VNIIMT Optimal Control System for Hot Blast Stoves

Improving hot blast stoves efficiency by using an innovative Optimal Automotive Control System based on hot blast stove computer simulation and optimization
**Task:**
To increase hot blast temperature by 20–30 °C which allows to save 0.65–1% of coke without necessity of expensive hardware modernization.

**Problem**
Hot blast production by means of metallurgical hot blast stoves is characterized by the following features:

- significant fluctuations of caloric content of blast furnace gas (up to 40 %) (Fig. 1);
- different hot blast stoves wear and defects such as “sort cuts”, checkerwork melting and obstruction;
- seasonal variations of air temperature in burners and cold blast temperature.

This results in the following defects which decrease performance characteristics of hot blast stoves unit:

- gas incomplete combustion;
- reduction of dome temperature in heating period;
- underheating or overheating of the checkerwork by the end of the heating period which results in wide fluctuation of the maximum gas temperature in the area under checkerwork (up to 70 °C) (Fig. 2).

As a result hot blast produced by the stoves has reduced temperature which leads to increased coke consumption in blast furnace iron making process.

At present time the technological process is lead by qualified personnel which carries out the hot blast stoves control quite competently. However, a man is physically unable to percept, interpret, and analyze all the information about process coming to him and to determine the optimal values of control parameters on its base. That is why ability of the operator to increase hot blast temperature with help of his experience and talent only is considered to be depleted.

**Idea:**
To lay this difficult, tedious, requiring great attention work on hot blast stove control on Optimal Control System (OCS), which in real time scale, taking into account the technological situation on control object, will determine such control parameters values with which machine can achieve maximum hot blast temperature with minimal fuel consumption with the assigned technological limits on control parameters values.
VNIIMT Optimal Control System essence

The core of Optimal Control System is Hot Blast Stove Computer Simulation and Optimization subsystem (HBS-CSO) which includes:

- hot blast stoves determined mathematical model;
- algorithms for model parameters identification;
- optimization algorithms.

HBS-CSO The optimal control system structure is represented on fig. 3.

The measured technological process parameters values are given to the forecasting determined mathematical model. The model parameters are constantly being corrected by the identification algorithm. Such correction is carried out by minimization of the indicators values deviations calculated according to the model of indicates values deviations calculated according to the model and of conforming measured values in order to provide high accuracy of indicators forecasting and maximal adequacy of the model to the real process.

The adequate to the process mathematical model calculates and gives to operator the process parameters values not available for direct measurement such as checkerwork temperatures distribution, stove efficiency, harming gas flows rate etc. These are the so called “indirect measurements” of parameters which allow operator to control the technological process more efficiently.

With the help of optimization algorithm, turning to the mathematical model process parameters optimal values are calculated in accordance with the assigned optimization criterion.

The optimal control parameters values either directly influence the process, optimizing plant operation parameters (operation mode on-line), or they are given as an “advice” to the machine operator (operation mode off-line).

VNIIMT Optimal Control System performance

- maximizes dome temperature;
- increases hot blast temperature by 20 – 30 ºC by means of selecting optimal operation modes for each stove;
- decreases coke consumption by 0.65 – 1 %;
- decreases gas consumption by means of optimization of combustion modes;
- extends stoves life span by means of continuous monitoring and control of checkerwork temperature distribution along all it’s volume;
- improves efficiency of iron making process
- improves cast iron quality
- finds optimal gas consumption in order to achieve preset wasted gas temperature in the area under checkerwork by the end of heating period;
- continuously monitors process parameters:
• checkerwork temperature distribution in every point of time and volume;
• efficiency of every stove and of stoves unit as a whole;
• heat balance of every stove and of stoves unit as a whole;
• harming gas flows rates from checkerwork to combustion chamber in blow mode.

VNIIMT Optimal Control System structure

1. measurement instrumentation and actuating mechanisms;
2. programmable logic controllers (PLC) with appropriate software installed;
3. supervisory control and data acquisition PCs (SCADA);
4. PC with VNIIMT Optimal Control System licensed software installed.

Cost-performance:
For an average blast furnace with a volume of 2038 m³ estimated coke saving alone produces economic effect of more than $1 800 000 a year.
Thus payback period does not exceed 0.5 – 1 year.

Implementation
VNIIMT has a wide experience in the field of metallurgical industry which includes design, production and commissioning of broad range of metallurgical machines and implementation of innovative solutions. VNIIMT provides whole range of the services relating to Optimal Control System implementation:
• inspection of existing stoves unit features and finding out the necessary design effort and estimated economic effect of VNIIMT Optimal Control System implementation;
• complex design of VNIIMT Optimal Control System and integration into existing automatic control system;
• design and commissioning of software for PLC and SCADA system, hardware, and instrumentation;
• complex delivery of necessary hardware and instrumentation;
• personnel education and training;
• warranty and after-sales service.

All the works about implementation of the system take less than 12 months can be done without shutting down the blast furnace.

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