

MONITORING OF ANODE GAS PARAMETERS IN SODERBERG POTS

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In solving the tasks of creating environmentally acceptable and competitive Soderberg aluminium reduction technology, one of the major aspects of work is ensuring the efficient removal and after-burning of waste anode gases from pots.

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In the existing technology, the state of pot burner components and the conditions of after-burning, and waste gases are controlled by the process staff occasionally and only visually. With a large amount of pots, such control takes a lot of time, not to mention the analysis of the current and previous conditions of the burner operation mode.

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In order to implement automatic control of pot fume exhaust fan parameters, we have developed a system which, allows for the continuous monitoring of anode gases for a group of pots and display controlled parameters at automation tools of lower and upper levels.

The automatic control system for pot fume exhaust fan parameters (further referred to as the system) is intended for monitoring and displaying temperature and waste gas depression values from burners on the operator's board at data acquisition cabinets (DACs) in a digital format and communication of this data to the information

and process network of the smelter (Fig. 1). This is a unique system, which was implemented in the aluminium reduction process for the first time. The conditions of system operation meet the operational requirements for reduction process equipment.

The depression influences the volume of the fumes exhausted, the amount of air inflow, and finally, the effectiveness of after-burning of harmful components of anode gas. The temperature of anode gas after-burning products is determined by many process parameters of the pot: the consumption and composition of anode gas, its initial temperature, the amount and temperature of air inflow, the quality of anode gas and air mixing in the burner. The higher the after-burning temperature, the more efficient the anode gas thermal neutralization.

The following temperature probes are used in the system:

- TC201 (Wika) thermocouple with a head and sensing element in a protective barrel:
 - the acceptable operational temperature + 1200°C;
 - measuring range 0-1000°C;
 - error $\pm 3.2^{\circ}\text{C}$ at a temperature of +800°C;
- pressure probe – METRAN-100:
 - maximum measuring limit 0.40 kPa;
 - measuring range: -0.4-0 kPa;
 - acceptable basic error limit $\pm 0.5\%$.

The task of controlling the specified parameters has been solved by means of using SIMATIK S7-300 type controllers installed in DACs within the system. For galvanic isolation of input signals from probes, DSCT32-01-type (depression) and DSCT47K-04 (temperature) galvanic separation modules are installed in the unit communication cabinets (UCCs).

Reduction of the operational temperature for depression converters is achieved by means of mounting them on anode frame supports, which allows them to be moved as far as possible from the pot allowing them to cool off by natural ventilation.

On the structural level, automatic control of process parameters has been implemented on two levels: the lower and the upper levels.

The lower-level tools (instrumentation and control) perform the following functions:

- measure the current values of process parameters;
- convert the level of measured signals.

The upper-level tools (controllers) perform the following functions:

The automatic control system for pot fume exhaust fan parameters is unique. It is used in aluminium production for the first time.

Fig. 1
Installation locations for the temperature probe sensing element and the connection of the vacuum gauge pipe



This is a unique system used in the aluminium reduction process for the first time. The conditions of system operation meet the operational requirements for reduction process equipment.

Diagram of temperature fluctuations and depression behind burners of a pot

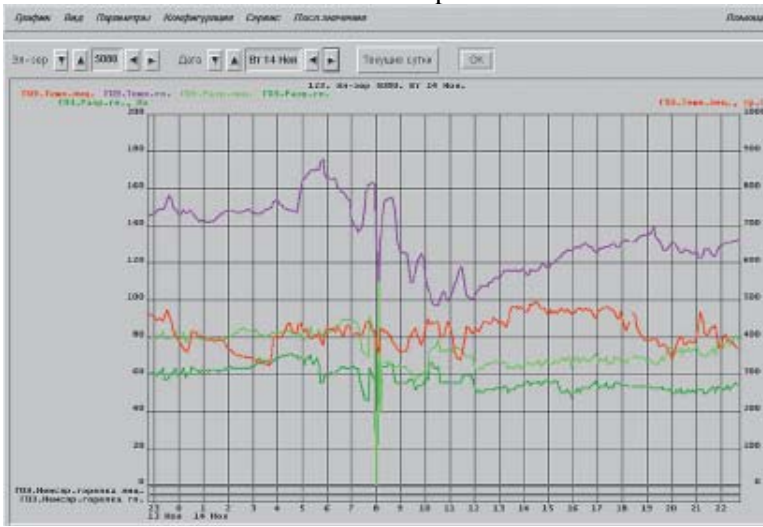


Fig. 2 As soon as at the pilot testing stage of the system equipment, we revealed some problems which render reliable and efficient work of the system impossible if they are not solved. The first problem is protection of thermal converters of temperature probes from the destructive impact of high-temperature chemically active anode gas flow. The 1 mm thick protective stainless steel barrel provided by the temperature probe design is not able to withstand the destructive impact of the gas flow. In order to solve this problem, it was proposed to use additional protective covers installed on temperature probe measuring units, with the construction of the insert device for mounting the probes at the gas flue. Another problem is gradual

- collection and processing of data from instrumentation and control;
- analysis of probe data and formulating appropriate messages for communication to the informational and process network;
- alarm initiation if the process parameters go beyond the limits.

The current values of the measured temperature and waste gas depression from the burner are received in the FCC from each pot burner to galvanic signal converters. Besides galvanic converters, the FCC accommodates power supply for depression probes and the automatic switch, via which power voltage is supplied to the equipment in the cabinets. The components listed are the lower-level tools. The converted signals are transmitted from FC cabinets to the corresponding DA cabinet, to analogue signal input modules, then transmitted to the pot control box, and then – to the database of the smelter information and process network.

This system is connected with the smelter information and process network by means of the PROFIBUS information network. The system provides for transmission of data on the values of controlled parameters and process deviations to the network database, as well as archiving and storing data for a certain period.

build-up of sampling units of depression pipelines and the pipelines themselves by combustion residue and sludgy deposits. This leads to misinterpretation of the actual depression values in gas flues, burner parameters, and requires regular cleaning of build-up points.

The system allows for on-line control of burner conditions, evaluation of the impact of process factors on their operation, assessment of the stability and steadiness of operation for various burner constructions.

The system allows for controlling the condition of burners, assessing the stability and steadiness of their operation, and the impact of process factors on it.

For displaying the controlled parameters, we use Elvis, the system of reduction process visualisation. As an example, Fig. 2 demonstrates the diagram of temperature and depression changes behind burners of a pot.

Gradual build-up on sampling devices in depression pipelines and the pipelines themselves with combustion residue and sludge deposits is a problem.

One can see on the diagram that the temperature of the anode gas and depression are constantly changing, depending on the process condition of the pot.

temperature of fumes behind the burner with a counter-flow heat exchanger is smaller than for slot burners by 1.4-1.8 times. This is caused by heat removal from anode gas after-burning products for heating the air supplied to the burner in the heat exchanger.

The comparison of monitoring data for all pots of a half-section demonstrated that the upper temperature level is mainly below 700°C. The depression changes from 100-140 Pa in the pot closest to the depression source to 30-70 Pa in the pot farthest from the depression source. The range of temperature and depression changes does not depend on the remoteness of the pot from the depression source. The replacement of anode studs and the anode effect using the existing technology increase the gas temperature by 50-90°C.

The average depression in burners with a counter-flow heat exchanger equals or exceeds that in slot burners by 1.1-1.8 times. This means that the dynamic pressure and, therefore, the volume of fumes exhausted from burners with a counter-flow heat exchanger is equal to or smaller than from slot burners. Depression on the closest and farthest burners, relative to the depression source, differs by 1.6-3.2 times. Therefore, to ensure the same aerodynamic conditions, it is necessary to level out the depression in burners using depression controllers located in the dust precipitation chambers.

Table 1 presents the indicators for the fume exhaust fan system and anode gas after-burning process, obtained based on the monitoring data on certain days between June 30th and July 14th, 2006. The analysis of monitoring data was made in respect of burners with a counter-flow heat exchanger and slot burners used at Krasnoyarsk aluminium smelter.

The stability of the thermal operation of burners was assessed with the frequency of fume temperature reductions behind the burner below 100°C. The frequency of reducing the preset temperature of fumes behind burners with a counter-flow heat exchanger was 1.2 times per day, and behind slot burners – 1.3 times per day, i.e. 7% lower.

The stability of burner operation was assessed by the range of fume temperature fluctuations. According to the monitored system data, the range of fume temperature fluctuations behind burners with a counter-flow heat exchanger is narrower than that behind slot burners by 1.1-1.8 times. This testifies to a higher stability of operation of burners with a counter-flow heat exchanger, with the difference in measurements being smaller than the specified range in clean gas flues. The average

As a general criterion of burner operation, we selected the period (in %) during which the temperature in the reducing bend was in the following ranges: below 200°C (no flame), 200-600°C (medium-rate burning), over 600°C (active burning). The comparison of results of experimental data processing for the burner monitoring system

in the period from August to November, 2006 demonstrates the advantage of burners with a counter-flow heat exchanger over slot burners by their period of operation at various temperature levels.

Burners with a counter-flow heat exchanger have a few advantages compared to slot burners.

Table 1

Fume Exhaust and Anode Gas After-Burning Process Indicators

Date: June 30th, 2006

Indicators	Side	Burners with a counter-flow heat exchanger						Slot burners					
		Pot number					Average value	Pot number					Average value
		501	502	503	504	505		506	507	508	509	510	
Range of temperature fluctuations, °C	tapping	46	513	60	135	134	177.6	98	648	630	350	687	482.6
	alley	409	232	335	260	169	281.0	253	662	710	414	609	529.6
Stability of operation (frequency of fume temperature reductions below 100°C, times/day)	tapping	6	1	1	1	0	1.8	0	2	2	2	4	2
	alley	2	1	0	1	1	1.0	0	2	4	2	0	1.6

Date: July 7th, 2006

Indicators	Side	Burners with a counter-flow heat exchanger						Slot burners					
		Pot number					Average value	Pot number					Average value
		501	502	503	504	505		506	507	508	509	510	
Range of temperature fluctuations, °C	tapping	235	183	185	330	364	259.4	37	281	436	723	692	433.8
	alley	247	476	118	127	152	224.0	295	180	52	610	351	297.6
Stability of operation (frequency of fume temperature reductions below 100°C, times/day)	tapping	3	0	0	0	0	0.6	0	1	2	4	0	1.4
	alley	0	0	0	0	0	0.0	0	0	7	0	0	1.4

Date: July 14th, 2006

Indicators	Side	Burners with a counter-flow heat exchanger						Slot burners					
		Pot number					Average value	Pot number					Average value
		501	502	503	504	505		506	507	508	509	510	
Range of temperature fluctuations, °C	tapping	487	194	81	197	104	212.6	197	-	148	409	575	332.3
	alley	224	547	224	563	305	372.6	446	275	836	760	588	581.0
Stability of operation (frequency of fume temperature reductions below 100°C, times/day)	tapping	4	1	0	0	9	2.8	0	2	1	1	1	1.0
	alley	1	4	0	3	5	2.6	0	1	4	3	0	1.6

Date: July 7th, 2006

Indicators	Side	Burners with a counter-flow heat exchanger						Slot burners					
		Pot number					Average value	Pot number					Average value
		501	502	503	504	505		506	507	508	509	510	
Range of temperature fluctuations, °C	tapping	235	183	185	330	364	259.4	37	281	436	723	692	433.8
	alley	247	476	118	127	152	224.0	295	180	52	610	351	297.6
Stability of operation (frequency of fume temperature reductions below 100°C, times/day)	tapping	3	0	0	0	0	0.6	0	1	2	4	0	1.4
	alley	0	0	0	0	0	0.0	0	0	7	0	0	1.4

Experiments on controlling the depression and volumes of fumes exhausted, conducted in the potroom with the automatic alumina point-feeding system, demonstrated that the actual decrease of the average volume of fumes exhausted from one burner was 50-58 nm³/hr. The minimum and maximum volumes of fumes exhausted from burners in the test pot half-section with a controlled depression differed by 1.2-1.4 times, and in the pot half-section with a non-controlled depression – by 2.0-2.2 times. The content of CO in anode gas after-burning products with depression and controlled fume exhaust volumes reduced by 1.4-3.3 times.

Currently, a diagnostic complex is created for reduction process control, where the anode gas monitoring system is an integral part.

Photo by: U.I. Storozhev

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 Currently, a diagnostic complex for reduction process control is in place, where the anode gas monitoring system is an integral part.

