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FLAT HOT-PRESSING TECHNOLOGY FOR THE PRODUCTION OF WOOD PLASTIC COMPOSITE

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Abstract. Wood plastic composites (WPCs) are advanced and promising materials that combine the advantageous properties of both wood and polymers. They are characterized by excellent performance, including high mechanical strength, dimensional stability, resistance to moisture and biological degradation, and improved durability under variable environmental conditions. The possibility of utilizing recycled raw materials such as wood waste and thermoplastic polymers in WPCs is also considered an environmentally sustainable alternative to conventional wood-based panels. WPCs can be manufactured using a variety of processes, including extrusion, injection molding, and compression molding, depending on the intended geometry and application of the final product. WPCs are usually made by extrusion. This method allows for the production of products with unlimited length and a small cross-section. However, it is unsuitable for the manufacturing of large flat composite boards. Flat pressing is a promising method for making WPC boards. However, this method is still underdeveloped in WPCs production and requires further research.

Key words: wood plastic composites, flat pressing, polymer, wood particles.

Introduction

In view of the global awareness of environmental challenges and the need to reduce waste accumulation as well as harmful emissions, the wood-based composite materials industry is increasingly implementing more environmentally friendly and sustainable alternatives. One effective approach of addressing these issues is the production of wood plastic materials (WPCs) based on the utilization of recycled polymers and wood residues, which complies with the principles of the circular economy and is regarded as an environmentally safe technology [1-3]. Flat hot pressing is one of the most efficient methods for manufacturing WPCs. The main advantages of this method include the possibility of using wood fillers of various particle size fractions, which enables optimization of the internal structure and

properties of the products, as well as ensuring high forming accuracy and improved mechanical performance of the finished boards. The technology of flat pressed WPCs (FPWPCs) production is characterized by a high degree of technological similarity to particleboard and fiberboard (MDF/HDF) manufacturing processes, particularly at the stages of raw material preparation and mat formation. Specifically, similar raw materials can be used as fillers for, such as wood particles obtained from woodworking residues or from the targeted comminution of low-grade wood. This makes it possible to apply well-established and proven technological solutions. Accordingly, preparatory stages such as size reduction of wood to the required dimensions, fractionation (classification according to particle geometry), and drying to a specified moisture content are expediently carried out using process schemes adopted from particleboard production [4,5]. At the comminution stage, drum and disc chippers are employed to produce wood particles of standardized dimensions [6]. Subsequent fractionation is performed using screening or pneumatic classifiers, which allow the removal of excessively coarse or fine particles and optimization of the granulometric composition of the filler. Drying is carried out in drum or aerodynamic dryers, providing intensive moisture evaporation without overheating the wood particles [5]. The initial stages of the FPWPCs manufacturing process are therefore similar to conventional particleboard production; however, they exhibit certain specific features resulting from the nature of the interaction between wood and a thermoplastic matrix. The technological flow scheme for FPWPCs production is presented on Figure 1. The main stages of recycled polymer preparation include the following:

- **Collection and sorting.** At this stage, polymer waste is collected from various sources: household, commercial, and industrial, subsequently sorted by polymer type [7,8].

- **Preliminary cleaning.** The sorted polymers undergo preliminary cleaning to remove coarse contaminants such as labels, caps, food residues, and similar impurities [9].

- **Preliminary size reduction.** After cleaning, the polymers are shredded or

crushed in grinders or shredders to obtain small fragments (flakes). This facilitates further cleaning and processing of the material [7,10,11].

- **Fine cleaning and separation.** The shredded flakes undergo deep cleaning to remove mineral, organic, and metallic inclusions. Magnetic separators, automated cleaning lines, hydro-separation, and pneumatic separation systems are employed [7,8,12,13].

- **Fine grinding (pulverization).** At this stage, the cleaned flakes are ground into powder with a specified particle size. This form is convenient for subsequent use in the manufacture of new composite products [14,15].

- **Fractionation.** The resulting powder is classified into particle size fractions using sieves, vibratory separators, or air classifiers, enabling precise control of product quality in accordance with production requirements [16].

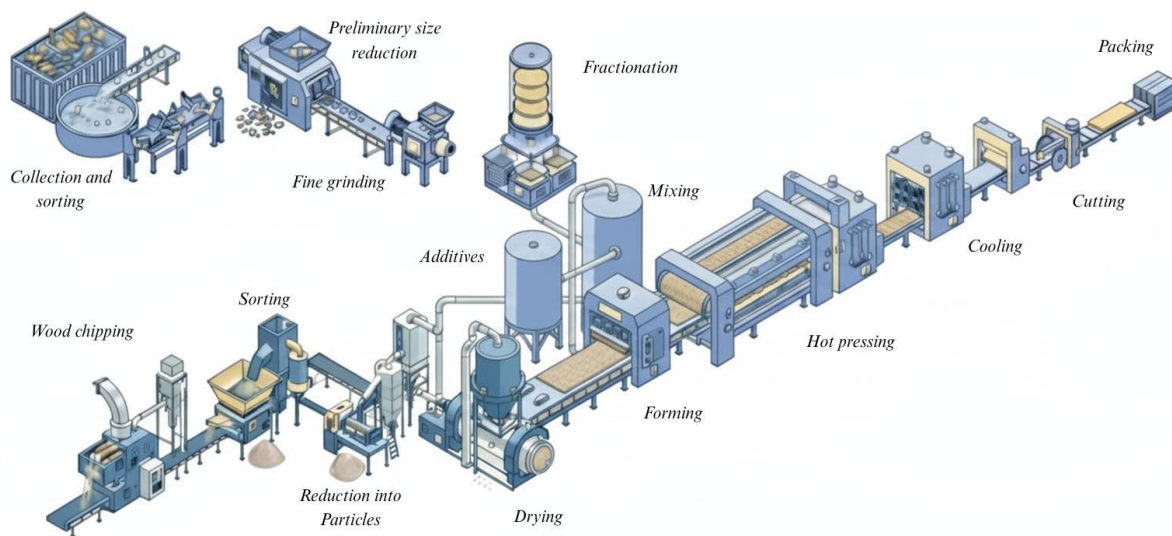


Figure 1 – Technological scheme for FPWPC manufacturing

The key technological difference between FPWPCs and particleboard production lies in the component mixing stage. It is at this stage that a uniform distribution of the polymer within the composite volume is achieved, which determines the quality of interfacial adhesion and, consequently, the physical and mechanical properties of the finished material. Unlike particleboard production, which employs liquid thermosetting synthetic resins, FPWPCs manufacturing uses a

thermoplastic polymer in solid form, requiring specific approaches to the mixing process.

The wood/polymer mixture is blended in a dry state using high-speed mixers [17]. In this process, the polymer is fed into the mixer in powder form, while the comminuted wood particles are introduced as chips with a moisture content not exceeding 3%. Mixing is carried out through intensive mechanical and turbulent action, ensuring uniform distribution of the polymer throughout the wood mass. Various modifying additives are introduced into the wood/polymer composition, including technical paraffin [18]. For the implementation of the dry mixing method, high-speed paddle mixers are most commonly used, in which intensive mixing is achieved by blade rotation at speeds of 800–1000 rpm [19,20]. Such equipment enables the production of a homogeneous mixture within a short processing time (2–5 minutes).

Hot pressing is the determining stage of the technological process for manufacturing wood-based composite materials [4,5]. The formed mat, which at the preceding stages represents a loose composite mixture of wood particles of various size fractions and polymer powder, is transformed during hot pressing into a monolithic, consolidated material. Under elevated temperature conditions, the polymer component transitions into a highly elastic or molten state, acquiring flowability and the ability to wet the surface of wood particles [21]. The simultaneous application of high pressure ensures intensive densification of the loose mass, elimination of interparticle voids, and the formation of intimate contact between the components of the composite. Consequently, at the hot-pressing stage, such key parameters of the finished material as density, internal structural homogeneity, physical and mechanical properties, and service performance are determined [21].

The hot-pressing durability of FPWPCs under pressure during hot pressing depends on their thickness, target density, initial surface temperature, and wood particle content, polymer type and other factors. In particular, the duration of hot pressing can be calculated using a developed and validated mathematical model [21].

After completion of the hot-pressing stage, when the formed mat is converted

into a monolithic board with the required geometric parameters and density, ensuring the stability of the obtained structure becomes essential. At this point, the polymer matrix remains in a molten or highly elastic state, and the internal stress–strain state of the material is still unbalanced. Therefore, the next critical operation of the production cycle is cooling, which constitutes the final stage of the hot-pressing process and is crucial for stabilizing the structure and properties of FPWPCs [22]. It is during this stage that the polymer phase transitions into a solid state (crystalline or amorphous), resulting in the fixation of internal bonds within the composite.

Controlled temperature reduction ensures the geometric stability of the product and prevents the development of residual stresses, cracking, and warping, thereby determining the final quality and reliability of wood–polymer boards [22]. The durability time of FPWPCs under pressure during the cooling stage is determined by their thickness, target density, initial surface temperature, and wood particle content, polymer type and other factors. The cooling duration can be calculated using a developed mathematical cooling model [22].

After cooling and conditioning, the FPWPCs are transferred to the mechanical processing section, where operations are carried out using equipment and processing regimes conventional for particleboard and fiberboard production.

Summary and conclusions.

The technological process of flat pressed wood plastic composites manufacturing is largely similar to the production processes of particleboard and fiberboard. However, the introduction of thermoplastic polymers and their recycled parts into the composite formulation, instead of thermosetting resins, leads to significant changes in the technology and necessitates the use of different types of production equipment. These differences are most pronounced at the stages of component mixing, composite mat formation, and hot pressing. An additional operation specific to the use of thermoplastic polymers in wood-based composite production is cooling under pressure, which differs substantially from the cooling of particleboard, where fan-type cooling equipment is typically employed. The incorporation of thermoplastic polymers also results in modifications to hot-pressing

regimes, particularly with respect to processing temperature and duration under pressure.

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DETERMINATION OF THE FIELDS OF APPLICATION OF COMPOSITIONS BASED ON NATURAL RUBBER LATEX

ВИЗНАЧЕННЯ СФЕР ЗАСТОСУВАННЯ КОМПОЗИЦІЙ НА ОСНОВІ ЛАТЕКСІВ НАТУРАЛЬНОГО КАУЧКУ

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Анотація. В роботі розглядаються сфери застосування латексів натурального каучуку у промисловості для створення композиційних матеріалів, покриттів та адгезійних з'єднань. Недоліком латексів на основі цього каучуку є низька стабільність зберігання розчинів, що не перевищує 1 рік з моменту виготовлення, через самовільну його коагуляцію, а також низька маслобензостійкість покриттів та адгезійних з'єднань на основі цього каучуку. Запропоновано для рециклінгу самовільно зкоагульованого натурального каучуку проводити його хімічну модифікацію шляхом епоксидування із використання органічних перкислот з отриманням латексу епоксидованого натурального каучуку, що в свою чергу підвищить маслобензостійкість композиційних матеріалів на їх основі.

Ключові слова: натуральний каучук, латекс, адгезія, хімічна модифікація, епоксидований натуральний каучук.

Abstract. The paper considers the areas of application of natural rubber latexes in industry for the creation of composite materials, coatings and adhesive compounds. The disadvantage of latexes based on this rubber is the low storage stability of solutions, which does not exceed 1 year from the moment of manufacture, due to its spontaneous coagulation, as well as the low oil and gasoline resistance of coatings and adhesive compounds based on this rubber. It is proposed to recycle spontaneously coagulated natural rubber by chemically modifying it by epoxidation using organic peracids to obtain epoxidized natural rubber latex, which in turn will increase the oil and gasoline resistance of composite materials based on them.

Key words: natural rubber, latex, adhesion, chemical modification, epoxidized natural rubber.

Вступ.

Латекс натурального каучуку являє собою водну дисперсію частинок каучуку. При введенні в нього емульсій інших матеріалів, наприклад, олій, смол або розчинників, не відбувається повного змішування їх з каучуком: частинки цих речовин залишаються диспергованими у водному середовищі і відокремленими одна від одної. Безпосереднє змішування емульсій розчинника