of the pure ABS. The specimens, reinforced with inorganic material, namely glass beads, demonstrate higher hardness.
3. The produced specimens with additive materials are appropiate for working conditions that do not involve tensile loads but require high hardness.

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