THE POSSIBILITY OF USING RECYCLED POLYPROPYLENE SUPOL HT345E

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Exploitation of plastic waste is current issue in part of recycling in this present. Current recycling appears possibility of manufacturing of composite materials WPC (woodplastic composite). While a few decades ago as a plastic matrix used thermosets, currently often is using thermoplastics. The reason among other things is also able recycling these composite materials. The most common example exploitation of plastics is currently PVC, PE and PP. Application of construction thermoplastics (PA, POM, PET) is limited with increased processing temperature, at which there is a degradation of lignin in the wood. The problem of exploitation of thermoplasts in comparison with thermosets is high viscosity of thermoplastic melt and decrease of wettability whit wood sawdust. For this reason is increasing of attention for determine of maximum quantity of filler wooden components.

KEYWORDS

extruder, polypropylene, wood sawdust, particles

1 INTRODUCTION

The paper summarizes partial results of R&D at the Faculty of Mechanical Engineering in Bratislava in the field of wood-plastic composites. Research is done in close cooperation of the two institutes: Department of Technology and Materials and Department of manufacturing systems, environmental technology and quality managment Institutes have the necessary instrumentation and machinery: crusher, dryer, sieves, extruders, shredders, and so on.

Figure 1. Extruder EB 30

2 CHARACTERISTIC OF EXPERIMENTAL MATERIAL

As an experimental material was used composite material in which the binder phase is polypropylene and the filler phase is wood waste. Polypropylene was obtained primary recycling, more particularly milling a gating systems.

The Supol HT345E is used in manufacturing of automotive interior components. It is copolymer of polypropylene with ethylene and with additive of talc. It has good resistance against UV radiation, it is suitable for injection molding technology and it is characterized by good impact resistance [Maier 1998].

The basic properties are shown in Tab. 1, which indicates significant melt flow rate, which corresponding to plastic materials that suitable for injection molding. The suitable plastic materials for extrusion are plastic materials with melt flow rate lower than 10g/10min [Bledzki 2004].

Figure 2. Sieves Retsch AS200 digit Figure 3. Dryer BINDER ED 23

Properties	Value	Unit
Density	0,95 – 1,35	[g/cm³]
Modulus of elasticity	2000	[MPa]
Melt flow rate	26	[g/10min]
Ignition temperature	> 400	[°C]
Decomposition temperature	> 300	[°C]
Form	granulate	[-]
Color	different	[-]
Solubility in water	insoluble	[-]

Table 1. Basic properties of PP - Supol HT345E

The basic mechanical properties such as strength, ductility and hardness, were obtained on solver workplace and these are shown in Tab. 2 [Kozak 2015].

Properties	Value	Unit
Strength	25,7	[MPa]
Ductility	7,77	[%]
Hardness	47,6	[Shore D]

Table 2. Basic mechanical properties of PP - Supol HT345E

The measured values of strength are in comparison with literary sources are almost the same. The small dimensions are probably caused by different amount of talc.

The wood waste is from spruce and it is characterized by relatively wide range of dimension fractions. The dimensions and shape of wood elements was very uneven, therefore there are sifted 4 fractions at preparation of composite material of the woodplastic. It was found that the smallest fractions showed the most uniform specific surface areas of the particles. Particles of experimental fractions were elongated shape. However, they can not be characterized as one-dimensional, because the value of the thickness and width is not differ. The basic properties of spruce are shown in Tab. 3 [Klement 2015].

Properties	Parallel to the grain		Across to fibers	
	w = 12%	w > 30%	w = 12%	w = > 30%
Tensile strength	90	-	2,7	2
Compressive strength	50	19	4	-
Shear strength	6,7	4,3	-	-
Flexural strength	78	44	-	-
Young's modulus	14960	-	550	-
Compressive modulus	13650	-	290	-
Shear modulus	573	-	-	-
Flexural modulus	11000	8600	-	-
Brinell hardness	32	-	12	-
Toughness	-	-	4,6	-

Table 3. Basic properties of spruce

3 EXPERIMENT METHODOLOGY

Sorting of the starting particles was performed on the sieving device Retsch AS200 digit (Fig. 2), at sieving was used a sieve with mesh sizes 0,5 mm, 1 mm, 2 mm and 4 mm.

The measuring device monitored dimensions of individual fractions after sawdust have been sorted and then was intended their specific surface and volume. Relatively small diffusion of values was registered at smallest fractions 1 and 2. On base of shape and dimensions of nozzle of twin screw extruder EB30 (Fig. 1), the fraction number 2 was identified as most suitable and it was used at next experiments.

For investigation of necessary amount of polypropylene for sheathing sawdust at process of processing, there was calculation by the thickness of minimal binder layer that was selected as 10 μm.

Average value of particles:

(a = length, b = width, c = thickness of the particles)

a = 1,9 mm

b = 0,9 mm

c = 0,5 mm

The surface of one particle:

$$P_{č} = 2 \times (a \times b + b \times c + a \times c) = 6{,}22\, mm^2 = 622 \times 10^{-4}\, cm^2 \qquad (1)$$

The volume of one particle:

$$V_{č} = a \times b \times c = 0{,}855\ mm^3 = 855 \times 10^{-6}\, cm^3 \qquad (2)$$

The weight of one particles:

$$G_{č} = \rho_{č} \times V_{č} = 0{,}5 \frac{g}{cm^3} \times 855 \times 10^{-6}\, cm^3 = 427{,}5 \times 10^{-6}\, g \qquad (3)$$

In one gram of the powder is:

$$n = \frac{1}{427{,}5 \times 10^{-6}\, g} = 2339 \text{ particles} \qquad (4)$$

The total surface of the particles:

$$S_{č} = n \times P_{č} = 2339 \times 622 \times 10^{-4}\, cm^2 = 145{,}48\, cm^2 \qquad (5)$$

To create a binder layer on each particle of thickness h = 10 μm in 12g sawdust is necessary

Volume of Polypropylene (PP):

$$V_{PP} = S_{č} \times h = 145{,}48\, cm^2 \times 0{,}001 cm = 1{,}38\, cm^3 \text{ binder} \qquad (6)$$

Weight of binder // on 1g powder is:

$$G_{PP} = \rho_{PP} \times V_{PP} = 0{,}95 \frac{g}{cm^3} \times 1{,}38\, cm^3 = 1{,}31\, g \qquad (7)$$

One gram of wood sawdust with layer PP 10 μm has weight 2,31 g.

There was further determined ratio of polypropylene and wood sawdust at single mixture intended for processing.

Followed drying sawdust, that was necessary for decreasing of moisture, that could cause problems during extrusion [Najafi 2007]. The sawdust dried into a hot air dryer to maximum moisture of 2%.

After drying sawdust there were prepared individual weight of each component and followed by processing. Homogenizing of mixtures was carried out directly in the extruder. Four types of mixtures have been pushed out with different ratios of components. While one dose had weight of 1000 g. The first mixture contained the amount of polypropylene that were calculated for necessary layer to sheathing the wood sawdust with a thickness of 10 mm, in the second mixture there was added 30% more of polypropylene, in the third there was added 50% more of polypropylene and in the last one there was 20% less of polypropylene than in a mixture with calculated layer.

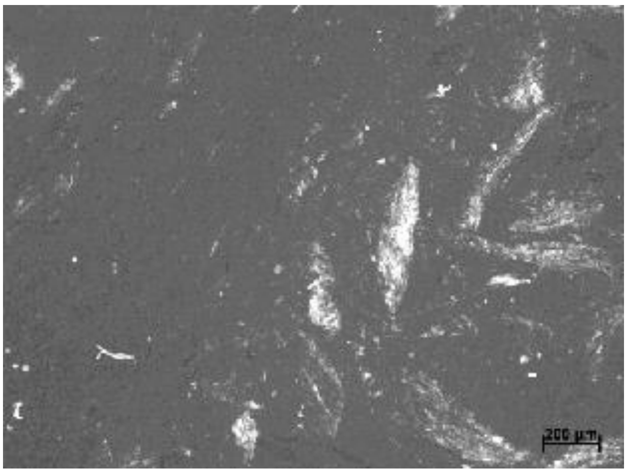

Figure 4. Mixture with 50% PP, transverse section

Pushed samples were prepared for mechanical grinding. The samples from each type of material were monitored in transverse and longitudinal direction. The structure of each

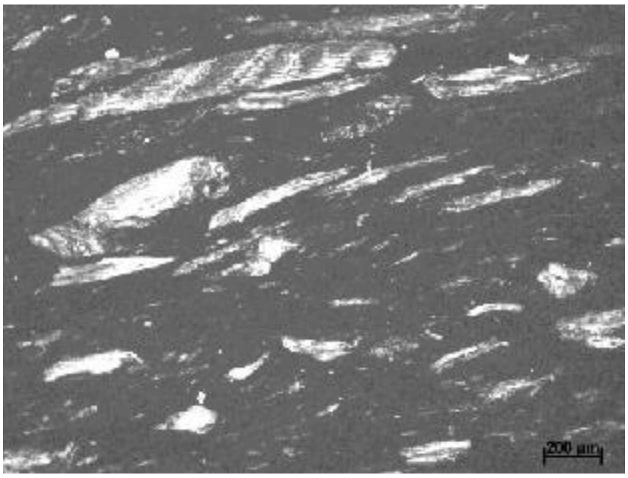

Figure 5. Mixture with 50% PP, longitudinal section

sample was monitored by optical microscopy, while concentrated primarily on the monitoring of orientation of wood particles and their sheathing of polypropylene.

From the Fig. 4 and Fig. 5, there is visible that the composition material with lowest contents of sawdust is uneven distribution of sawdust in the transverse (Figure 4) and also in the longitudinal direction (Fig. 5). There were not pores in the structure. The orientation of wood sawdust is obvious from Figure 5.

The structure of materials with 30% more of content polypropylene in comparison by the calculated amount is obvious in Fig. 6. (transverse direction) and in Fig. 7. in longitudinal direction. The orientation of greater part of wood particles in the pushed direction is obvious again. The amount of polypropylene was again enough to sheathing wood particles. The structure of composite with contents of PP increased 30% is without pores similary like the structure of composite with contents of PP 50% more.

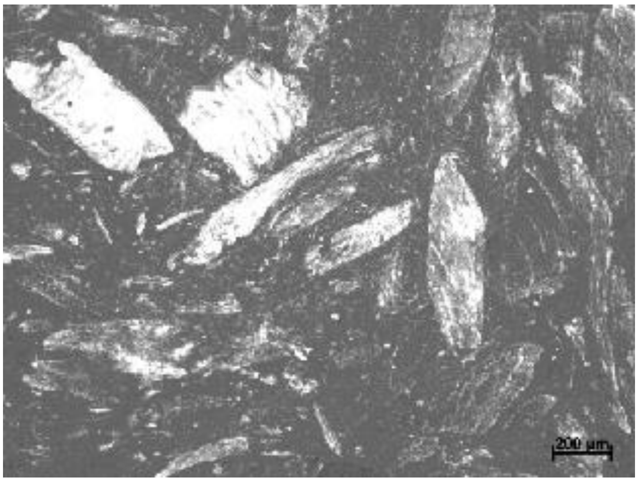

Figure 6. Mixture with 30% PP, transverse section

The structure of composites with the calculated amount of binder phase is shown in Figure 8 (transverse section) and Figure 9 (longitudinal section). In comparison to composites with inceased of amount PP, there are pores in the structure, that indicating impaired of fluidity due to the small amount of binder phase.

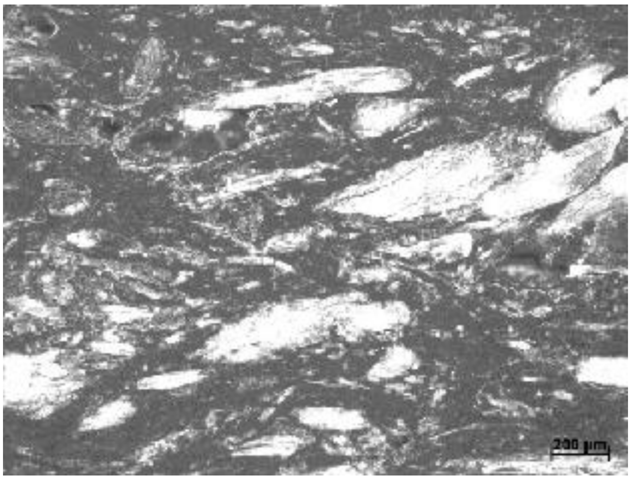

Figure 7. Mixture with 30% PP, longitudinal section

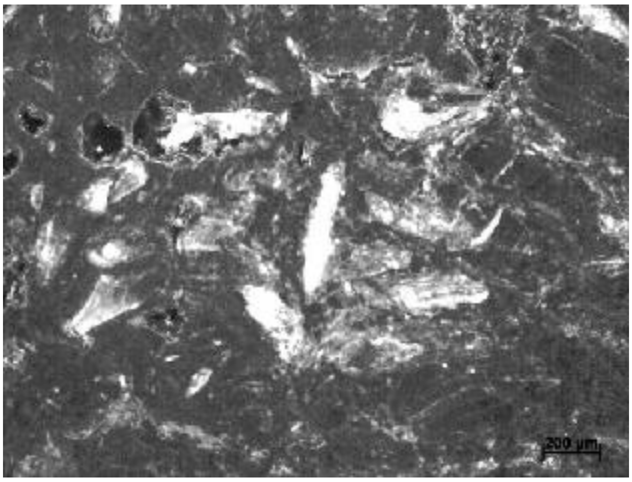

Figure 8. Mixture with calculated amount of PP, transverse section

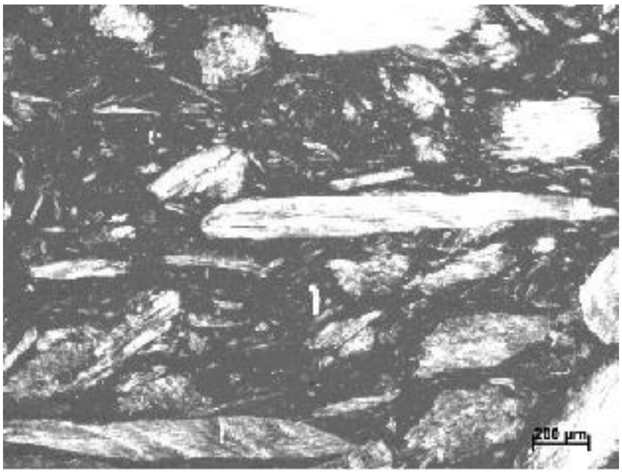

Figure 9. Mixture with calculated amount of PP, longitudinal section

In addition to monitoring of structure were carried out hardness tests Shore D and tests of absorbability where the samples were wetted in water during 50 hours. The aim of monitoring of absorbability was assess the function of non-absorbability plastic "coat" as barrier for moistening of wood particles.

4 SUMMARY OF ACHIEVEMENTS

Size and shape spruce wood particles were very uneven, so for the preparation of a composite material were culled 4 fractions. It was found that the smallest fraction - the fraction smaller than 0,5 mm and a fraction of between 0,5 and 1 mm have the most even surface areas of the particles, of course, with the highest value. Based on the dimensions of the nozzle to the twin screw extruder used for preparing wood plastic composite material was selected fraction in the range 0,5 to 1 mm.

Calculation to ensure sufficient sheathing the wood particles was conducted in accordance with the minimum thickness of the binder layer for 10 μm polypropylene layer [Mirowski 2010]. Calculation was found that 1 g of wood sawdust sheathing with a layer of polypropylene has given a weight of 2,31 g.

Wood sawdust be dried before processing in a hot air dryer, thereby reducing moisture from 7,6 to 1,73 %. Please note, however that the moisture is a surface moisture and no a volume moisture. More efficient drying can be expected as in a vacuum dryer.

A plastic share for preparing wood plastic composites was copolymer polypropylene. This material is convenient for processing by injection technology. For processing by injection technology is corresponding to a melt flow index of 26 g / 10 min. Wood plastic samples were prepared in twin screw extruder, which allows intensive mixing of plastic and wood participles. On the one side, the relatively high melt flow index is good supposition for the leak of plastic flow between the wood particles, but on the other side is too high for extrusion technology. For extrusion technology are recommended plastic materials with melt flow index lower than 10 g/10 min. For this reason arose problems with the shapes and continuity of extruded materials.

The calculated volume of plastic in the starting mixture with 10 μm thick sheathing layer has proved to be boundary. In the structure were pores and the insufficient sheathing wood particles with non-absorbent polypropylene showed an increase in absorbability properties of wood composite. When the amount of polypropylene is 30% more than was in the starting mixture the non-absorbability is about 2% by further increasing the amount of polypropylene to 50% more the non-absorbability has decreased by half. The resulting value of non-absorbability (1,17 %) is negligible.

Increasing the amount of plastic phase was reflected in a slight increase hardness. Increasing the amount of polypropylene by 30 % led to the hardness higher by 1,14 % and increasing the amount of polypropylene by 50% led to the hardness higher by 12,12 %.

CONCLUSION

The project aim was prepared composite material on wood plastic basis. The binder phase is formed by polypropylene and the wood phase is formed by spruce sawdust. Samples were prepared on a twin screw extruder device. The starting composition of the mixture was determined by calculating in order to ensure sheathing the wood particles with polypropylene. The aim was prepared non-absorbability wood plastic compisite. At the calculation of amount of the binder phase were taken into account dimensions wood parts, which were dimensions that match the size of the extrusion nozzle. The experiments confirmed that the calculated amount of plastic was not enough for sheathing wood sawdust because the material was porous. Increasing the amount of polypropylene by 30 % led to absorption of moisture at approximately 2 % and the overall increase of plastic phase by 50 % eliminated practically the moisture absorption.

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