Dynamic Performance Monitoring of Current Control System for Fused Magnesium Furnace Driven by Big Data

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***Abstract*--By analyzing the dynamic characteristics of the smelting process of fused magnesium furnace (FMF), a kind of dynamic performance monitoring method driven by big data for current control system of FMF is proposed. The dynamic performance indexes of the current control system can be calculated with big data technology on the cloud server, then the online and offline evaluation of the running state and controlled effect of FMF smelting process are realized. Besides, in order to verify the effect of the performance indexes evaluating and monitoring method, the remote and mobile monitoring system of the dynamic performance evaluation indexes of current control system is developed and the system is successfully applied to a fused magnesia plant in China.**

Key words: Dynamic performance assessment of control system, remote and mobile monitoring, big data.

I. INTRODUCTION

At present, the current control of FMF includes the current setting optimization algorithm, the tracking control algorithm of current loop, and so on. Since the FMF is a submerged arc furnace, the three-phase electrodes are located under the raw materials and the smelting process is smelting while feeding, so the dynamic characteristics of FMF smelting process always change[1]. Because of frequent fluctuation of three-phase currents, it is very difficult for field operators to monitor and evaluate the dynamic performance of current control system according to the fluctuation of current.

With the development of ICT technologies, such as cloud computing, mobile computing and big data, and so on, it provides new technical tools to help us to monitor the fused magnesium furnace factory better and more comprehensively[2]. In order to enable control engineers and enterprise managers to master the production situation anytime and anywhere, the development of a dynamic performance monitoring system of current control system is of great significance for the auxiliary control engineers and enterprise managers to realize the production evaluation and decision-making. The system is based on cloud computing, industrial big data and other technologies to realize the real-time statistics of the dynamic performance indexes of the current control system, and then realize the online and offline evaluation of the running status and the current control effect of the smelting process[3].

Although the presented methods can realize the evaluation of the corresponding performance index of control system, it has some limitations for the characteristics of the controlled object or control method. In this paper, we propose a big data driven dynamic performance monitoring method for current control system of FMF. A series of dynamic performance indexes of the current control system are presented by analyzing the dynamic characteristics of the FMF. A dynamic performance monitoring system of current control system is developed with the help of cloud computing, industrial big data and other technologies. It includes a web application and mobile app to realize remote and mobile monitoring of abnormal, non-optimal, optimal and other operating status of the smelting process of fused magnesia, effective evaluation of the current control effect, and thus providing more intelligent support for the control engineer and the enterprise manager in the production evaluation and decision-making.

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II. DYNAMIC PERFORMANCE INDEX MONITORING REQUIREMENTS ANALYSIS OF CURRENT CONTROL SYSTEM

There is close relation between the three-phase current fluctuations in the smelting process of the FMF and the operation status and control effect of the smelting process. In order to achieve the evaluation of abnormal smelting, non-optimal, and optimal conditions, as well as the evaluation of current tracking effect, it is necessary to establish a series of dynamic performance indexes of the current control system and conduct real-time statistics and monitoring. In addition, in order to enable the operator to discover the problem as soon as possible and minimize the loss, when the index value found in the monitoring process exceeds the threshold range, an over-limit alarm should be implemented.

III. DYNAMIC PERFORMANCE INDEX OF CURRENT CONTROL SYSTEM EVALUATION

A. Dynamic Performance Index of Current Control System

There are nine performance indexes presented in order to realize the evaluation of the smelting condition of the FMF, which will be described as follows. *MAICur* and *ACSONICur* are used to evaluate whether there is any abnormal condition in the smelting process of FMF. *MSOICur* and *ACSSOICur* are used to evaluate whether the smelting process of FMF is in optimal condition. *MAECur* and *AECSCur* are used to evaluate whether the current tracking control is good, which reflects if the control algorithm or control parameter selection is appropriate. *AverCur* is used to evaluate the current value which reflects if the current set point selection is reasonable.

MAFCur and *AFCSCur* are used to evaluate the evenness of the raw material in the smelting process, which reflects the level of product grape.

B. Dynamic Performance Index Evaluation Method of Current Control System

Dynamic performance index evaluation of current control system is divided into two modes: online evaluation and offline evaluation.

1) Online Evaluation

Taking the setting period of the set value of the current as the evaluation interval, the entire smelting process of FMF is divided into a number of time intervals, as shown in Fig. 1.

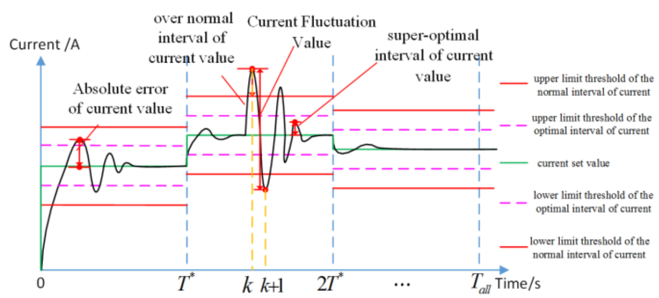

Fig.1. The simplified schematic diagram of dynamic performance index evaluation curve of the current control system.

In the Fig.1, each time interval length (setting period of set value) is N sampling periods, i.e. $T^* = NT$, T_{all} represents the smelting time of a furnace product, T represents the sampling period. The online evaluation function calculates each performance index of each time interval section in the smelting process in real time. According to experience, the field operator can give the reasonable threshold range for each performance index. Then it can be evaluated that the control effect is good or bad by comparing the difference between the calculated values of each performance index and reasonable threshold range. The index evaluation curve can be drawn to more intuitively evaluate the smelting status and current control effect of the current interval section.

2) Off-line Evaluation

When a furnace production is completed, the actual energy consumption per ton (ECPT) of the furnace can be measured, therefore, it's possible to evaluate whether the whole furnace production status is optimal or not by comparing the actual ECPT of product with the set value of target ECPT of product before production.

Offline evaluation is based on online evaluation. Firstly, the dynamic performance indexes of the current control system are calculated in each time interval in the smelting process of the FMF. Then the relationship between the optimized production situation of the whole furnace and the smelting status as well as current control status in each interval is comprehensively analyzed according to the on-line evaluation results of each time interval and the optimized production status of the whole furnace.

IV. Implementation of Dynamic Performance Index of Current Control System

The remote and mobile monitoring system of the dynamic performance evaluation indexes of current control system is developed and the UI of remote system is shown as Fig.2.

Fig.2. The dynamic performance monitoring interface of current control system.

Firstly, the real-time process data of the underlying transmission is stored in the MySQL database in the cloud server, and then the cloud sever-side applications load the real-time process data from MySQL database. All data access interfaces are encapsulated as Restful API for mobile App and remote system invocation. In order to ensure that the developed dynamic performance monitoring functions of control system are widely applicable to both the control evaluation of the FMF production and other process industries, all developed dynamic performance calculation functions are also encapsulated and deployed as web service (Restful API) to rapidly develop dynamic performance index monitoring terminals for other process industry control systems.

V. Conclusion

The remote and mobile monitoring system of the dynamic performance evaluation indexes of current control system is applied to a fused magnesia plant in Dashiqiao City, Liaoning Province to verify the effect of the evaluating and monitoring method of performance indexes. The application result shows that the dynamic performance evaluation method of the current control system can realize the dynamic performance evaluation of the control system correctly and effectively. It also provides a more intelligent support for the production evaluation and decision making of the control engineers and enterprise managers.

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