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INFLUENCE OF CONTAINER CLAMPING FORCE ON THE DURATION OF LOADING MUNICIPAL SOLID WASTE INTO A GARBAGE TRUCK

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Анотація

У даній роботі наведено дані щодо тривалості завантаження твердих побутових відходів у сміттєвоз в залежності від сили затискання контейнера.

Ключові слова: завантаження, маніпулятор, сміттєвоз, тверді побутові відходи, регресійний аналіз, регресійна залежність.

Abstract

This paper presents data on the duration of loading municipal solid waste into a garbage truck depending on the clamping force of the container.

Keywords: loading, manipulator, garbage truck, municipal solid waste, regression analysis, regression dependence.

Introduction

Collection and transportation of municipal solid waste to places of further treatment in Ukraine is carried out mainly by body garbage trucks, the working loading bodies of which are made in the form of manipulators, and the drive of which is hydraulic [1-6]. Almost 3700 garbage trucks are used in Ukraine, which are capable of compacting municipal solid waste, reducing transportation costs and the required area of landfills for disposal. The municipal economy of our country must be provided with modern, highly productive and multifunctional garbage trucks, which play a key role in the system of collection, transportation and disposal of municipal solid waste. The effective operation of such machines is one of the basic factors of environmental safety of urban areas and ensuring the sanitary condition of settlements. According to official statistics, every year in cities and urban-type settlements of Ukraine, about 54 million m³ of municipal solid waste accumulates [7-11], with 93.8% of this volume being sent to landfills and landfills, 2% being burned at waste incineration plants [12-15], and only 4.2% of waste ends up at secondary raw materials collection points or waste processing enterprises [16]. At the same time, the annual increase in the amount of municipal solid waste is about 0.5% [17], which indicates a stable trend towards increasing the load on the waste management system. In the context of a constant increase in the volume of municipal solid waste and increased environmental requirements, timely and rational organization of the processes of collection, transportation, processing and disposal of municipal solid waste is of particular relevance, since the ecological situation in cities, as well as the sanitary and hygienic living conditions of the population, directly depend on this. Increasing the quality standards of municipal services for citizens, in particular in terms of sanitary cleaning of territories, puts forward new requirements for the technical level and energy efficiency of specialized vehicles. Garbage trucks of modern designs must ensure not only effective collection and compaction of waste, but also minimize energy consumption, reduce the time of loading and unloading operations, and also comply with environmental standards for emissions of harmful substances.

Research results

In the scientific article [18], the equations of motion of a small-sized pneumatic wheeled front loader are described in the form of a system of nonlinear differential equations of motion during self-oscillations, and an analysis of the influence of individual parameters of the loader on the parameters of self-oscillations is made. The main regularities and parameters of the self-oscillation processes of the loader are theoretically determined. The influence of individual parameters of a small-sized pneumatic wheeled front loader on the initial parameters of self-oscillations is also established.

In the work [3], a calculation scheme and a mathematical model of a hydraulic drive of a manipulator-type front loader with a brake valve are presented, which takes into account the results of experimental determination of the resistance moment on the faceplate of an adjustable pump due to the stochastic

component of the resistance moment.

In the materials of the scientific article [19], a nonlinear mathematical model of the hydraulic drive for the rotation of the manipulator lever in the technological operation of loading municipal solid waste into a garbage truck is proposed, the study of which allowed obtaining a regression dependence of the duration of the rotation of the manipulator lever on the distance between the centers of rotation of the lever and the rod and the initial value of the angle of inclination of the hydraulic cylinder axis to the horizontal, on the basis of which the optimal values of the specified parameters were determined, for which the value of the duration of the rotation of the manipulator lever is minimal [20]. At the same time, in the process of research, the initial data that correspond to the real parameters of the basic model of the garbage truck KO-436 [21] were used as parameters of the mathematical model.

In the scientific paper [22], regression dependences of the quality indicators of transient processes during the start-up of the hydraulic drive for turning the manipulator lever on the operation of loading municipal solid waste into a garbage truck were revealed, and it was also established that the decrease in the intensity of the increase in wear of the fleet of garbage trucks of municipal enterprises, in particular the drive and mechanisms that ensure the loading of municipal solid waste into a garbage truck, is positively affected by the reduction in the distance between the centers of rotation of the lever and the rod.

In the article [23], a linearized mathematical model of the hydraulic drive for turning the manipulator lever on the technological operation of loading municipal solid waste into a garbage truck was published, which allowed obtaining approximate analytical dependences of the pressure in the pressure line of the hydraulic cylinder, the angular velocity and the angle of rotation of the manipulator lever on time.

In the article [24], a mathematical model was developed that allows determining the optimal geometric parameters of the manipulator structural elements, taking into account the maximum boom reach, load capacity and a number of other kinematic characteristics of the machine. Such a model is an important tool for design engineers, since it provides the possibility of rational selection of dimensional parameters of structural elements in order to increase the efficiency of the manipulator and ensure its reliability during operation. At the same time, special attention is paid to the peculiarities of the operation of articulated joints that operate in a cyclic mode, which is typical for manipulator-type machines. It was established that under such conditions, the formation of a full-fledged hydrodynamic friction mode is impossible, since the lubrication process occurs mainly in the semi-dry and boundary friction modes. This leads to increased requirements for the properties of the materials of the parts, the quality of the surface finish and the efficiency of the lubrication system, since it is these factors that determine the wear resistance and durability of articulated joints in real operating conditions. Unlike the steady-state regime of hydrodynamic friction, the operation of sliding bearings in conditions of semi-dry or boundary friction is accompanied by more intense wear of the friction surfaces. This leads to a gradual loss of kinematic accuracy, the appearance of additional dynamic loads, shock loads and vibrations, which, in turn, cause the development of fretting corrosion and premature destruction of parts. To reduce the friction force, it is proposed to use special coatings of the conjugate elements of the manipulator hinges, in particular lead, phosphate and indium. It has been proven that the intensity of contact wear can be significantly reduced by using lubricants based on oils and fats, as well as greases, which at a temperature of 25 °C acquire a thick, ointment-like consistency. In addition, the feasibility of using phosphate and anodic metal coatings, which contribute to better retention of lubricants on friction surfaces, increasing the efficiency of their operation and the durability of the units, has been determined.

In the scientific paper [25], a method for synthesizing the trajectory of a manipulator robot taking into account its degrees of mobility is considered. It is shown that the bending of the rod forms support reactions in the contact zone, similar to the work of a beam resting on two supports. Based on the determined contact pressure, it is possible to estimate the potential wear processes of the surfaces of the hydraulic cylinder, rod, and grounding bushing. It was established that even in the absence of a complete risk of loss of strength by the rod during bending, contact stresses that reach approximately one third of the material's tensile strength can significantly accelerate the wear of friction surfaces. This approach allows us to more accurately explain the causes of the formation of characteristic wear patterns and determine the features of their identification. The materials of the article [26] present the results of the analysis of the design features of the grippers of the manipulators of body garbage trucks and the study of their reliability. Based on the conducted research, a calculation model of a garbage truck was developed, which was considered as an oscillatory system. The analysis revealed the peculiarities of the oscillations of the garbage truck frame during operation, and revealed the regularities of the formation of forces in the interaction of the elements of the “grab - tank -

grab" system. Studies have shown that the greatest loads fall on the traction and rod of the hydraulic cylinder, and these loads increase with increasing container mass. At the same time, a change in the mass of the garbage truck itself does not affect the magnitude or amplitude of the loads, but leads to a change in their frequency characteristic. During operational observations, it was found that the main cause of garbage truck failures is wear and corrosion of the working surfaces of the working equipment parts. In particular, 32% of all failures in the hydraulic drive system occur in hydraulic cylinders. Failures of these units are associated with wear of the working surfaces of the mating parts, deformations of the rod and cylinder under the action of operational loads that arise due to uneven body loading, as well as abrasive wear in difficult operating conditions. The main factor in the failure of the hydraulic drive is the intensive wear of the working surfaces of the key parts of its design, in particular the spools and housings of the hydraulic distributors, as well as the rods of the hydraulic cylinders. An additional factor of degradation is hydroabrasive damage, which occurs as a result of untimely replacement of the working hydraulic fluid and the use of poor-quality or worn sealing elements, such as hydraulic cylinder seals. This leads to the penetration of dust particles and wear products into the sliding zone, which significantly accelerates the destruction of the working surfaces. To increase the resource and restore the performance of the parts, it is recommended to use the technology of chrome plating in cold self-regulating electrolyte, which ensures the production of chrome coatings with high quality of the deposit, increased wear resistance and sufficient productivity, which makes it one of the most promising methods for restoring worn elements of hydraulic drives.

In [27], an analytical study of a linearized improved mathematical model of the functioning of the hydraulic drive of the mechanism for loading municipal solid waste into a garbage truck was conducted. The developed model takes into account the main design and operational parameters of the hydraulic system, in particular, the characteristics of the hydraulic cylinders, pressure losses in the hydraulic lines and the influence of external loads. Linearization of the equations of motion made it possible to obtain analytical dependencies suitable for further engineering analysis and assessment of the dynamic operating modes of the mechanism. As a result of the study, in particular, an approximate dependence of the duration of container overturning was obtained, taking into account the wear of friction pairs in the hydraulic cylinder and hinge joints.

In the materials of the article [28], an improved nonlinear mathematical model of the operation of the hydraulic drive of the mechanism for loading municipal solid waste into a garbage truck during container overturning is proposed, which takes into account the wear of friction pairs and allowed us to numerically study the dynamics of this drive during start-up and determine that taking into account the wear of friction pairs significantly affects the main parameters of the hydraulic drive for container overturning during loading municipal solid waste into a garbage truck. It was established that the duration of container overturning during loading municipal solid waste into a garbage truck increases in a power-law relationship with increasing wear of the hydraulic cylinder.

According to the resolution of the Cabinet of Ministers of Ukraine No. 265 [29], one of the priority areas of state policy in the field of municipal solid waste management is ensuring the introduction of modern, highly efficient and environmentally safe garbage trucks that meet European standards. This involves the modernization of existing rolling stock, improvement of basic model designs, use of energy-saving hydraulic drives and automated process control systems.

In this regard, determining the regression dependence of the duration of loading municipal solid waste into a garbage truck on the clamping force of the container, which can be used in the development of a methodology for engineering calculations of the parameters of the mechanism for loading municipal solid waste into a garbage truck, is a relevant scientific and technical problem. Solving this problem will allow increasing the productivity of municipal equipment, reducing fuel consumption, reducing the time for performing technological operations and ensuring environmental safety during the operation of garbage trucks.

Table 1 shows the values of the duration of loading municipal solid waste into a garbage truck for different clamping forces of a container weighing 150 kg [30].

Table 1 – The value of the duration of loading municipal solid waste into a garbage truck for different container clamping forces [24]

Container clamping force, kN	0.6	1	1.8	1.96	2.1
Duration of loading municipal solid waste into a garbage truck, s	15.3	16	16.8	35.6	35.9

Using the data in Table 1 by the least squares method [31] using the developed computer program "RegAnaliz", which is protected by a certificate of copyright registration for the work [32], and described in detail in the works [33, 34], it is possible to obtain a pairwise regression dependence describing the dependence of the duration of loading municipal solid waste into a garbage truck on the clamping force of the container, which requires further research.

Conclusion

Data are provided on the duration of loading municipal solid waste into a garbage truck depending on the clamping force of the container.

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