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## ПЕРЕДУМОВИ СТВОРЕННЯ МАЛОГАБАРИТНОЇ МОДУЛЬНОЇ ДРОБІЛЬНО-СОРТУВАЛЬНОЇ УСТАНОВКИ ДЛЯ ПЕРЕРОБКИ ТВЕРДИХ ПОБУТОВИХ ВІДХОДІВ

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**Анотація.** Виникнення та збільшення кількості відходів руйнування значно ускладнює проблему управління та відновлення твердих побутових відходів. Існуюче дробильно-сортувальне обладнання малоефективне на ділянках з невеликим запасом сортувальних відходів, що характерно для районів зі зруйнованими війною спорудами. У зв'язку з цим, виникає необхідність у створенні малогабаритної пересувної установки продуктивністю до 5 т/год.

*Ключові слова:* Відходи руйнування, дроблення, сортування, пересувна установка

## PREREQUISITES FOR THE CREATION OF A SMALL-SIZED MODULAR CRUSHING AND SORTING PLANT FOR PROCESSING SOLID MUNICIPAL WASTE

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**Abstract.** The emergence and increase in the amount of demolition waste significantly complicates the problem of managing and recovering solid household waste. Existing crushing and sorting equipment is inefficient in areas with a small supply of sorting waste, which is typical for areas with structures destroyed by war. In this regard, there is a need to create a small-sized mobile unit with a capacity of up to 5 t/h.

*Keywords:* Waste destruction, crushing, sorting, mobile plant

**Introduction.** The Law of Ukraine “On Waste” defines waste as any substances, materials and objects, which are formed in the process of human activity and are not used further at the place of formation or identification and from which their owner must get rid of by utilization or disposal [1].

The increase in industrial production is inextricably linked to the growth of waste that is used at a particular enterprise. The bulk of the waste, which amounts to billions of tons, is generated by mining and processing companies, metallurgical plants, machine-building plants, and construction materials manufacturers, forming man-made deposits. They occupy thousands of hectares of territory in the form of waste heaps, waste rock dumps, and tailing pits. As a result, huge areas of land are taken out of agricultural use, the condition of the adjacent air basin deteriorates due to the presence of large amounts of dust, and there is a threat of chemical contamination of surface and groundwater.

Industrial waste is generated in much smaller quantities. First, it accumulates at enterprises that may be located at a considerable distance from each other, then it is collected in a designated place, sorted and then sent for recycling to obtain secondary resources. This traditional scheme creates an irrational use of vehicles for waste transportation.

The amount of solid domestic waste in the world is catastrophically increasing. In Ukraine alone, according to 2021 data, up to 500 million tons of waste is generated annually, including from primary (76%) and secondary (about 18%) production, from agriculture (about 2%). Another 2% is domestic waste - about 12 million tons of it is produced annually. These data have changed considerably after the outbreak of hostilities related to the Russian aggression, which significantly aggravated the existing acute problem of waste management, recovery and utilization.

**Objective.** Based on the analysis of literary sources describing the structure of demolition waste, to substantiate the relevance of the task of creating mobile equipment capable of improving the efficiency and quality of work in the dismantling and restoration of war-damaged buildings and structures.

**Material and results of the research.** Published in The New York Times, the results of a large study conducted by a group of American scientists show that between February 2022 and December 2023 alone, about 210,000 buildings in Ukraine have been destroyed. Unfortunately, this figure continues to increase. Hundreds of thousands of tons of waste from the destruction of settlements are added to the existing production and construction waste. The essential difference and complexity of processing such waste is the uncertainty of the formed conglomerate, possible presence of harmful components and explosive objects in it.

The law of Ukraine [2] defines the term demolition waste as parts (fragments) of damaged (destroyed) objects, as well as materials and objects that were inside or near such objects at the time of damage (destruction) and/or dismantling and that have fully or partially lost their consumer properties and cannot be further used at the place of their formation or discovery.

Destroyed cities (Fig.1) or settlements (Fig.2) have a long territory littered with all kinds of debris, which is difficult for the movement and maneuvering of vehicles during the waste sorting process. The creation of temporary sites for the collection of separated waste is also problematic, while the productivity of dismantling completely (Fig. 3) or partially (Fig. 4) demolished buildings and structures is insignificant with mandatory manual dismantling. For this reason, the use of high-capacity machinery is inefficient and can be limited to 1...5 t/h.



Fig.1. – Destroyed city



Fig.2. – Destroyed settlement



Fig.3. – Completely destroyed buildings



Fig.4. – Partially destroyed buildings

Such a huge amount of waste generated in a relatively short period of time cannot be processed at existing sorting stations and enterprises. The consequence of this is excessive filling of existing dumps, the formation of unauthorized spontaneous dumps, the need to create new specialized landfills for waste storage.

Lack of effective recycling leads to soil pollution, greenhouse gas emissions, hydrogen sulfide, irrecoverable loss of secondary raw materials and ecological disaster. Most of these millions of tons of construction waste are secondary

resources and can be reused. There are two ways to dispose of waste: landfill disposal, or recycling for use in restoring damaged facilities and constructing new buildings. Both ways are problematic. The problem of exportation is the lack of landfills, loss of huge areas, negative impact on the environment. The problem of recycling is the lack of mobile small-sized equipment.

Existing mobile crushing plants are focused on medium and fine crushing of raw materials (concrete, brick, etc.). High productivity (tens of tons per hour) is associated with the complexity of collecting and loading the feedstock, the plants require an additional loading device, have significant dimensions and metal consumption, limited territorial maneuvering and production of marketable products in a wide range of material sizes. Demolition waste also contains materials (glass, plasterboard, ceramics, marble, etc.) that are sorted and stored during manual disassembly, and whose conversion into secondary raw materials or marketable products requires obtaining fine-grained and powdered material. This will save natural resources, significantly reduce transportation costs and reduce the load on landfills. However, the lack of effective recycling technology and high-performance crushing and screening equipment does not allow us to positively solve this urgent problem.

Even such a brief overview shows the complexity of demolition waste management and the feasibility of creating small-sized mobile crushing and screening equipment with a capacity of up to 1-5 t/h for on-site waste processing to produce secondary raw materials.

Such a plant can be created on the basis of a vibrating jaw crusher with an inclined crushing chamber. On the laboratory sample of the crusher were conducted studies on crushing of demolition waste:

- Crushing of reinforced concrete of initial size 100mm allowed to separate three components: steel reinforcement, crushed stone and fine fraction of concrete.
- Crushing of sheet glass with thickness of 4mm allowed to obtain cleaned glass with a sharp or tapered edge of 0,1...3mm coarseness.
- Crushing of glass containers was carried out using bottles. Varying the parameters of the crusher, the final product of required fractions from 100 $\mu$ m to 5500 $\mu$ m was obtained, which is a finished marketable product.
- Crushing of gypsum board sheets made it possible to separate the gypsum component from the cardboard.

### **Conclusions.**

1. Existing crushing and sorting plants mainly process large-sized concrete and brick component of waste with high hourly productivity (up to 300t/h) and their use at the waste generation site with manual sorting is inefficient.
2. Analysis of scientific and technical sources shows the need to create a small-sized mobile crushing and screening plant with a capacity of up to 5t/h,

capable of processing most of the components that make up the waste, with the receipt of marketable products.

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2. Про затвердження Порядку поводження з відходами, що утворились у зв'язку з пошкодженням (руйнуванням) будівель та споруд внаслідок бойових дій, терористичних актів, диверсій або проведенням робіт з ліквідації їх наслідків та внесення змін до деяких постанов Кабінету Міністрів України: Постанова КМУ № 1073 від 27.09.2022 р. URL: <https://zakon.rada.gov.ua/laws/show/1073-2022-%D0%BF#Text>

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## ФАКТОРИ РИЗИКУ ТРАНСПОРТУВАННЯ ШВИДКОПСУВНОЇ СІЛЬСЬКОГОСПОДАРСЬКОЇ ПРОДУКЦІЇ

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**Анотація.** Запропоновано систему факторів, виражених в індикативних показниках, які відображають вплив внутрішнього та зовнішнього середовища на рівень ризику процесу транспортування швидкопсувної сільськогосподарської продукції в ланцюгах поставок. На основі певної системи індикативних показників сформовано нечітко-множинну модель оцінки рівня прийнятності запропонованих груп логістичних ризиків.

*Ключові слова:* ланцюг постачань, нечітка логіка, ризик, система факторів, транспортування.

## RISK FACTORS OF TRANSPORTATION OF PERISHABLE AGRICULTURAL PRODUCTS

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**Abstract.** A system of factors expressed in indicative indicators that reflect the impact of internal and external environment on the level of risk of the process of transportation of