АКТУАЛЬНІ ПИТАННЯ ТЕХНІЧНИХ НАУК

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DESIGN AND ANALYTICAL STUDY OF FLOATING CONTAINERS FOR PLASTIC TRANSPORTATION

The relevance of the work lies in the need to create vessels and floating facilities for collecting plastic waste in water areas. The analysis of the current state of the ecological fleet showed the feasibility of using small-tonnage vessels additionally equipped with floating tanks.

The design and analytical study *will focus on identifying problematic issues in their design and modernization with the development of an action plan.*

In this study, system analysis methods were applied. The information base includes regulatory documents and the authors' original scientific and practical developments in solving design problems. It is determined that it is possible to increase the buoyancy of tanks by using new lightweight composite materials that will meet the requirements of buoyancy, hydrostatic strength, climatic conditions of the area and are able to neutralize negative factors of substances that persist for a certain time. Preference is given to gas-filled polymeric materials and syntactic foams. It is possible to increase the usable volume of containers for collecting plastic waste through the implementation of a layered composite body design, where each layer will have a different density and its own functional purpose. Modernization of the structure can also be used to transport other substances that pollute sea and river areas. The development is recommended for implementation in design and production companies for shipbuilding and ship repair.

The economic efficiency of *the project is based on the principles of modernization of a floating container for transporting plastic with a wide range of physical and chemical properties. It is advisable to process sorted plastic waste by grinding it into powder for subsequent use in road construction.*

The scientific and practical significance of *the work lies in developing a new approach to expanding the ecological fleet and cleaning marine and river waters from pollution.*

The prospects for *the authors' further research are to determine the influence of hydrological and environmental features of water bodies on the design characteristics of floating containers.*

Key words: *ecological fleet, plastic waste, water areas, design, modernization.*

Problem statement. The collection of plastic waste in sea and river water bodies, along with its subsequent transportation for utilization or recycling, is a strategically important issue, the solution of which will help improve the ecological condition of water bodies. Solving this problem will require the development of vessels and watercraft of the ecological fleet.

Due to their high weather and chemical resistance, most polymers undergo destructive processes

during storage in natural conditions, transforming into micro- and nanoparticles found in marine animals and algae, which will negatively affect hydrochemistry and hydrobionics.

Analysis of recent research and publications. The pollution of the world's oceans poses a real environmental threat. Port activities, the development of hydrotechnical engineering construction, domestic and industrial discharges – all this leads to the accumulation of toxic substances in the marine environment: petroleum hydrocarbons, phenols, synthetic surfactants and biogenic substances. Waste management in marine environment is regulated by: International Management Code for the Safe Operation of Ships and Pollution Prevention; International Convention on the Prevention of Pollution by Dumping of Wastes and Other Matter; International Convention for the Prevention of Pollution from Ships (MARPOL 73/78); Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters.

In contemporary maritime navigation, the ecological fleet [1, pp. 125-136], which includes garbage collection vessels, is used to treat ship waste and clean up the water space from the debris. Improving their technical and operational performance is possible through additional equipment with floating installations for collecting oil spills, sewage, fuel emulsions, solid objects (bottles, metal, glass), silt, etc. [2, pp. 4-15]. They are floating berths, pontoons, barriers, and containers. Their design and modernization is a new scientific and technical area that has been developing over the past decade.

According to the United Nations data [3], approximately 8 million tons of plastic enter the oceans: due to their low density, they are carried by the wind, accumulate near the coastlines, and are transported to the seas by river runoff.

The widespread use of various types of plastic in everyday life, combined with inadequate sorting has resulted in an uncontrolled waste management process that often disregards the chemical composition, toxicity, and degradability of polymers, most of which are polyethylenes, polypropylenes, polyvinyl chlorides, polymethyl acrylates, photoroplasts, etc. The development of modern technologies for creating composite materials is intended to give them new or highly specialized properties by introducing pigments, stabilizers, fibers and other fillers into their composition. Due to their high weather and chemical resistance, most polymers undergo destructive processes during storage in natural conditions, transforming into micro- and nanoparticles found in marine animals and algae, which will negatively affect hydrochemistry and hydrobionics [4, pp. 20-25].

Considering the information provided, it should be noted that the development and operation of technical measures for marine debris collection in the water space is relevant. It necessitates developing constructive measures in the vessel elements design, which will reliably isolate the collected plastic marine debris until it is recycled or disposed of and prevent it from re-entering the environment. It is possible to increase the mobility of floating installations using lightweight composite materials, each with a specific functional purpose.

The purpose of the study is, with the help of project-analytical research, to identify the key challenges in the design and modernization of floating containers for transporting plastic waste in sea and river waters.

Presentation of the main material of the study.

The research methodology is based on a systematic approach and methods of data analysis [5, pp. 48-54]. The information base consists of regulatory documents and the authors' own scientific and practical developments in solving project problems [6, pp. 46-49], [7, pp. 18-26], [8, pp. 48-59]. The information is summarized in Table 1: problematic issues related to the design of floating containers for collecting plastic waste and possible ways to solve them are presented.

Table 1

Key Challenges in the Design of Floating Containers [compiled by the authors]

Challenges	Solutions
Providing additional buoyancy	Development and application of new buoyancy materials
Reduction of mass and size indicators	Development of a layered structure of a floating tank, the use of composite liners
Reliable insulation of plastic debris	Study of cargo properties, use of chemically inert materials
Strength Prediction in Swing Conditions	Formulation and Solution of Strength Problems

It is possible to increase the buoyancy of tanks by using new lightweight composite materials that will meet the requirements of buoyancy, hydrostatic strength, and climatic conditions of the area and are able to neutralize negative factors of substances that persist for a certain time. Preference is given to gas-filled polymeric materials and syntactic foams [9, pp. 174-180].

The development of measures for the modernization of floating containers for plastic waste trans-

porting is based on a practical analysis of the design of a well-known floating container with a nesting container [6, pp. 46-49]. In modern shipbuilding practice, the modernization of individual elements is considered as an alternative to the construction of new vessels and watercraft: this will make it possible to increase technical and operational indicators, environmental and economic factors to the latest level through the introduction of new design solutions and technologies using new materials. The floating container (Fig. 1) consists of an outer shell (1) made of carbon steel or aluminum alloy, inside of which there is a container (2) for plastic waste, which has a layered structure and consists of a highly elastic polymer body (4) and a syntactic-type buoyancy material layer (5). After unloading the waste, the working volume (6) is flushed using a pump (7).

It is possible to increase the usable volume of containers for collecting plastic waste through the implementation of a layered composite body design, where each layer will have a different density and its own functional purpose. The collected plastic is stored in a floating container for a certain time, and then transported to recycling or disposal sites. In the study [10, pp. 176-182], the author considers technological directions and possibilities of recycling plastic waste. It is advisable to process sorted plastic waste by grinding it into powder with its subsequent use in road construction.

A program of measures has been developed that can be used to modernize existing floating tanks for transporting plastic in the aquatic environment (tabl. 2).

Table 2

Program of measures for the modernization of a floating container for plastic transportation [compiled by the authors]

Measures	Terms of reference
Increase in the usable volume of the container	• Changes to the design of the nesting container • Solving Computational Problems of Loading and Stability • Solving design problems to determine overall dimensions and optimal thicknesses
Reduction of mass and size indicators	Rational selection and replacement of structural materials
Management of processes for improving technical and operational indicators	• Cargo plan optimization • Development of models for the operation of floating facilities for different routes and climatic conditions of water areas
Setting up technological production	Development of material and technical base

Modernization of the structure can also be used to transport other substances that pollute sea and river areas.

According to the developed recommendations, it is possible to create other floating facilities for collecting and storing garbage that pollutes the coastal

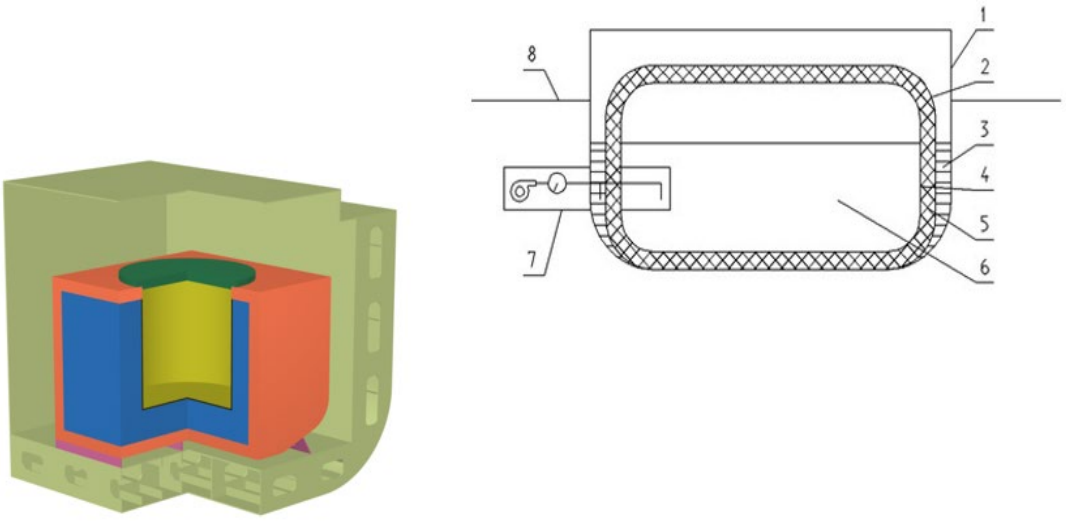

Fig. 1. Floating container with nested elastic container [compiled by the authors, 6, pp. 46-49]:
1 – outer cladding; 2 – a container for plastic waste; 3 – water ballast; 4 – polymer container body; 5 – a layer of buoyancy material; 6 – working volume of plastic waste; 7 – pumps; 8 – water area

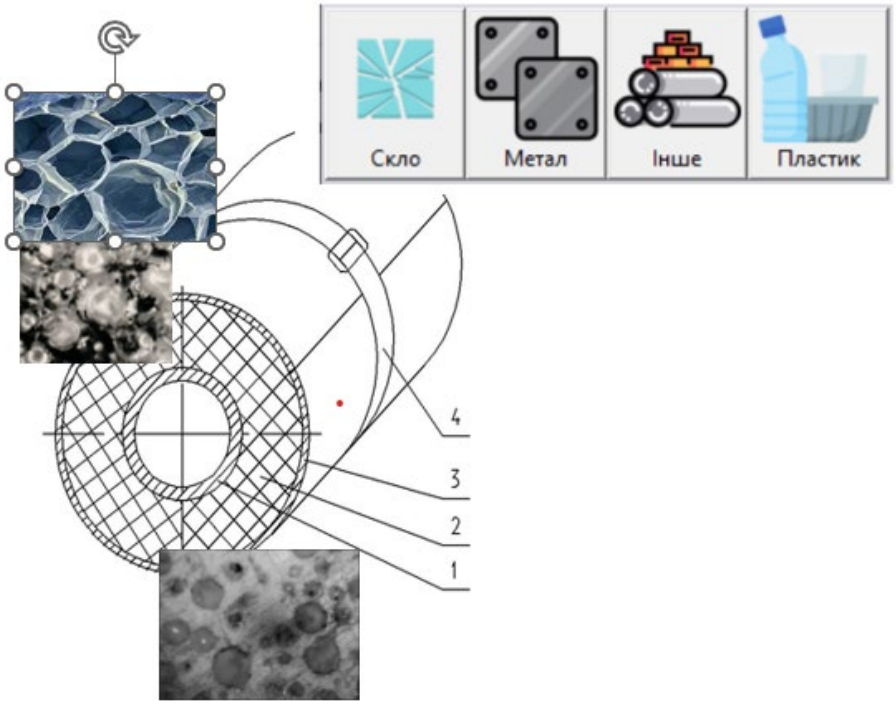

Fig. 2. Floating barrier element [compiled by the authors]: 1–3 – layers of various buoyancy materials; 4 – fasteners

zone. These can be floating berths, pontoons, and barriers.

As an example of implementation, Fig. 2 shows a floating barrier, the sections of which are made up of various elements and materials.

The scientific and practical significance of the work is to develop a new approach to expanding the ecological fleet and cleaning sea and river waters from pollution.

The cost-effectiveness is based on the principles of modernizing the existing design of a floating container for plastic waste transporting.

Social impact. The collection of plastic waste in sea and river waters and its subsequent transportation for disposal or recycling is an urgent and strategically critical issue, the solution of which will help improve the environmental conditions of sea and river waters.

Conclusions and prospects for further research. The analysis of the operation of the ecological fleet vessels has shown the prospects of using offshore technical facilities for collecting plastic waste in sea and river waters and its short-term storage until it is transported to recycling facilities.

It has been determined that the buoyancy of tanks can be increased by using new lightweight composite materials that meet the requirements for flotation, hydrostatic strength, local climatic conditions while being capable of neutralizing the harmful effects of persistent substances.

A program of measures has been developed that can be used to modernize existing floating tanks for transporting plastic in the aquatic environment.

The development is recommended for implementation in design and production companies for shipbuilding and ship repair.

The prospects for the authors' further research are to determine the influence of hydrological and environmental features of water bodies on the design characteristics of floating tanks.

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Щедролосєв О. В., Казимиренко Ю. О., Дрозд О.В., Бойко Л. М. ПРОЄКТНО-АНАЛІТИЧНЕ ДОСЛІДЖЕННЯ ПЛАВУЧИХ ЄМКОСТЕЙ ДЛЯ ТРАНСПОРТУВАННЯ ПЛАСТИКУ

Актуальність роботи зумовлено необхідністю створення суден і плавучих засобів для збирання пластикового сміття у водних акваторіях. Аналіз сучасного стану екологічного флоту показав доцільність використання малотонажних суден, додатково оснащених плавучими ємкостями.

***Проєктно-аналітичне дослідження** полягатиме у виявленні проблемних питань з їх проєктування та модернізації з розробкою плану заходів.*

*Для досліджень використано **методи** системного аналізу, інформаційну базу становлять нормативні документи і власні науково-практичні напрацювання авторів з розв'язання проєктних задач. Визначено, що підвисити плавучість ємкостей можливо шляхом застосування нових легковажних композиційних матеріалів, що відповідатимуть вимогам плавучості, гідростатичної міцності, кліматичним умовам місцевості та здатні нейтралізувати негативні чинники речовин, що зберігаються певний час. Перевага надається газонаповненим полімерним матеріалам та синтактним пінопластам. Збільшити корисний об'єм ємкостей для збирання пластикового сміття можливо через реалізацію шаруватої конструкції композитного корпусу, де кожен шар матиме різну щільність і своє функціональне призначення. Модернізація конструкції може бути використана також для транспортування інших речовин, які забруднюють морські і річкові акваторії. Розробку рекомендується до впровадження у проєктних і виробничих фірмах з суднобудування і судноремонту.*

***Економічна ефективність** проєкту ґрунтується на принципах модернізації плавучої ємкості під транспортування пластику з широким діапазоном фізико-хімічних властивостей. Відсортоване пластикове сміття доцільно піддавати переробці здрібненням на порошок з подальшим його застосуванням у дорожньому будівництві.*

***Наукове і практичне значення** роботи полягатиме у розробці нового підходу до розширення екологічного флоту та очищення морських і річкових акваторій від забруднення.*

***Перспективи** подальших досліджень авторів полягатимуть у визначенні впливу гідрологічних і екологічних особливостей водних басейнів на проєктні характеристик плавучих ємкостей.*

***Ключові слова:** екологічний флот, пластикове сміття, акваторії, проєктування, модернізація.*