UDC 681.5.015 : 622.771

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APPLICATION OF MODEL PREDICTIVE CONTROL IN THE GRINDING AND CLASSIFICATION PROCESSES OF IRON ORE

A contemporary, formalized approach to synthesizing control systems through mathematical optimization methods is encapsulated in the theory of Model Predictive Control (MPC). This theory focuses on the control of dynamic objects using predictive models.

This approach was initially employed for controlling processes where the use of traditional methods proved extremely challenging, due to the intricate complexity of their mathematical models. Recently, the application domain of MPC has seen considerable expansion, now encompassing a diverse range of technological sectors. This includes industries such as chemical processing, where precise control of reactions is crucial; automotive, particularly in advanced driver-assistance systems; aerospace, for optimizing flight control systems; energy, in managing smart grid operations; and pharmaceuticals, for controlling drug manufacturing processes. This widespread adoption highlights MPC's adaptability and effectiveness in managing complex, multivariable systems across varied industrial landscapes [1,2].

The main advantages of MPC are: solving the problem of constrained optimal control regardless of the level of complexity of the object; consideration of current and future constraints on state variables and control function; multi-criteria optimization; simple scaling of the principle of control algorithm construction from a single-connected system to a multi-connected one, from linear to nonlinear; realization of the state observer based on the same model used for predicting the object motion; realization of an observer of external disturbances based on the same model that is used to predict the object motion; possibility to apply both continuous and discontinuous control functions; clear determinism of the algorithm and no need for preliminary training [3-5].

Among the actual theoretical problems of MPC, we can mention the following: the problem of control system stability to inaccuracies of the mathematical model [3]. The existing approaches to its solution are difficult to realize in practice because they require significant computational resources; consideration of random perturbations that may occur in the system at future moments [4]; development of effective methods for building nonlinear models of complex technological processes for the realization of nonlinear MPC [5].

In the initial stage of grinding and classification of iron ore, MPC can effectively manage the key technological parameters that influence the quality of raw material processing. This includes the control of iron ore feed volumes into the mill, which vary based on mineralogical and technological characteristics, as well as the content of valuable components in the ore. Additionally, MPC can regulate the volumetric filling of the mill with ore material and the ball load, ensuring optimal processing efficiency. Furthermore, it can maintain desired density modes in both the mill and classifier, thereby enhancing the overall effectiveness of the iron ore processing system. These capabilities demonstrate MPC's significant role in optimizing the processing stages for better quality and efficiency.

Optimizing the parameters of the technological process will enable the achievement of maximum ore grain liberation, enhance the energy efficiency of the processing, reduce iron losses to tailings, and improve the quality of the iron ore concentrate. This approach underscores the importance of precise control in maximizing both the efficacy and sustainability of ore processing operations.

References

1. **Camacho E.F., Bordons C.** Model predictive control. London: Springer-Verlag, 2004. 405 p.
2. **Qin S. J., Badgwell T. A.** A survey of industrial model predictive control technology. Control Engineering Practice. 2003. Vol. 11, no. 7. P. 733–764. https://doi.org/10.1016/s0967-0661(02)00186-7.
3. **Rawlings J. B.** Tutorial overview of model predictive control, IEEE Control Systems Magazine, 20(3) : 38-43, 2000.
4. **Van Hessem, D.H.** Stochastic inequality constrained closed-loop model predictive control with application to chemical process operation, PhD Thesis, Dup Science, The Netherlands, 2004. ISBN 90-407-2489-X
5. **Henson M. A1.,** Nonlinear model predictive control: current status and future directions, Computers chem. Eng., vol.23, 187-202, 1998.