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Analysis of Literatures on Increasing the Energy Efficiency of Excavators

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Abstract:

This article analyzes scientific and scientific-practical research on the improvement of a single-bucket excavator.

Keywords: excavator, analysis, research, improvement.

Introduction

Earthworks are one of the most expensive, but at the same time promising types of construction work. In the valuation, their participation is more than 10% [1]. When performing road construction works, earth-moving machines are involved, mainly with a bucket capacity of 0.15 ... 4.0 m3. The maximum use falls on excavators of the 4th and 5th groups (bucket capacity 0.65 and 1 m3).

Main Part

In a market economy, the replacement and modernization of the actual fleet of single-bucket excavators becomes problematic due to the unreasonably high rate of formation of depreciation funds in comparison with the increase in prices for functional analogues of heavy road construction equipment that is planned to be retired from the work process. In the current circumstances, in order to ensure the accelerated pace of development of the construction industry and a significant reduction in the accompanying operating costs, an increase in the efficiency and completeness of the use of the capacity of the existing fleet of earthmoving equipment is possible by improving the performance of the workflow. An increase in the reliability of units and mechanisms of road-building machines is possible by reducing energy consumption and improving the dynamic characteristics of the working process [2,3]. The urgency of the task increases with the deterioration of the operating conditions for the development of a soil environment with high rheological and strength characteristics.

One of the possible ways to solve a particular problem is the use of active replacement working equipment, based on a decrease in the strength characteristics of soil masses, subject to subsequent excavation due to its softening [4,5,6].

A number of excavators of various size groups have mechanisms that automate some soil excavation operations. Many shovel excavators are versatile machines with a variety of quick-change working equipment. The mechanization of the processes of crushing and removing oversized and boulders, finishing the surface of the slopes of an earthen structure and the bottom of excavations, loosening frozen and hard-to-dig soil is provided by the shift of working equipment [7].

The results of the analysis of technical materials confirm that the intensification of the development of energy-efficient working bodies (EEW) is increasing in the direction of complicating their design: manipulating working equipment, working bodies of intensifying action, etc. There is no doubt that the level of complexity of design tasks will only increase.

One of the topical issues of increasing technological capabilities, improving the energy efficiency of the use of modern road construction machines, in particular single-bucket excavators, is the expansion of the range of interchangeable working equipment of effective action. Modeling, development and production of excavators and interchangeable working equipment for them is carried out by the English company JCB, the world-famous concern Hitachi, LLC Komatsu CIS, the machine-building company KRANEKS, Ivanovo, Kovrov, Voronezh, Yaroslavl, Tver excavator plants, Omsk transport engineering plant and many other organizations.

The problems of the effectiveness of the use of the developed equipment by world manufacturers are solved considering the characteristics of the developed soil and the technical characteristics of the hydraulic drive of the base machine [7,8].

At the same time, a significant number of failures in the design of the working body in contact with the soil medium was recorded. The most characteristic are the violation of the design geometry of the teeth and significant reactive forces that prevent the destruction of the soil mass. Many researchers have come to the unanimous conclusion that the resistance forces in the development of soils depend not only on the rheological properties of the soil, but also on the design and kinematic features of the working body. As a result of the research carried out by N.S. Galdin, R.A. Kabashev, V.N. Kuznetsova, M.S. Kulgildinov, A.S. Rebrov [9,10,11,12] found that the angles of the teeth on the bucket, the design geometry of the bucket and the energy efficiency of the working body are far from optimal values. These factors create unsatisfactory dynamics of the working process, which significantly reduces the values of the bucket filling factor during the loading period.

In solving problems of optimizing the design geometry of the teeth of the working body of earth-moving machines, the researcher V.N. Kuznetsova developed a mathematical model of the dynamic interaction of the working body of the ripper with the soil, considering the spatial distribution of forces. Also V.N. Kuznetsova proposed a methodological framework that determines the optimally effective parameters of the ripper.

In the works of the Kazakh scientist R.A. Kabashev reflects the results of research in the field of predicting the wear of the working bodies of earth-moving machines. He proposed mathematical models of cutting-edge wear depending on the environment and soil category. R.A. Kabashev substantiated the hypothesis that when the excavator teeth wear out, additional cutting forces create a critically stressed state of their working body and significantly reduce the reliability of the machine. He also developed a method for calculating the durability of the working body of the excavator, considering the change in the projection of the acting forces on the worn teeth of the bucket.

A.S. Rebrov [13] in his work established the main parameters of the teeth depending on the bucket capacity. To exclude the front wall of the bucket from the digging process, A.S. Rebrov [13] proposed optimal values for the initial shape and radius of the tooth point. This provision is currently relevant for almost all excavators made in Russia.

Basically, all scientists are unanimous that the prevailing value of the soil excavation resistance force extends to the frontal parts of the cutting working bodies of rippers and the teeth of excavator buckets.

Of the variety of soil development methods, high efficiency is observed with the active method [14,15,16]. The use of active working equipment increases the efficiency of machines in the development of frozen soil. A reasonable choice of working, design and energy parameters of active working bodies form the productivity of machines [17,18,19,20,21,22,23].

The use of such machines makes it possible to significantly increase the force on the cutting edge of the working body in comparison with the characteristics of the machine developed due to its capacities. As a positive fact, it can be noted that the impact of active and reactive forces on the main machine is reduced, which ensures the durability and reliability of its operation.

The development of a structurally weakened array requires significantly less energy consumption, which increases the reliability of the equipment and reduces specific operating costs. The significance of this provision is especially high in the development of powerful excavation equipment, in which design flaws were made.

Proceedings of Professor N.S. Galdin are devoted to the study of soil destruction processes using active equipment. N.S. Galdin developed mathematical models of the active working body, substantiated the main factors influencing the process of soil destruction by the active action ripper tooth, and also laid the foundations for creating a successful computer-aided modeling system.

Conclusion

Practical experience and the available scientific and technical potential for improving the efficiency of methods for developing soils of various categories shows that the use of energy-efficient working bodies of active action makes it possible to increase the efficiency of the use of earth-moving equipment and increase the overhaul periods of its reliable operation in the processes of construction production. However, the problem of efficient redistribution of energy (hydraulic drive and power plant) at various stages of the technological process of excavation with an excavator remains unresolved.

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