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Automatic control of supplying the uninterrupted action loading machine at casual outside influence

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Abstract

The condition of the loading process research, working out the principles and installations of automatic control of supplying the loading machines with grabbing claws is considered. The experience of application of discrete control system with regulated upper and lower levels of turning in the adjusters of loading the grabbing part engines is based. The task of automatic control providing, with the consideration of occasional character of forming the load with the grabbing claws, the achievement of maximum productivity at keeping power and energy limits, is formulated. The necessary mathematical models and control algorithms, the peculiarity of which is preliminary modeling of the process, putting the results into the system of microprocessing control and consideration of deviations from the standard variant, are worked out. Using the offered system provides with the productivity increase up to 15 %, increasing the reliability and reducing labour capacity in the machine control.

1. Introduction

Loading machine with grabbing claws was patented for the first time by Joseph Joy in 1916. The unique trajectory of the claws movement became the standard in the branch and is used at underground loading macines, and cutting combines all over the world. The machines of 2PNB-2 type produced in Russia are the greatest part of the loading machines parks at the Eastern Donetsk Basin mines. They are equipped with twin grabbing claws and, in

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spite of their having been industrially produced, are hand-operated. Casual character of forming loads to the drive of grabbing claws mechanism owing to non-homogeneous characteristics of the pile material and changing conditions of forming the volumes of grabbing the material with the claws makes impossible to use the machine resources completely even at the considerable experiences of the operator. In consequence of it the problem of creating an automatic equipment which would give the possibility to increase the reliability and efficiency of the machine in the whole and decrease the labour capacity of the loading process for the operator is quite actual.

2. Short history of working out the system of controlling supply

The collective bodies of scientists of the Novocherkassk polytechnical institute (now Platov South-Russian state polytechnic university (NPI)) [1, 2], the Communarsk mining metallurgical institute (the town of Altchevsk, Ukrainian SSR) [3], the institute of geotechnical mechanics of the Academy of Science of the Ukrainian SSR (the city of Dnepropetrovsk) [4], as well as the Copeisk and Yasnogorsk plants producing the machines of this type had been going in for working out the systems of the automatic control of the loading machines of the PNB type during the last 50 years.

The main problem is the principle of the supply control which is determined with physics of the process of interaction of grabbing claws with the pile. The two conceptions are based: 1) the velocity of automatic supply should change smoothly into the functions of loading in the drive of the grabbing part [1]; 2) interrupted supply of the machine the beginning and ending of the cycle of which depend on the level of load in the drive [2]. Among the realized in the experimental and tested models there were machines with a regulated drive of direct current [3], double-differential hydrodrive [1], asynchronous drive with relay-controlled and impulsive regulators [2, 5]. Produced by the Copeisk machine building plant the machine 1PNB-2D with relay-controlled regulator of supplying passed industrial test successfully [2, 5], other models were tested in stand conditions.

3. Peculiarities of the loading machine interaction with the mining mass pile

Working out the system of automatic control of supplying the loading machine should be based on the results of the analysis of interactions in the system of "the pile – loading organ – travelling part – drive – control system".

The conclusions about the interaction of the pile and the loading organ of the machine with grabbing claws are based both on the materials of the preceding research [6-8] including the loading organs with grabbing spiders having the similar regularities [9, 10], and on the results of computer and physical modeling conducted in the mechatronic system of automatic control [1-4, 11, 12]. The interaction of the control system and the loading machines is reflected in the works [13-15], the influence of casual processes at loading large lumps material is reflected in the works [16, 17].

As the preceding investigations showed, at loading the pile of large lumps rock of more than 0.5 m high, discrete supplying control (i.e. the cycle of supplying should include 2-4 scooping) is the most effective. However, unlike the previously created relay regulator [3], for the concrete conditions automatic choice of regulating parameters should be realized, i.e. the upper J_u and lower J_l levels of turning in the adjusters of loading in dependence on the current load to the drive of the aggregate of limitations. When the loading reaches the meaning J_u, the supplying stops, when the loading reaches the meaning J_l, the supplying renews. Besides, on the previous investigations casual character of forming loads is not considered, but it is especially essential at loading large lump material.

Load M to the claws, and therefore the current of engines of the grabbing part in the period of every disc rotation is the separate realization of the casual function M from corner of turning the driving crank φ. Moreover, the considered casual function $M = f(\varphi)$ has a number of peculiarities:

- mathematical expectation and correlative function at changing the corner of turning $0 \le \varphi \le 2\pi$ do not stay constant but consist conditionally of four parts – inculcation of the claw into the pile, scooping the portion of the material, pushing the portion of the material into the conveyer and idle running;
- in the process of loading the machine and the loading organ installed on it are in two conditions:
  - immovable – with working some quantity of scooping;
  - supplying – moving the machine to the pile. In each of these conditions some conditional depth of inculcation and the volume of the material in the active zone is realized, that is why the characteristics of the