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SHORT COMMUNICATION – KRATKO SAOPŠTENJE

WOOD PLASTIC COMPOSITES: TECHNOLOGIES

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ABSTRACT

Current trends in the field of ecology encourage manufacturers to create materials that are environmentally acceptable, but also customer have requirements on the properties of the applied materials and their durability. In the fact of this reason, in some branches of industry (flour / automotive / construction) are created "Green materials", created by combining a plastic matrix (mostly PP, PE, PVC) and natural fibers. One of these materials are the Wood Plastic Composites (WPC) materials – wood-filled plastics (as an alternative solution). The WPC components (matrix + reinforcement + additives) are mixed under the influence of hight temperature into a mixture followed by a forming step. Forming technologies suitable for WPC products include extrusion, injection molding and calendring. The presented paper is focused on the possibilities of WPC profile forming technologies. This research was supported by grant KEGA 030TUKE-4/2018.

Key words: Wood Plastic Composites, natural fibers, technologies.

INTRODUCTION

From the 90s of the 20th century, professional work began, and technologists paid increased attention to applications of natural fibers (lignocellulosic, mineral, and animal) to the automotive, construction, flooring industry. Natural fibers can replace synthetic/glass fibers in plastic matrices (PE, PVC, PP, epoxy) based on three attributes:

- reduction of input raw material costs, shorter production cycles of composite materials, lower material weights,
- identical/similar mechanical properties (compared to glass fiber reinforced components), good dimensional stability and sound insulation,
- recyclability of primary raw materials, non-toxicity, CO_2 neutrality (carbon neutrality means achieving a balance between carbon emissions and their absorption from the atmosphere into carbon interceptor) (Campilho, 2016).

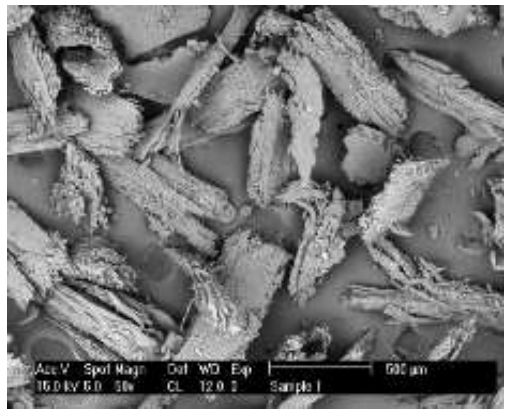


Figure 1. Scanning electron microscope image of sawdust (Atuanya and Ibhadode, 2011)

In the commercial processing of WPC materials, there have applied wood flours from softwood and hardwood, plant fibers and different types of starches. We are talking about lignocellulosic fibers in the case of the mentioned materials. Many scientific studies point to the possibility of using waste from the agricultural industry – as an alternative to wood flour, in achieving similar properties of the WPC product (more than 95% of WPC products originating in China made of agro-waste) - see. Tab. 1 and Fig. 1 (wood sawdust). It is possible to use recycled paper (e.g. newsprint) with the addition of modifiers as a source of cellulose fibers (Chen et al., 2016, English et al., 1997).

Table1. Example of waste utilization and study from agricultural production in WPC products

Material of reinforcement	Matrix	Study / Reference
Wheat stalks	Polypropylene	Hornsby et al., 1997
Coconut shells	Polypropylene	Bledzki et al., 2010
Rice husks	High density polyethylene	Yao et al., 2008
Corn stalks	High density polyethylene	Panthapulakkal et al., 2007
Olive stones	Polyethylene	La Mantina et al., 2004

MANUFACTURING TECHNOLOGIES

Frequent manufacturing technologies of WPC materials include extrusion – for linear profiles, injection molding – for 3D components of regular and irregular shapes; for the production of flooring, it is possible to apply the little-mentioned method of calendaring – rolling (calendering). Before the extrusion/injection molding process itself, it is necessary to ensure the stages of the process – see Fig. 2 (Niska and Sain, 2008).

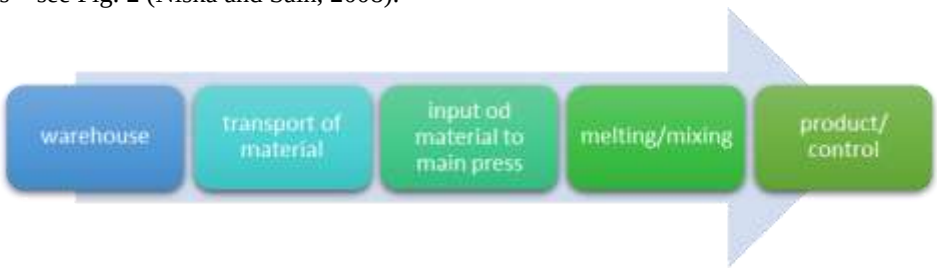


Figure 2. Stages of manufacturing process (storage – silo, big-bags/transport of material – pneumatic, mechanical system of transport/input material to main press – continuously, discontinus loading of press/ melting / mixing) (Niska and Sain, 2008)

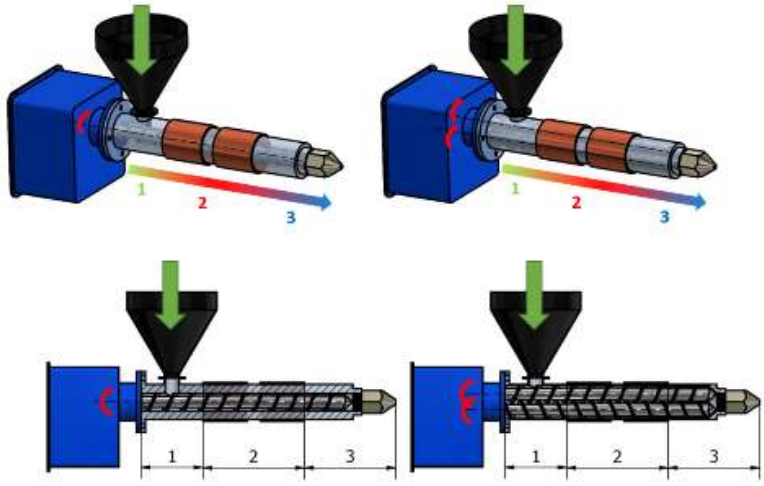
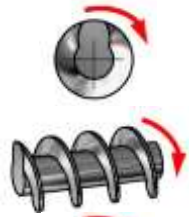
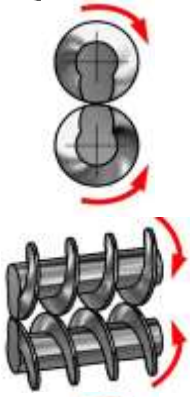


Figure 3. Extruders – single screw extruders, double screw-extruders

The primary task of the extruder is to melt the polymer, mix the individual components and allow the mixture to be transported into the matrix (extrusion phase of the final product). Four types of extruders (presses) have used in the production of WPC profiles: single-screw press, double-screw press with co-engaging / counter-engaging screws (Fig. 3) and WoodtruderTM. Individual types of presses describe Tab. 2.

Table 2. Type of press machines – advantages/disadvantages (Niska and Sain, 2008; Gardner et al., 2015)

Type of press machines – description	Advantages	Disadvantages	Graphical interpretation
One roll press machine – designed in 1935, primarily for thermoplastics, the ratio of length mainly to ratio $\frac{L}{d} = \frac{34}{1}$	Low invsetment costs, ceretified manufacturing technologies	Necessary mixture drying system, premixing of the mixture (production of pellets)	
Two roll press machine the first type – especially for WPC products with PVC matrices	Low speed	Necessary mixture drying system, premixing of the mixture, higher purchase price (compared to a one roll press machine)	
Two roll press machine the second type – designed in 1953 by CoperionWerner & Pfleiderer	Variable drive	Higher purchase price (comparison to first type of machine)	
Woodtruder™ – ration $\frac{L}{d} = \frac{28}{1}$ + one roll press machine + control + press tool + tank with cooland + saw + table for fluid drainage	It is not necessary to pre-prepare the material by drying (moisture is removed by a vacuum deaeration mechanism) and premixing	Purchase price	–

The key to the successful production of a WPC product is a perfect dispersion – dispersion of the wood component in the plastic matrix. To create a homogeneous mixture, the screw mechanism of an extruder usually uses directly if it is necessary to premix the mixture, thermokinetic mixers are applied in bulk. Tensions arise on the surface and the screw, allowing the material to be pushed through the die. The speed of movement of the material is directly proportional to the friction force, the diameter of the screw and the rotational speed of the screw. The increasing L / d ratio of the screw requires considerable energy inputs, which results in disproportionate temperature increases (possible decomposition of components – wood/polymer) – this phenomenon is characteristic of single-screw presses. Possibility to minimize this undesirable phenomenon – by applying twin-screw mechanisms with co-screws/Woodtruders (the residence time of the mixture in the main press is shorter, the decrease in time is due to increased movement speed, which is eliminated by eliminating backpressure energy efficiency). Production of granulate (pellets) – is similar to the production of WPC profile – the first step of the production process is mixing wood flour and plastic matrix (with the addition of additives), components are fed to the main press by separate dosing devices (plastic melting and mixing press machine). In the final stage of production, the fiber is extruded through the die of the press. It is then cooled in a water bath and divided into granules. Before use, the granules are freed of excess moisture (drying phase).

CONCLUSIONS

There is a need to increase the lifetime of conventional renewable materials. In the production of processing wood-filled plastics itself, it uses the obtained wood flour as a secondary product in the furniture production. To a limited extent, it is possible to use recycled plastics (as a substitute for virgin plastic). The waste is not generated during the production of profiles – extrusion or injection molding technology. In this process, there is no need to use formaldehyde or volatile, harmful substances. In addition to the input parameters of the process, the main aspect of the production technology is also a dispersion of components – it can be obtained by additives or a suitable design of press machine.

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