UDC 794:622.765.55

N.S.Pryadko, G.M.Saksonov, E.V.Ternovaya

IMITATING MODEL OF THE MINERAL GRINDING CLOSED CYCLE

Introduction. Last time the closed cycles are widely used in mineral grunding technology for decrease of process power consumption. The main idea of the fine grinding closed cycle consists that from a mill due to carrying medium (water, air) movement obviously not enough ground material is taken off, which in the external qualifier (hydraulic and pneumatic qualifiers, cyclones, screens) is divided into ready according to its size product and larger, directed for regrinding to the same mill. Thus, an over grinding of material and mill power consumption is decreased. In work [1] circuits of the basic types of the grinding closed cycles are developed and the influence degree of a ground material sizing structure on a mill productivity is established.

The work purpose is grinding kinetics research in the technological circuit of the closed type. It is required to estimate influence of the basic technological parameters of grinding (dynamics of a material loading, grinding time, the initial fractional structure and required dispersion) on parameters of productivity. For achievement of the research purpose there were solved the following tasks:

1. Construction of imitating model of the process equipment interaction in set grinding circuits.
2. Carrying out of experiments, gathering and the statistics analysis of model behavior on the basis of the lead experiments.
3. Development of offers on grinding efficiency increase.

Grinding process of mineral raw material in the closed cycle is examined as dynamic system. As the dynamic system we consider an object or process for which the a condition concept as sets of some values at present time is unequivocally determined, and the law (evolution) which describes initial condition change eventually and allows to predict on an initial condition the future condition of dynamic system [2]. The choice of the evolution description law sets a concrete kind of mathematical model of corresponding dynamic system.

The conceptual model of researched system is submitted as the block diagram on fig. 1. The system consists of one material entrance stream (В), the store (Н), mill (М), the qualifier (К), a output stream (П). Realization of model examines a material movement in all technological system at the continuous closed grinding cycle (a bunker - feeder, a mill and the qualifier).

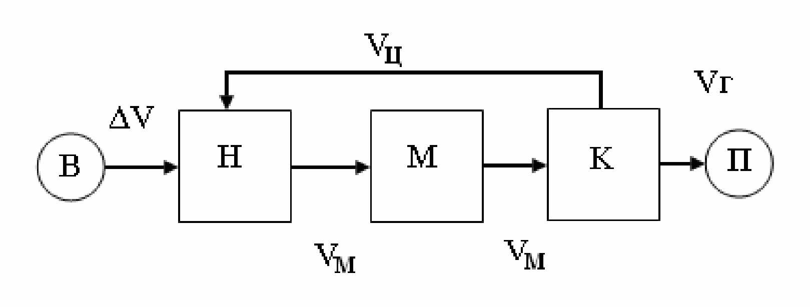

Fig. 1 The model block diagram

In model it is supposed, that the stream represents a different fractional mix of loose material B, discrete portions ΔV of which moves in store H at regular intervals Δt. During this time interval the portion of the material which is in store Vm, moves in a mill M, it is ground, and then product gets in the qualifier K. In the qualifier some volume of ready material Vг separates, and the volume of material Vц = Vм - Vг moves to the store. Thus, Vм = ΔV + Vг.

For keeping such balance it is supposed that during the initial moment of time in a mill there is a volume of material Vм, i.e. the first loading of volume ΔV in the store is carried out simultaneously with loading of a ready product Vг stream. For realization of this condition the switch K is included into the model block diagram, which at the moment of model start-up loads volume of material Vм into a mill, then switches and during all model operating time is in this state. In model it is supposed that the material volume Vм, acting in a mill, should be also constant and is accepted equal Vм = kм Vмел, where Vмел - a mill volume, kм - factor of a mill loading for which grinding process has the best efficiency. For definiteness according to experimental data it is accepted that kм = 0.75.

In a stationary mode the store receives material volume Vг, volume loading ΔV = kм Vмел - Vг is simultaneously generated. These two volumes added and move to the mill. Thus, the material volume ground in a mill is always constant but fractional material structure is various.

The fractional structure is changed in three units of the technological circuit: in the mixer where two streams with various sized particles move; in a mill where there is large size fraction grinding; in the qualifier where ready product fractions are separated. Therefore the material fractional structure a in model is changeable and is determined by factors k [x] *i*, where [x] is an index of a technological circuit zone where this factor is defined, and *i* is a number of a mix fraction. Thus ∑k [x] *i*=1.

On fig. 2 corresponding factors on various technological zones of grinding plant are shown.

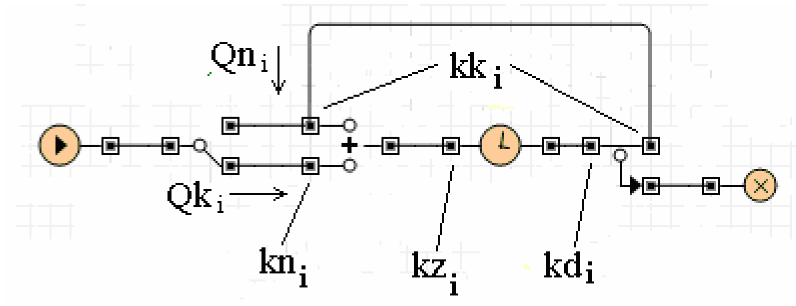

Fig. 2 Model block diagram in a stationary mode

At the initial moment of time (at the moment of model start-up) it is supposed, that the material fractional structure which is in a mill, corresponds to structure of a loading material stream and is determined by a matrix of factors *kni*

Material size composition loading to a mill is determined by dependence: $kz_i = (Qn_i \cdot kn_i + Qk_i \cdot kk_i) / \sum (Qn_i + Qk_i)$, where *Qni, Qki* - the *i* fraction charge from a feeder and a return flow (circulating loading), accordingly; *kni, kki* - size composition factors for the *i* fraction moving from a feeder and a return flow. The material size composition of a secondary material stream coming to the mill after the qualifier (circulating loading) is determined by dependence: $kk_i = \sum (Qn_i + Qk_i) kd_i / \sum (Qn_i + Qk_i)$.

The material size composition leaving the mill in this model is defined on a grinding kinetics basis, i.e. at grinding the material weight for the time Δt is defined by grinding selective function *Sij* which shows a share of *i* destroyed fraction for a time unit. In developed model selective function is set by a triangular matrix of grindability factors *aij*, determining a share of material volume which passes as a result of destruction from *i* fractions in *j* fraction and is defined by ratio $kd_n = kz_1 \cdot \sum_{j=1}^{8} a_{nj}, n = 1...8$, for definiteness it is chosen eight fractions.

The selective function matrix looks like $\begin{matrix} a_{11} & 0 \ldots & 0 \\ a_{12} & a_{22} \ldots & 0 \\ \ldots & \ldots & \\ a_{18} & a_{28} \ldots & a_{78} \end{matrix}$

As modeling tool it has been chosen the new generation tool of imitating modeling AnyLogic, supporting concepts and several modeling method means: discretely - event modeling, system dynamics and agent modeling [3]. The basic building blocks of AnyLogic model are active objects which allow modeling any objects of the real world. The active object is a corresponding class copy which is realized by creation of own active objects or use of AnyLogic library objects and their connection determining. AnyLogic interprets created classes of active objects in Java classes. Therefore the model allows using all advantages of object-oriented modeling.

During experiments on model the model parameter variation (volume of a loaded material and circulating loading, time of grinding and initial fractional structure and required dispersion) is carried out, dependences of these parameters on other parameters in time are received. Thus there is realized monitoring of technological circuit change of the basic structural elements, material size composition characteristics on each element of the technological circuit, stream sizes in each technological circuit branch, mill loading value during all process. Change research of an initial material and ready product connection has shown an existing dependence of mill productivity on its loading and an initial material size at the initial grinding stage. After a stable mill operating establishment productivity depends on a separate fraction ratio in material total amount before grinding and after it with other things being equal. It allows developing optimization criteria of a mill productivity management on the control basis of material loading volume and circulating loading taking into account the new specific material surface calculated on ratio of separate fractions.

After model tests expression for the switch K has been determined. It is named as an over grinding parameter and calculated like ration of the finniest fraction volume on a mill input to the largest fraction volume on a mill output where a product moves to qualifier, i.e. *K=kz5/kd1*. Thus, the material volume moving to the mill is defined by the formula $V_n = K \cdot км V_м - V_ц$.

On fig. 3 experimental results on influence definition of material dispersion on grinding plant productivity are shown.

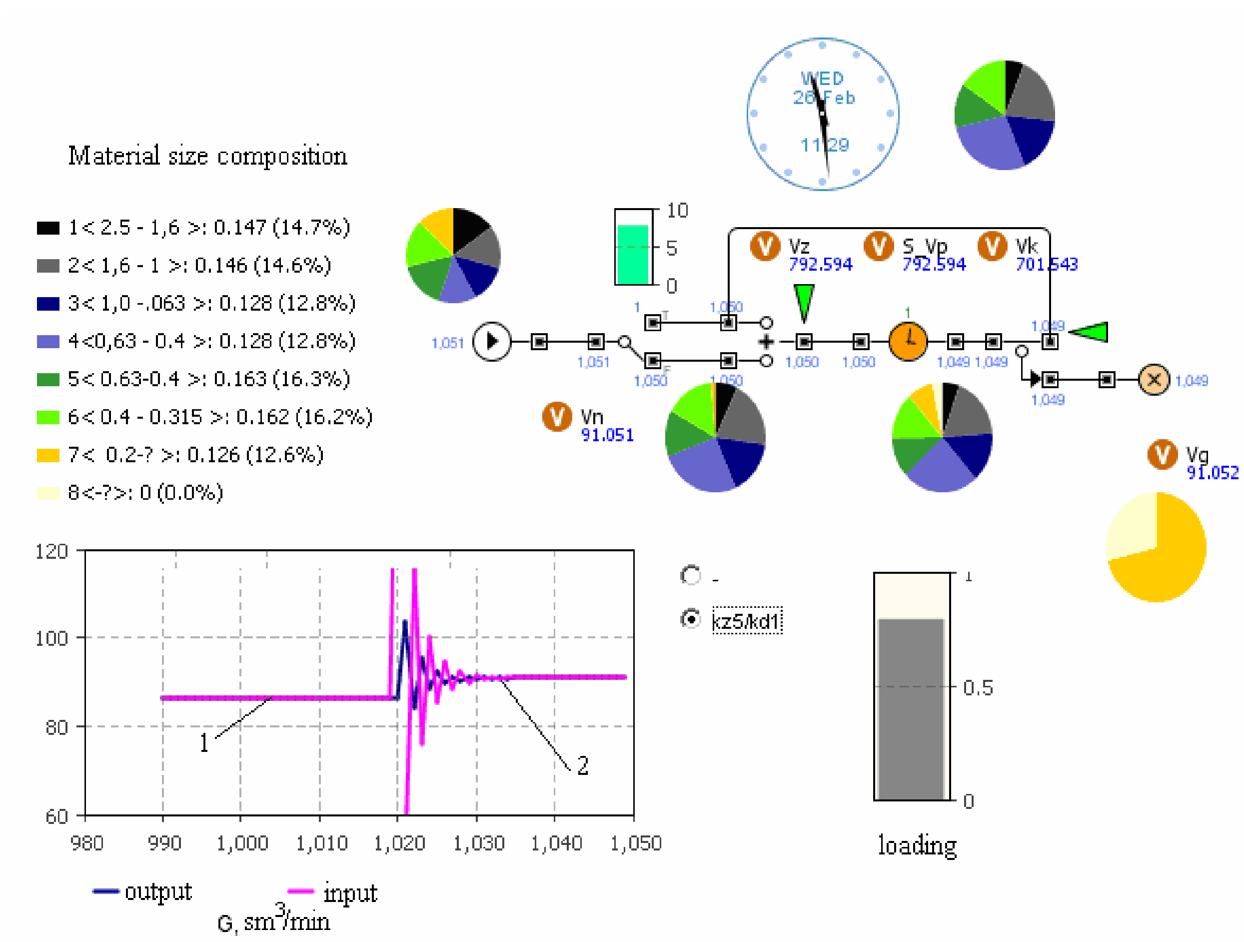

Fig. 3 General view of an operating program window at model tests

On schedule $G\ (t)$ fig. 3 figure 1 designates productivity at $K = 1$ i.e. when influence of acting fine fraction volume is not taken into account. After switching on an over grinding control mode, i.e. at К> 1, productivity increase on 5-7 % with other things being equal (a curve 2) is observed.

Conclusions

1. The application opportunity of developed modeling method for grinding process research in closed cycle technological circuits has been shown.

2. The model describes only fractional structure kinetics in units of the closed cycle technological circuit. Process dynamics in namely mill unit should be considered from other positions.

3. The described model can be used for creation of a technological process control system.

4. The developed model complex is necessary to investigate by the operation on a various standard size mills, particularly laboratory and industrial jet mills.

BIBLIOGRAPHY

1. Пилов П.И. Снижение энергопотребления в замкнутых циклах тонкого измельчения руд / П.И. Пилов, Н.С. Прядко //.– Металлургическая и горнорудная промышленность.– 2013.– вып. 6 .– С. 173 – 181.

2. Анищенко В.С. Знакомство с нелинейной динамикой: лекции соросовского профессора: Учеб. Пособие. Москва-Ижевск: Институт компьютерных исследований, 2002.-144с.

3. Киселева М. В. Имитационное моделирование систем в среде AnyLogic: учебно-методическое пособие / М. В. Киселева. Екатеринбург: УГТУ - УГЛИ, 2009. 88 с.