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GRANULATE FROM POLYURETHANE WASTE FOR THE PRODUCTION OF SHOE SOLES

ГРАНУЛЯТ ИЗ ОТХОДОВ ПОЛИУРЕТАНОВ ДЛЯ ПРОИЗВОДСТВА ПОДОШВ ОБУВИ

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ABSTRACT

WASTE ANALYSIS, POLYURETHANE, GRANULATE, TECHNOLOGY, STRUCTURE, PROPERTIES

The article presents an analysis of polyurethane waste in order to confirm the possibility of producing granules from them. A process flow diagram for granulate production has been developed. Granulate was produced according to the proposed scheme. On the basis of the produced granulate, trial castings of samples of materials were developed in order to confirm the possibility of manufacturing materials for shoe soles from it.

АННОТАЦИЯ

АНАЛИЗ ОТХОДОВ, ПОЛИУРЕТАН, ГРАНУЛЯТ, ТЕХНОЛОГИЯ, СТРУКТУРА, СВОЙСТВА

В статье представлен анализ отходов полиуретанов с целью подтверждения возможности производства из них гранулята. Разработана принципиальная технологическая схема получения гранулята. Получен гранулят по предлагаемой схеме. На основе полученного гранулята были получены пробные отливки образцов материалов с целью подтверждения возможности изготовления из него материалов для подошв обуви.

Synthetic plastics first appeared in 1835 after the discovery of the polymerisation reaction performed with vinyl chloride by Henri Victor Regnault.

Among synthesized plastics, polyurethanes, mainly in the form of foams that are the leading plastics used in the world.

Dr. Otto Bayer was the first who synthesized polyurethanes in 1937. The production of polyurethane foam on an industrial scale began in the 1950s, and their use grew slowly until the 1990s. Technological progress has led to the emergence new formulations, and the production of polyurethanes is increasing from year to year.

Polyurethane elastomers are rubber-like materials that are manufactured by the reaction of isocyanates with a hydroxyl group in the polyols (alcohol) to which a curative agent is added. The major isocyanates used are either toluene diisocyanate (TDI) or methy-diphenly diisocyanate (MDI), and the polyols are of either polyether or polyester. Various additives are added to these elastomers during their processing to enhance certain properties for specific applications and reduce costs. Polyurethane elastomers are used in various industries.

The PU sole (footwear polyurethane) market size is estimated at USD 4.2 billion in 2019 and projected to reach USD 5.9 billion by 2024, at a CAGR of 7.6 %. Polyurethane is used in footwear to provide the perfect combination of ergonomics, microclimate, and comfort. The superior properties of polyurethane as shoe sole material, growth in footwear sales, and increasing production in the growing economies are expected to drive the PU sole (footwear polyurethane) market [1].

During the production of shoes, a lot of waste is generated, the removal of which difficult and unecological. This waste also includes waste based on polyurethane. Due to a large amount of this waste, it is necessary to look for suitable recycling technologies and opportunities for using this recycled material in practice, for example, polyurethane granules. As for the outstanding ratio of properties, polyurethane granules are an interesting secondary raw material for the potential production of materials for the bottom of shoes.

Investigation of properties of polyurethane waste

The initial stage of research was devoted to studying the properties of polyurethane waste. Chemical, physical, microscopic, and spectroscopic analyses of the waste were performed. The results of the analysis were summarized in Table 1.

Granulate production technology

The basic technological scheme for granulate production includes the following stages: grinding of waste polyurethane foam (PU), drying, granulation, quality control, and packaging [3].

The porosity of the obtained granulate (Fig. 1) was analyzed by scanning electron microscopy (SEM) "VEGA II" LSH of TESCAN (Czech Republic). The bulk density of the granulate is 0,47 g/cm^3 (Standard 11035.1-93).

Table 1 – Waste characteristics

Name of the waste	Appearance	Chemical composition, properties, formula	Physical properties	Microscopic analysis	Spectroscopic analysis
Waste PU foam	Trim material black with a brilliant shade	Polyurethane 100 % [2], without additional inclusions [-CO-NH-R_1-NH-CO-O-R_2-O]	Very flexible, elastic material at room temperature, soluble in glacial acetic acid	There are remaining spherical vapors, no additional inclusions or defects found there	Are various fluctuations in the groups

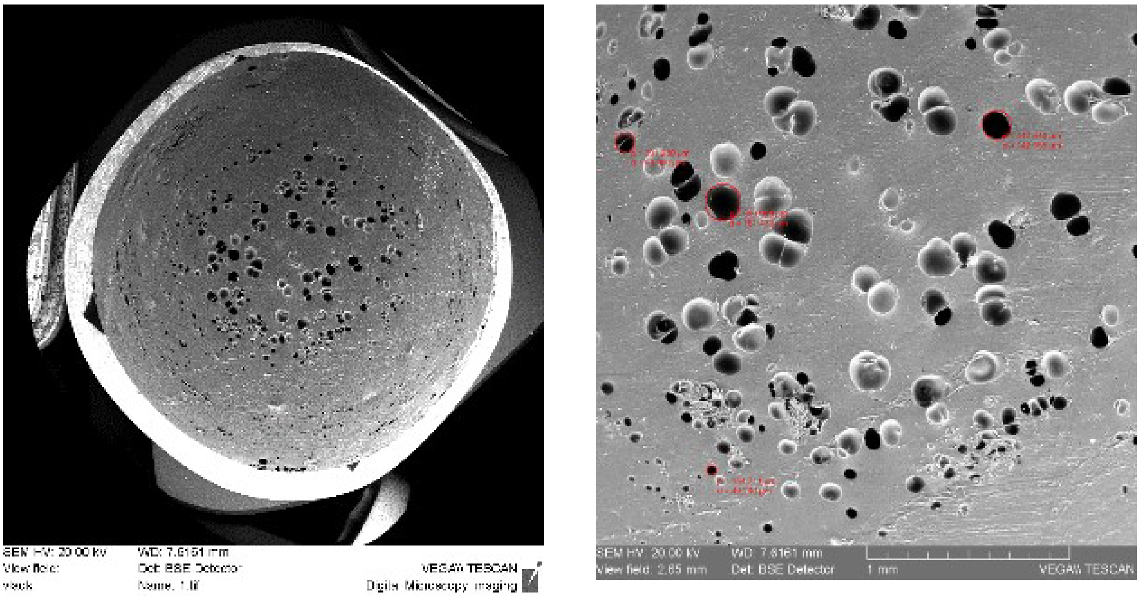

Figure 1 – Porosity of the resulting granulate

Further, test castings of samples of materials were made from the granulate in order to confirm the possibility of manufacturing materials for shoe soles from it. The study of the physical and mechanical characteristics of tensile cast samples based on the produced granulate was carried out in accordance with Standard 11262-80 [4]. The average values of the properties of granulate samples are the following: ε-260 %, σ-8 MPa, E-20 MPa. The structure of the produced cast samples is shown in Figure 2.

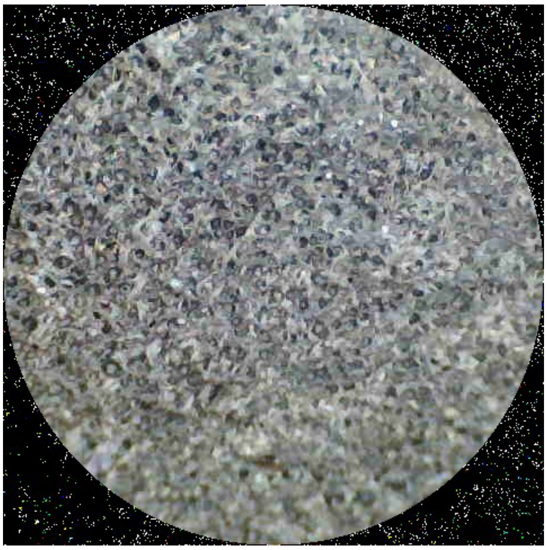

Figure 2 – The surface view of the cast samples

The sample has a loose, slightly porous structure; the pores are well formed, have small diameters of a regular spherical shape of 2-3,5 microns, no additional inclusions or defects were found.

Thus, it can be noted that the structure of the obtained materials meets the requirements for materials for shoe soles, the physical and mechanical characteristics of the samples are higher than the standard values. In this regard, it is possible to produce materials for shoe soles from the obtained granulate in the future.

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