CSITA
ISSN 2414-9055

UDC 622.7: 658.562
https://doi.org/10.31721/2414-9055.2017.3.2.4

AUTOMATED CONTROL OF CLASSIFICATION IN A HYDROCYCLONE WITH INCOMPLETE INFORMATION

SAVYTSKYI A.I., PhD, Associated Professor, TYMOSHENKO M.A., PhD-student
Kryvyi Rih National University

Abstract. The main areas of achievement of economic benefit in iron ore enriching is to increase the productivity of production units and improving the quality of the product, which requires a complex automation of enrichment processes. Control of processing complex is costly – expensive measuring equipment and considerable computing power. In addition, iron ore beneficiation process should be viewed as a distributed system consisting of separate processes with separate control systems, interconnected and influenced each other. Considering hydrocyclone of one single, the second stage of grinding, can greatly simplify the calculations and allow to consider possible reaction. It is advisable to use modern intelligent automated management tools - optimum and adaptive control, means of artificial intelligence, fuzzy logic, genetic algorithms, hybrid models. Studies show that the fuzzy control of hydrocyclone of second stage of grinding allows to take into account a lot of dependencies and develop the controlling influences, dependent on many parameters. In addition, this approach allows to work in the face of uncertain parameters. The presented control system learns and configures itself, as well as takes into account the link with the previous and subsequent grinding stage, affecting the overall distributed system. Further studies suggest a deeper study of the relationship between the mechanisms of the various grinding stages.

Keywords. Hydrocyclone, enrichment, control system, distributed systems, fuzzy logic.

Introduction. Taking into account the trends in the development of the modern world market the main direction of improvement of production is to reduce the cost of the product. This goal is achieved through a comprehensive optimization of production processes through the introduction of modern technologies. It is improving the quality of the automation of industrial processes is the main way in addressing the issue of energy production.

Enrichment complex includes many technological units that perform different operations and are different in design, which respectively require different approaches in the construction and implementation of control systems. In addition, the enrichment devices are in the relationship and a direct impact on each other's work; require many measuring devices, fixing various physical quantities, which leads to an increase in computing power required

These difficulties can be avoided by using a distributed control. Considering the complex of enrichment of iron ore as one big system of decentralized allocation mechanisms, that are in a constant relationship, can be synthesized the control system for each mechanism of each stage individually. This approach makes it possible to increase the speed and reduce the load on the overall system and reduce the requirements for computing power of the executive system [3].

Materials and methods. Earlier [4] considered the enrichment process control system based on the use of means of fuzzy logic. Let us consider a separate hydrocyclone separation processes in the second stage.

At effective work the automatic control system optimizes hydrocyclone qualitative and quantitative parameters of the flow with a reduction in the cost of the concentrate as a whole. Regulation of the hydrocyclone is directed to achieve two objectives: quantitative (productivity of the finished product) and qualitative (separation efficiency and particle size distribution).

Also, the hydrocyclone is inappropriate to consider separately from the sump associated with the previous grinding stage, and it also increases the number of parameters considered in the control of technological mechanism. Automatic control system of complex object should be based on algorithms that do not require extensive prior information about the control object [9-12].

Namely, the difficulty of compiling a mathematical model of the hydrocyclone determines the use of modern intellectual means, including the means of fuzzy logic.

In technological schemes of concentrators in the second stage are generally applied several hydrocyclones (each with its own drive). We will assume that the rest of the hydrocyclones is fully loaded according to the design standards and performance stage oscillation occurs only in the performance of one hydrocyclone. The control circuit is shown in figure 1.

The control system includes density sensors DT, that measure the density of the overflow and underflow (ρ_{over} and ρ_{under}); level sensor LT, which measures the height of pulp level (h) in the hydrocyclones sump; Flows FT, reflecting performance on input, overflow and underflow (Q_{input}, Q_{under} and Q_{over}) and a pressure gauge PT for measuring the pressure (P) in the pump of hydrocyclone. Also, using the frequency converter (FC) data on the pump motor speed is separately processed.

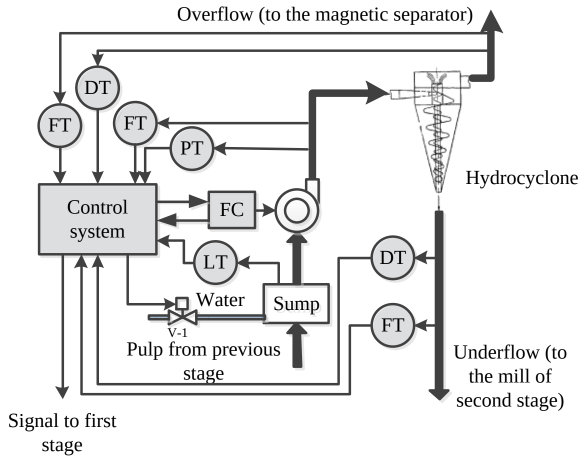

Figure 1. Scheme of hydrocyclone of second stage of enrichment

On the basis of the collected data control system calculates the value of the manipulated variable. Control is performed by adding water to the sump, if necessary, and adjusting the motor speed of hydrocyclones pump via the frequency converter. The basis of control is to maintain performance ratio of the sink and of the sand at a certain level. This is expressed by criterion

$$K = Q_{over}/Q_{under}; \quad \rho_{over} \le \rho_{over.n}; \ \rho_{under} \ge \rho_{under.n} \quad (1)$$

With adaptive approach to the construction of fuzzy control systems tuning of fuzzy inference blocks is carried out not only in the design process, but also during the normal operation of the system, in parallel with the object control process. Adaptive systems allow you to control the complex better, as in our case, non-stationary objects in comparison with conventional systems.

Results. In the circuit of Fig. 2 are used feedback controllers made on fuzzy networks FN1 and FN3 trained through identifier FN2. Learning through identity rather than directly on the object is needed to "do not disturb" the normal functioning of an object with trial impacts, used for training [16].

The disadvantages of the scheme can be attributed to the high demands on computing resources. The proposed control system is shown in Fig. 2. In Figure 2, the following notation: FC - frequency converter of motor; P - pump; HC - hydrocyclone; FN - fuzzy networks; V-1 - valve. FN1 based on the error signal e1, obtained from the difference between setting signal U $F_{eng.}$ and engine signal $F_{eng.}$, produces a control action on the FC. Reference signal of pulp level in the sump Uh with the received actual signal (h) gives error e2 coming to FN3, which controls the valve V-1 and, respectively, feeding process of water to the sump.

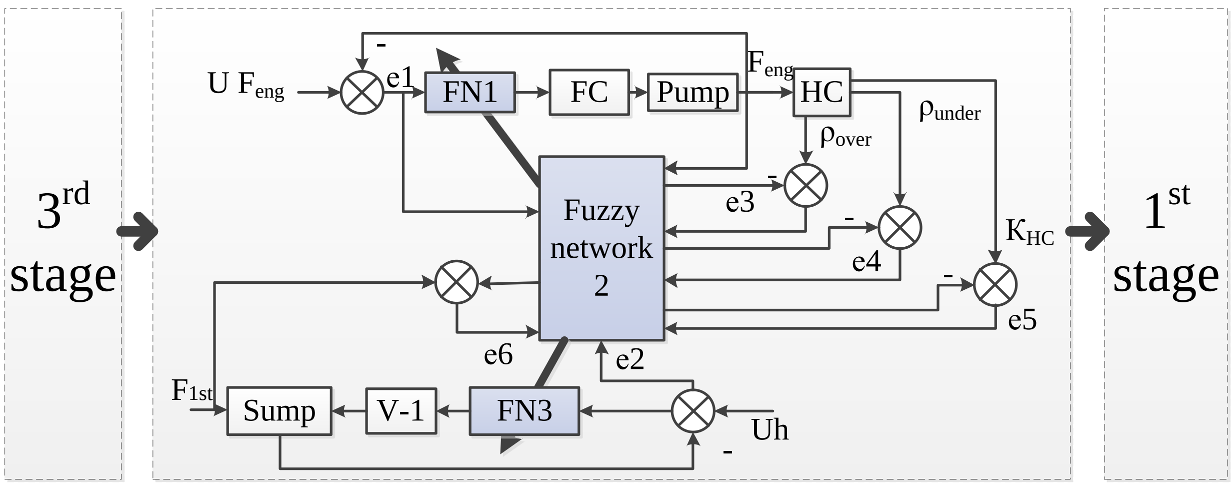

Figure 2. Algorithmic block diagram of the 2nd stage control system with uncertain parameters

The pulp level in the sump is also regulated in accordance with the productivity of the previous first stage (F 1st). Errors e3, e4 and e5, obtained as the difference between setting actions and measured on the hydrocyclone outputs parameter of density of the overflow and underflow (ρ_{over} and ρ_{under}) and ratio of productivities of the overflow and of the underflow (K_{HC}) is also provided to the FN2, as before considered e1, e2 and e6. On the basis of the error signal FN2 trains FN1 and FN3, and sends a signal to the FN of the first stage (block 1st stage). Also control system command signal from 3rd stage.

Conclusions. The proposed control scheme of hydrocyclone of the second stage of enrichment can improve the separation efficiency by increasing the density at its output by controlling the material feed to the hydrocyclone input, namely its feed speed while maintaining a constant pulp level in the sump of the hydrocyclone. Due to the fluctuations of characteristics of the input flow of pulp the most appropriate control system is a fuzzy system. When reaching the extreme values of adjustable parameters of the second stage, a correction signal is generated on the pulp parameters supplied from the first enrichment stage. Directions for further research are to improve relations with the mechanisms of the preceding and following stages.

References

1. Bogdanov O.S. Manual enrichment of ores. Volume 4. Enrichment Factory Enrichment plant, 2nd ed., Revised and enlarged. Moscow: *Nedra*, 1984.

2. Trop A.E., Kozin V.Z., Prokofiev E.V. Automatic control of technological processes of enrichment plants: Textbook for Universities, 2 nd ed. Moscow: *Nedra*, 1986.

3. Hahn A. G., Kartushin V. P., Soroker L. V., Skripchak D.A. Automation of enrichment plants. Moscow: *Nedra*, 1974.

4. Sbarbaro D., R. del Villar. Advanced control and supervision of mineral processing plants, 2010.

5. Povarov A. I. Hydrocyclones in mineral processing plants. Moscow: *Nedra*, 1978.

6. Yefimenko L, Tykhanskyi M. (2015). Information systems in the technological processes automatic control development by technical condition criterion. *Metallurgical and Mining Industry*, 1: 28 – 31.

7. Bass L., Angew Z. (1954). Contribution to the theory of grinding processes. Math. Phys., 5: 283 –292.

8. Ragot J., Roesch M., Degoul P., Berube Y. Transient study of a closed grinding circuit. 2-nd *IFAC Symp*. "*Automat. Mining, Miner. and Metal. Proc.*" – Pretoria. – 1977, 129-142.

9. Gurocak H.B. (1996). Fuzzy rule base optimization of a compliant wrist sensor for robotics. *Robotic Systems*, **13**: 475-487.

10. Wang L.X. (1993). Stable adaptive fuzzy control of nonlinear systems. *IEEE Trans. Fuzzy Systems*, **1**(2): 146–155.

11. Spooner J.T., Passino K.M. (1996). Stable adaptive control using fuzzy systems and neural networks. *IEEE Trans. Fuzzy Systems*, **4**(3): 339–359.

12. Schubert. H. Aufbereitung fester mineralischer. Leipzig: *Rohstoffe*, 1967.

13. Morkun V. Savytskyi O., Tymoshenko M. (2015). Optimization of the second and third stages of grinding based on fuzzy control algorithms. *Metallurgical and Mining Industry*, **8**: 22–25.

14. Toropov A. A. (2008). The calculation of the parameters of a new generation hydrocyclones. *Mining Journal*, **6**: 105-108.

15. Tikhonov O. N. Laws of effective separation of minerals during mineral processing. Moscow: Nedra, 1984.

16. Uskov A. A. (2004). Principles of construction of control systems with fuzzy logic. *Pribory i sistemy, Upravlenie, Kontrol, Diagnostika*, **6**: 7-13.