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ADAPTIVE SYSTEM OF CONTROLLING THE COARSE CRUSHING PROCESS

Summary. The linear model of a lump crusher KKD 1500/180 based on the comparative analysis of correlation and dispersion functions is proved in this article. To control the crusher performance the adaptive self-adjusted system is applied. The tuning of its parameters is performed on the basis of estimating the functions of spectral density of entrance and exit of the object. A block diagram of an adaptive control system of the crusher providing an aperiodic reaction with preset regulation time is proposed.

Keywords: crushing, adaptive control system, correlation function, dispersion function, spectral density.

Introduction

Automation of technological processes is one of the decisive factors to increase productivity, improve working conditions and increase economic indicators. High-speed and reliable facilities of management and control to provide target quality process are required to create new high-performance technological processes with a high speed of operation performance and considerable unity power.

Technological processes involved in concentrating production are rather typical objects of applying the methods of automatic control theory, but at the same time it is a particular area of automated control development as the called processes are subject to the action of casual indignations and possess considerable unsteadiness.

The process of coarse crushing is one of the main stages within the period of ore preparation. Therefore, organizing an effective control of crushing process is an actual task. In practice, stabilization systems of an active power of a crusher $P(t)$ at the preset level $P_{зад}$ by regulating an initial material stream of a crusher $Q(t)$ are the most widespread [1]. A block diagram of such regulation system is given in Fig. 1.

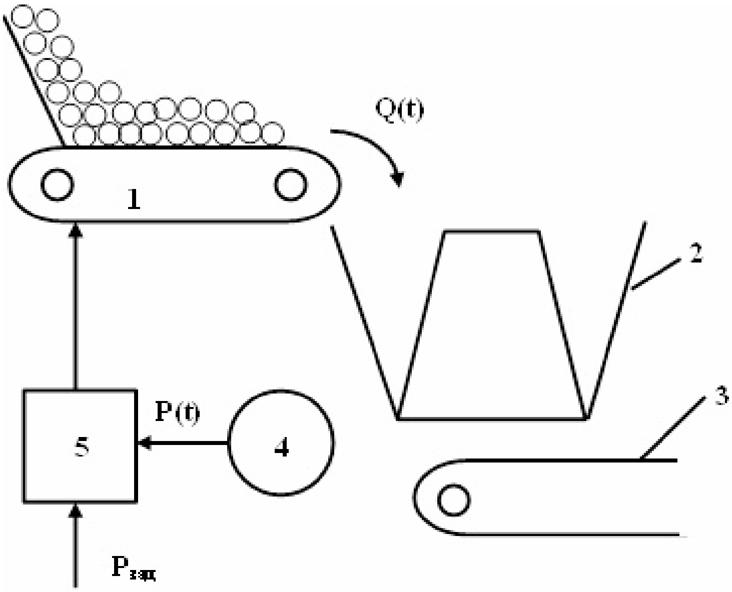

Figure 1–Block diagram of a crusher control system: 1 – a feeder; 2 – a crusher; 3 – an outfeed conveyor; 4 – an engine; 5 – a control unit

However, a rather simple problem of regulation becomes complicated due to the fact that the crusher as an object of control is a non-stationary object, whose parameters significantly depend on crushing material properties and a wear rate of a crusher working body. In such situation applying adaptive control systems is a viable option. [1, 2, 4, 6].

Analysis of current publications and formulation of research problem

Much attention was paid to the problem of developing the systems of automated, in particular, adaptive control of such processes as enrichment and ore preparation by a great number of researchers. So, one of the actual tasks arising while creating control systems is choosing the criteria and technique to identify model parameters. The methods of solving identification problems in an automated system designed tocontrol technological process of ore preparation are analysed in work [3].The complex method of identifying nonlinear dynamic processes of ore preparation is investigated. The application method to assess technological indicators of primary crushing quality of a jaw crusher of linear and square integrals establishing the connection of technological indicators of primary crushing quality with indirect integrated criteria of estimates and allowing to get sufficient reflection of the process peculiarities while changing unloading productivity and the level of crushing chamber filling is described in [5].

The system stabilizing the active power consumed by a crusher is considered in work [6] and the analytical self-adjusted system with the model of equation variations of the object [4] is applied to control a crusher. The systems of this type are constructed using the principle of forming two channels of signal transmission that allow compensating the indignant movements in the main contour generated by object unsteadiness.

Adaptive control efficiency is known to be defined in many respects by the time of selecting operational information relative to the object within the next quasi-steadiness period [7]. Therefore, the main objective of this work is to justify the structure of a crusher adequate model and organize the processing of operational information to assess its parameters.

Main part

Let us consider the process of creating the model of the crusher KKD 1500/180 along the channel of " aninitial material stream in a crusher $Q(t)$ which is the active power of the driving engine $P(t)$ ".In this case basic data are the processes of changing productivity $Q(t)\left[T/c\right]$ and power $P(t)\left[кВт\right]$ on a time interval $0 \div 400\,c$. This interval is much less than a quasi-steadiness period and therefore, the processes $Q(t)$ and $P(t)$ can also be considered as stationary. The correlation $k(\tau)$ and dispersion $D(\tau)$ functions constructed by the results of the realization process $P(t)$ are presented in Fig. 2. Dispersive function $D(\tau)$ defines the dependence of the correlative relation between the sections of the process $P(t)$ divided by an interval τ. Following the Fig. 2 we can conclude that $k(\tau)$ and $D(\tau)$ have slight difference. Therefore, it is possible to draw a conclusion that the crusher along a channel «$Q(t) - P(t)$» can be described by a linear model.

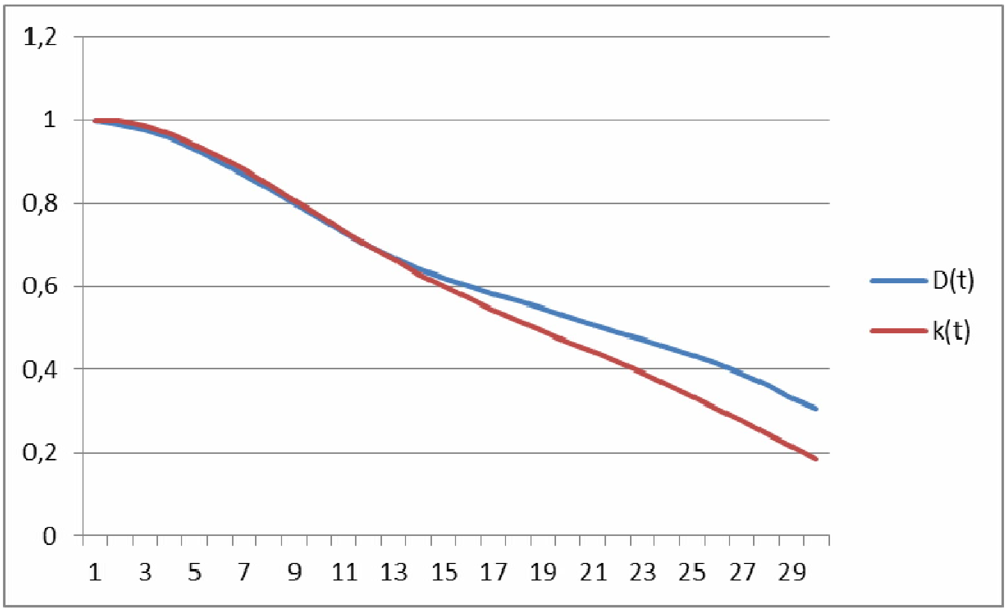

Figure 2– Correlative and dispersive functions of the process $P(t)$

Being directed by the practical expediency, the order of the differential equation of a conical crusher is chosen not higher than the second. Then a crusher transfer function along the channel «$Q(t) - P(t)$» is written as:

$$W_{BY}(p) = \frac{K}{T_1 p^2 + T_2 p + 1} \quad (1)$$

The graphs of spectral density $S_Q(\omega)$ and $S_P(\omega)$ of the processes $Q(t)$ and $P(t)$ respectively, for a certain quasi-steadiness period are submitted in Fig. 3

By applying the received functions of spectral process densities at the entrance and exit of the object it is possible to identify mathematical model parameters: K, T_1, T_2. We will designate $T \approx 400$ c as realization length $Q(t)$ and $P(t)$.

Then it is reasonable to estimate the transfer coefficient value K as the ratio of the values of an entrance stream $\vec{Q}$ and power $\vec{P}$ average on time on an interval T, i.e. $K = \frac{\vec{P}}{\vec{Q}}$. The obtained ratio of process spectral densities at the entrance $Q(t)$ and the exit $P(t)$ of a linear object was applied to calculate time constants T_1 and T_2 [2]:

$$S_P(\omega)=\left|W(j\omega)\right|^2 S_Q(\omega), \tag{2}$$

where $\left|W(j\omega)\right|^2$ is a square of the frequency characteristic module of the control object.

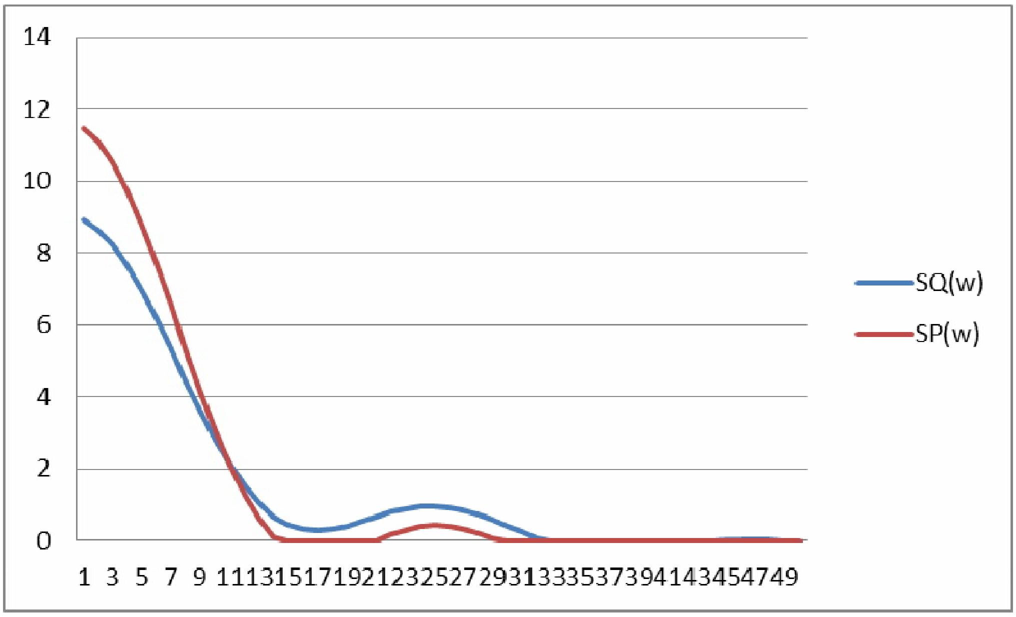

Figure 3– Graphs of the spectral density functions of processes $Q(t)$ and $P(t)$

As function $\left|W(j\omega)\right|^2$ depends on model parameters T_1 and T_2 of the object (1), a problem of their identification is reduced to the following optimizing task:

$$I(T_1,T_2)=\left[S_P(\omega)-\left|W(j\omega)\right|^2 S_Q(\omega)\right]^2 \to \min_{T_1,T_2} \tag{3}$$

According to the expression (3) the optimum values of parameters $T_1=15$ c; $T_2=8$ c providing the minimum value of the criterion $I(T_1;T_2)$ have been defined for spectral density functions presented in Fig. 3 As $T_2>2\sqrt{T_1}$ then roots of the characteristic equation of the model (1) are valid, and transfer function of the object can be set as the following:

$$W_{OY}=\frac{K}{(T_3p+1)(T_4p+1)}, \tag{4}$$

where $T_3\approx 5$ c; $T_4=3$ c.

The law of controlling the main contour of the adaptive system is chosen to provide good (or optimum) quality of transfer processes at the exit of the object (4). Fig. 4 demonstrates the block diagram of a control system where the main contour contains management object (4) and additionally two correcting devices W_{K1} и W_{K2} providing so-called aperiodic reaction [4] with reregulation being no more than 2% and preset time regulation.

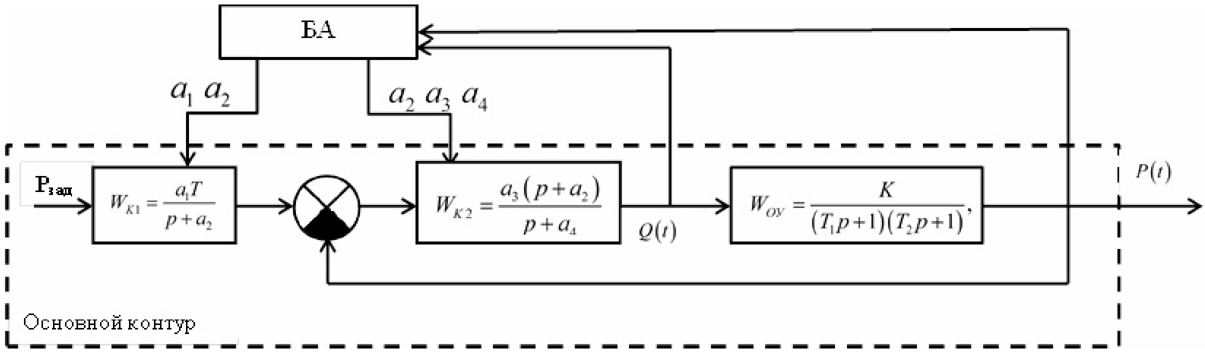

Figure 4– Block diagram of an adaptive control system

Setting parameters a_1, a_2, a_3, a_4 of correcting devices W_{K1} and W_{K2} is carried out at every period of quasi-steadiness in accordance with the estimates of model parameters of object K, T_1, T_2. Thus, the following operations are periodically performed in the adaptation block (AB):

1. The functions of the spectral planes $S_P(\omega)$ и $S_Q(\omega)$ are calculated after fulfilling the processes $Q(t)$, $P(t)$ within the interval $0 \div T$.

2. The value of object transfer coefficient is estimatedby $K = \vec{P} / \vec{Q}$.

3. The values of time constants T_1 и T_2 are calculated by solving an optimizing problem (3).

4. The parameters of the correcting devices a_1, a_2, a_3, a_4 providing aperiodic reaction in the main contour are calculated by applying a technique [4].

Conclusions

A linear structure of the model of a conical crusher KKD 1500/180 is stipulated based on the comparative analysis of correlation and dispersion functions of an object exit. The assessment of model parameters can be carried out based on estimating spectral density functions of a control object. A block diagram of adaptive system providing aperiodic reaction with reset regulation time is proposed.

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