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ЕКСПЕРИМЕНТАЛЬНІ ДОСЛІДЖЕННЯ ВИТРАТ ПАЛИВА ПОРТОВИМИ АВТОМОБІЛЬНИМИ КРАНАМИ

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Анотація. *Сучасність висуває перед українською портовою галуззю більш жорсткі вимоги до перевантажувальної техніки щодо забезпечення їх експлуатаційної надійності та мінімізації витрат.*

Особливо це актуально для автокранів, кількість яких у портах зростає щороку, витрати на паливо складають значну частку у собівартості робіт. Тому підвищення паливної ефективності автокранів є актуальною задачею.

Існуючі методи нормування витрати палива для автокранів враховують лише номінальну та максимальну вантажопідйомність, ігноруючи реальну масу переміщуваних вантажів.

В роботі досліджено витрати палива 22 автомобільними кранами, вантажопідйомністю 25 тонн, які експлуатуються в морських портах у зимовий і літній періоди протягом 10-17 років. Усі крани вчасно пройшли технічний огляд, визнані справними. Дослідження проводили протягом двох років, у літній та зимовій періоди.

На основі отриманих витратами палива в кінці зміни, за допомогою статистичних методів у MS EXCEL будували відповідні залежності. Автокрани виконували ідентичні операції з перевалки вантажів на судна.

Експерименти показали, що в зимовий період витрати палива збільшуються у порівнянні з літнім. На рівень витрат пального впливає кваліфікація кранівника та технічний стан механізмів крана.

Встановлено, що кваліфікація і стиль роботи машиніста істотно впливають на втрати палива.

Результати дослідження можуть бути використані для уточнення існуючих та розробці нових моделей.

Ключові слова*: автомобільний кран, витрати палива, крюковий режим, порт, експеримент.*

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EXPERIMENTAL RESEARCH OF FUEL CONSUMPTION BY PORT MOBILE CRANES

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Abstract. *Modernity puts forward more stringent requirements for the Ukrainian port industry for transshipment equipment to ensure their operational reliability and minimize costs. This is especially true for truck cranes, the number of which in ports is growing every year, and fuel costs account for a significant share of the cost of work. Therefore, improving the fuel efficiency of truck cranes is an urgent task.*

The existing methods of fuel consumption regulation for truck cranes take into account only the nominal and maximum load capacity, ignoring the actual weight of the cargo being transported.

22 automobile cranes with a lifting capacity of 25 tons, which are operated in seaports in winter and summer periods for 10-17 years, were selected as research objects. All cranes passed a timely technical inspection and were recognized as serviceable. The study was conducted for two years, during the summer and winter periods. The resulting data for each tap was processed using MS EXCEL at the end of the shift. The truck cranes performed identical operations of cargo transfer to ships.

Experiments have shown that fuel consumption increases during the winter season compared to the summer season. The level of fuel consumption is affected by the qualification of the crane operator and the technical condition of the crane mechanisms. The analysis showed that diesel fuel is consumed at a rate of 13-14% less than gasoline.

To cut down on how much fuel the crane uses, focus on training the people who use it and keeping the crane well-maintained.

Keywords: *mobile crane, fuel consumption, hook mode, port, experiment.*

Introduction. Mobile cranes are a key element in ensuring the smooth operation of transport infrastructure, including ports, railway stations, and airports. They play an important role in moving cargo between different modes of transportation, thereby integrating various links in the logistics chain. In ports, mobile cranes are used to transfer containers, general cargo, and bulk materials from ships to warehouses or railway platforms.

The contemporary landscape presents new challenges for the Ukrainian port industry, particularly regarding transshipment equipment [1-5]. This is especially true for truck cranes, the number of which in ports is growing every year, and fuel costs account for a significant share of the cost of work [6; 7]. Therefore, improving the fuel efficiency of truck cranes is an urgent task.

The modernization of port infrastructure by replacing cranes is a topic of constant discussion. However, a final plan or a commonly accepted approach has not yet been developed, as the approach to solving this problem is determined by several factors. These include the size of the port, the volume of cargo it handles, the types of goods it processes, the condition of its docks and existing cranes, the types and sizes of ships it serves, the processes it uses to move cargo, and its financial resources.

Due to economic realities and needs, each port makes its own decisions about modernizing its crane fleet.

In today's competitive port environment, fuel consumption is a critical parameter for truck cranes. Firms and companies are constantly looking for ways to optimize their fuel consumption, as it directly affects their profitability and competitiveness [6-9].

It should be noted that the fuel efficiency of truck cranes is influenced by a variety of factors, some of which vary widely [5-8].. The influence of the most significant factors has been sufficiently researched and taken into account in the standardization system [9]. However, in many cases, this is reflected only in the maximum values of the correction factors [6-8].

Correction factors for adjusting fuel consumption rates in ports are set individually, based on operating conditions, which causes them to differ.

Due to their specific nature, which involves performing cargo handling operations, truck cranes consume fuel in volumes that are significantly higher than those of conventional vehicles.

The fuel consumption rate for a truck crane is determined by separating two components: the rate related to movement (mileage) and the rate related to the operating time of the crane (moto-hours).

Thus, an accurate calculation of the required amount of gasoline or diesel fuel ensures that truck cranes are always supplied with fuel.

The purpose of the study is to determine the fuel consumption of truck cranes during cargo transfer at the port.

Data and methodology. It should be noted that the basic fuel consumption rates are determined by analyzing statistical data obtained from the operation of vehicles. However, the limited resources of ports do not allow for long-term observations of a large sample of vehicles of the same brand and model. Therefore, in practice, statistical processing methods are used to compare the results with those presented in the regulatory framework [9; 10].

The current fuel consumption standards for truck cranes are based solely on the rated and maximum weight of the load being lifted. This does not take into account the fact that the crane moves loads of different weights during operation.

The paper examines the fuel consumption of Automobile cranes with a lifting capacity of 25 tons, which are operated in seaports in winter and summer periods for 10-17 years. All cranes passed the technical inspection on time and were recognized as serviceable.

The popularity of the KS-55713 model in many countries is proof of its reliability, because it works successfully in difficult conditions and guarantees uninterrupted operation. Built-in state-of-the-art crane monitoring and safety systems minimize the possibility of accidents or damage.

Based on the obtained fuel costs at the end of the shift, the corresponding dependencies were constructed using statistical methods in MS EXCEL.

During these tests, the frequency and duration of stops, as well as fuel consumption, were continuously monitored and recorded, allowing for an assessment of the cranes' performance under real-world cranes. It is worth emphasizing that all cranes are equipped with telemetry data storage devices integrated into the load capacity limiting system. They record the operational indicators and load level of the crane during the entire period of its use.

Figure 1 shows a graph of the average fuel consumption of a truck crane in winter and summer when lifting a load weighing 20 tons. The resulting dependence is non-linear.

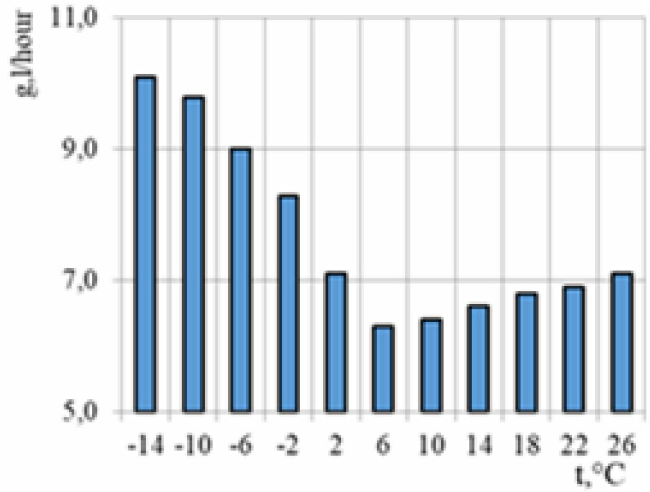


Fig. 1. Graph of the average fuel consumption of a truck crane in winter (1) and summer (2)

As the weather gets colder, cars start consuming more fuel. This is due to the need for preheating the engine and the increased energy consumption of cars during winter.

One of the aspects that has a significant impact on the fuel consumption of a truck crane, but is the least directly controllable, is the driver's qualifications and work style. Depending on their experience and skills, crane operators can have a significant impact on fuel efficiency. This applies not only to the maintenance of the crane but also to the selection of operating modes for loading and unloading operations.

Figs. 2 and 3 show the distribution of fuel consumption during the lifting of a 25-ton load by experienced (a) and novice (b) crane operators for vehicles with diesel and carburetor engines, respectively.

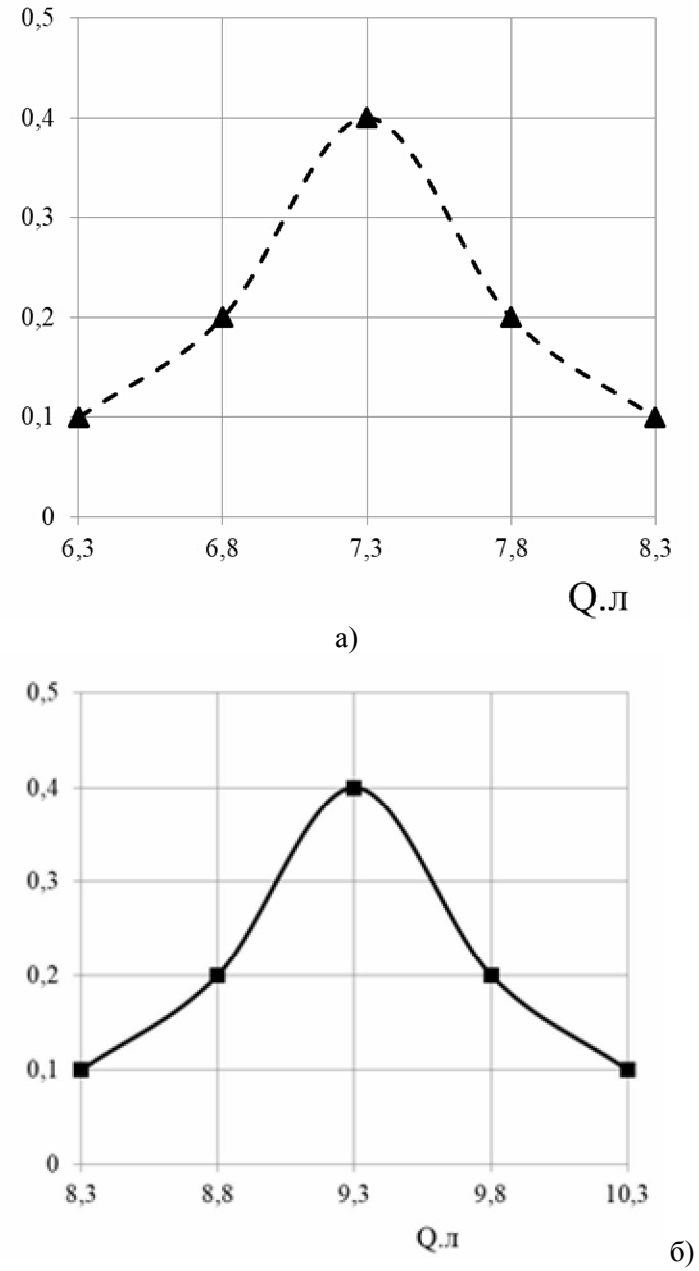
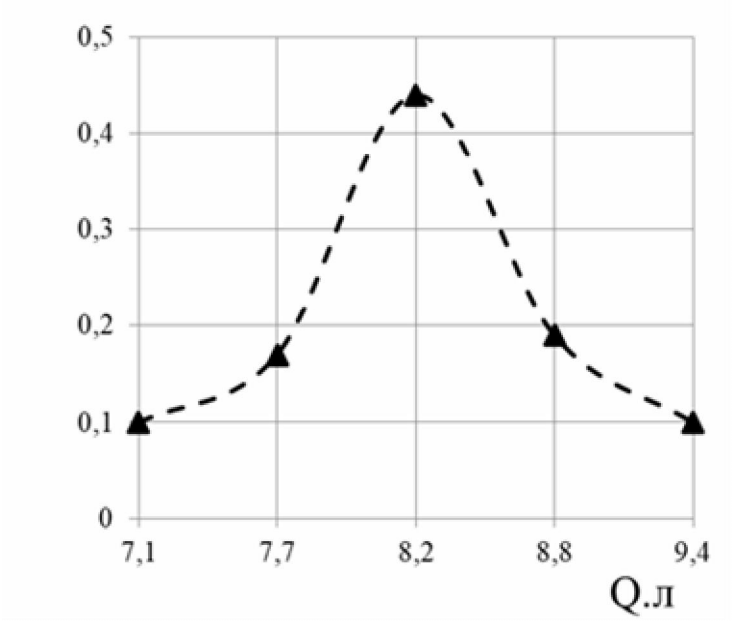
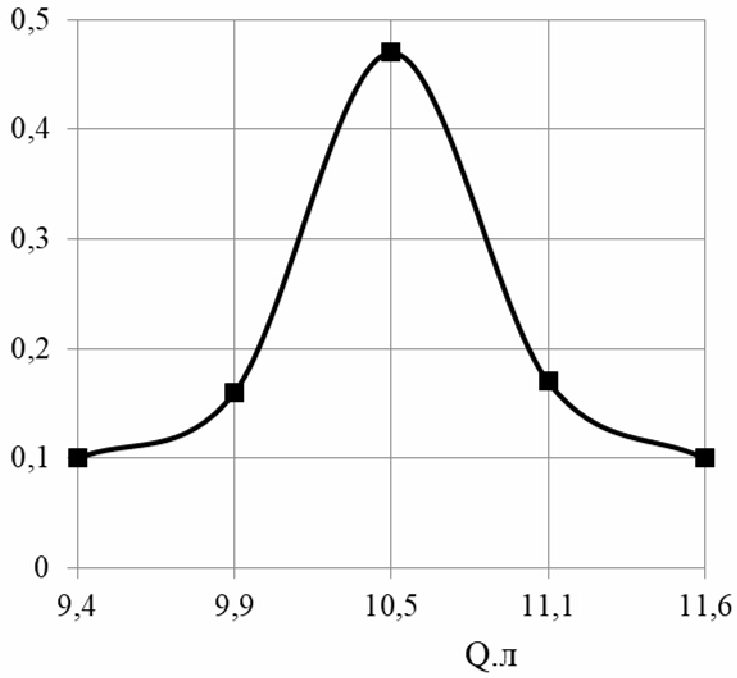


Fig. 2. Distribution of fuel consumption when lifting a 25-ton load by experienced (a) and novice (b) crane operators (diesel)



а)



б)

Fig. 3. Distribution of fuel consumption when lifting a 25-ton load by experienced (a) and novice (b) crane operators (carburetor)

Differences in the level of training and experience of crane operators can lead to significant discrepancies in fuel consumption. For example, in identical operating conditions, the difference in fuel consumption between crane operators of different qualifications reached 28 % (Fig. 2 and 3). This highlights the importance of training and professional development for crane operators, as well as the need for implementing control and motivation systems aimed at reducing fuel consumption.

The analysis showed (Fig. 2 and 3) that diesel fuel is consumed at a rate of 13-14 % less than gasoline.

It has been established that the actual fuel consumption usually exceeds the reference fuel consumption specified in the vehicle's technical specifications. There are numerous factors that influence fuel consumption in real-world driving conditions.

After a detailed technical examination of the crane, the following fuel overspends were identified:

1) Incorrect adjustment of the main carburetor jet. Or incorrect adjustment of the oil pump and diesel engine injection nozzle.

2) Wear and tear of the piston, piston rings, or cylinder.

3) Insufficient clearance between the shafts, bearings, and gearbox gears. .

4) Incorrect adjustment of the brake drum.

The impact of a crane operator's qualifications is a multifaceted aspect. An experienced and trained operator can control the crane more smoothly, avoiding sudden movements and unnecessary accelerations, thereby reducing fuel consumption. Additionally, a skilled operator can plan their work efficiently, minimizing the time the crane spends idling, which directly contributes to reducing the overall fuel consumption per shift.

The technical condition of the crane's mechanisms is an important factor that affects fuel consumption. Malfunctions in the engine, hydraulic system, and transmission can significantly increase fuel consumption. Problems with the engine (such as improper adjustments or worn-out components) can also lead to increased fuel consumption.

Thus, in order to minimize fuel consumption by the crane, it is necessary to pay attention to both improving the operators' qualifications and maintaining the crane in good technical condition. These factors are closely interconnected and have an impact on the fuel consumption of the crane.

Proper fuel consumption management helps to reduce operating costs, increase market competitiveness, and play an important role in reducing fuel expenses.

Conclusion. Fuel regulations, methods of tracking fuel consumption, and, most importantly, methods of minimizing fuel consumption are constantly at the forefront of management and engineering efforts. Effective fuel consumption management can lead to reduced operational costs and increased competitiveness in the market. The implement-tation of advanced technologies and the optimization of logistics processes also play a significant role in reducing fuel expenses. As temperatures decrease, vehicles exhibit an increased fuel consumption. This phenomenon can be attributed to the necessity of preheating the engine, as well as the heightened energy demands placed on automobiles during the winter months. The fuel consumption rate is affected by the crane operator's qualifications and the technical condition of the crane mechanisms.

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