Ecological and economic optimization of iron ore processing automated control

Vladimir Morkun

Vice-Rector for research, Doctor of Science, Professor, Head of Computer Science, Automation and Control Systems department
State Higher Educational Institution "Kryvyi Rih National University", Ukraine

Vitaliy Tron

PhD, Senior lecturer of Computer Science, Automation and Control Systems department
State Higher Educational Institution "Kryvyi Rih National University", Ukraine

Abstract
The ore preparation technological complex control criteria considering the factors of energy efficiency, environmental and economic performance of mining factory are considered.
Keywords: CONTROL CRITERIA, ORE PREPARATION, ENERGY EFFICIENCY, ENVIRONMENTAL AND ECONOMIC INDICATORS.

For the automated control formation, an ecological-economic system should be viewed as a hierarchical controlled dynamic system [1, 2].
However, it is necessary to take into account, that the important indicator of the mining enterprises effectiveness is the cost price and power consumption reduction of the raw iron ore extraction and processing technological processes [3-5, 12-14]. In modern conditions, on average of 5–8 ore technological varieties is processed on mining enterprises [6]. At the same time the mining operations system does not allow to produce the same type of ore long enough, which

leads to instability of raw mineral material composition which input to the beneficiation.

For solving the problem of energy-efficient ore beneficiation automated process control it is advisable to allocate such components: providing the timely information on iron ore characteristics in process streams and technological processes parameters optimization on the basis of the obtained data. Since the issues of iron ore raw materials characteristics operational control at various stages of its processing using modern methods are well studied in the works [5,8,12-23], it is advisable to explore the issue of ore preparation automated control optimization, considering energy, environmental and economic factors.

In general, for the automated control of mining enterprises organizational and technical processes is necessary to process $\overline{\psi} = \{\psi_i \mid i = 1 \ldots N_r\}$ tons of ore, which is represented by a N_r number of technological species and to provide a certain enterprise production volume contractual obligations $\Omega(\overline{\psi}) = \Omega^* \in \left[\Omega^{(l)}, \Omega^{(h)}\right]$ with a minimum amount of harmful emissions into the environment $\Theta(\Omega, \overline{\psi}, t) \to \min$ and maximum profit $Pf(\Omega, \overline{\psi}, t) \to \max$ at a certain time interval of *t*.
In [7] proved, that for the assessment of enterprise environmental and economic performance it is useful to compare the value of its harmful effects, and profit from the iron-containing products production, which takes the following form, considering the need to redesign several varieties of iron ore

$$\frac{\Theta\left(\overline{\Omega}, \overline{\psi}, t\right)}{Pf\left(\overline{\Omega}, \overline{\psi}, t\right)} \to \min, \qquad (1)$$

where $\Theta\left(\overline{\Omega}, \overline{\psi}, t\right)$ – is the mining enterprise dust and gas emission in the interval of *t*, ton; $Pf\left(\overline{\Omega}, \overline{\psi}, t\right)$ – is the profit from the product sales on the interval of *t*, hrn.

The total mining enterprise dust and gas emission is defined by indicators of unorganized and organized dust and gas emission [7], thus it is necessary to take into account each of these parameters dependence on the amount of processed technological species

$$\Theta\left(\overline{\Omega}, \overline{\psi}, t\right) = \Theta'\left(\overline{\Omega}, \overline{\psi}, t\right) + \sum_{j=1}^{N_\Theta} \Theta''_j\left(\overline{\Omega}, \overline{\psi}, t\right) \qquad (2)$$

where $\Theta'\left(\overline{\Omega}, \overline{\psi}, t\right)$ – is the organized dust emission in the interval of *t*, ton; $\Theta''_j\left(\overline{\Omega}, \overline{\psi}, t\right)$ – is the *j*-unorganized dust emission rate in the interval of *t*, ton.

The mining factory production profit considering the results obtained in [7] in terms of processing several technological variations of ore is given by, UAH

$$Pf\left(\overline{\Omega}, \overline{\psi}, t\right) = \sum_{i=1}^{N_\Omega} \Omega_i\left(\overline{\psi}, t\right) \cdot \mathrm{Pr}_{\Omega\, i}\left(\overline{\psi}, t\right) - \left[\sum_{i=1}^{N_\Omega} \Omega_i\left(\overline{\psi}, t\right) \cdot E_{\Omega\, i}\left(\overline{\psi}, t\right)\right]$$

(3)

where $\Omega_i\left(\overline{\psi}, t\right)$ – is the *i*-th names production output amount in the interval of *t* considering processing volumes of individual technological varieties,ton;
$\mathrm{Pr}_{\Omega\, i}\left(\overline{\psi}, t\right)$ – is the wholesale price of the *i*-th product names in the interval of *t*, hrn; N_Ω – is the number of the plant production names; $E_{\Omega\, i}\left(\overline{\psi}, t\right)$ – is the specific operating costs for the *i*-th name of the product, hrn/ton.

Considering the dependences (2) and (3) the ecological and economic efficiency criterion (1) of mining and processing plant which processing several ore technological types when optimizing the period consisting of T slots, will take the form

$$J_\Theta\left(\overline{\psi}\right) = \max_{t=1\sim T}\left\{\frac{\left[\Theta'\left(\overline{\Omega}, \overline{\psi}, t\right)\right] + \sum_{j=1}^{N_\Theta}\left[\Theta''_j\left(\overline{\Omega}, \overline{\psi}, t\right)\right]}{\sum_{i=1}^{N_\Omega} \Omega_i\left(\overline{\psi}, t\right) \cdot \mathrm{Pr}_{\Omega\, i}\left(\overline{\psi}, t\right) - \left[\sum_{i=1}^{N_\Omega} \Omega_i\left(\overline{\psi}, t\right) \cdot E_{\Omega\, i}(t)\right]}\right\} \to \min, \qquad (4)$$

It should be noted that in the market relations conditions the volume, mineral content, wholesale price and other characteristics of the mining enterprises products rather rigidly limited to contractual obligations to consumers. In other words, to significantly reduce harmful emissions into the environment due to the decrease in production volumes is impractical.

To meet the energy efficiency terms, as well as beneficiation features outlined in [9], it is appropriate to use the following criteria proposed in [8]: concentrate residues amount minimization in stock, the process equipment utilization rate maximizing, specific weight stabilization of each technological variety in the input stream.

It is necessary to consider the constraints posed by the technological process and mine raw ore limited supplies in the current period, the process equipment limited capacity and the preventive maintenance schedule, fixed in the contractual commitments concentrate amount and mineral content in it described in detail in [8]

Thus, the ore preparation generalized energy-efficient control criterion considering ecological and economic factors of the mining and processing plant activities it is advisable to form a conflict situations modeling device [11], taking into account the importance of each particular criterion.

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