The controlling of heating flow for coke plant

Marek Laciak[1] *and* ***Karol Kostúr***[1]

Riadenie tepelného toku koksovne

This paper deals with mathematical models dedicated to control the heating flows for coke plant. The model of heating flow is one of components for complex mathematical model for coke plant. The mathematical models are constructed on the basis of measured data for single blocks and sides of coke plant. Model provides prediction of the heating flow, from which is consecutively calculated the volume flow for mixed gas.

Key words: *control, coke plant, mathematical model.*

Introduction

Coking temperature is one of the primary variables in process of coking. Coking temperature is given by temperature achieved by combustion of the gas in melt scours. The highest measured temperatures are from 1280 up to 1350°C in production blast-furnace gas and 1150 up to 1200°C in production of the foundry coke. As the coking temperature is higher, as bigger is production of coking plant. Required temperature is assigned according to coking period. Function of control system is to calculate the heating volume forward for four hours. Calculated heating flow can provide required temperature during next four hours.

Technological process in coke plant

The coking plant process coal to coke. The coal is filled from coal tower to pressure and compositor machine. Created coal blocks in compositor machine are charged to coking chambers. Hot coke is lettered in coking chamber and to choke with water and after it, is transfer to coking stage. Outputs of coking plant are coking gas and coke.

The coking plant usually consists of several blocks (A, B, C) and it is mixed gas-heated. The mixing station mixes the blast-furnace gas and coke-oven gas. Then the mixed gas is distributed to blocks on coke and machinery side. Combustion of mixed gas is realized in 31 combustion chambers from the coke and machinery side. The volume flow of mixed gas depends on the output of the block and is regulated by a system of flap valves. At present time the ratio of mixed gases is constant. The combustion of gas fuel in combustion chambers is the source of heat, which by conductivity proceeds to the coal in coke chambers. The draft of combustion products from combustion chambers to the chimney is opposite to the gas flow from each side of each block and they are connected to the chimney (Kostúr, 2002; Kostúr a Pástor, 2002-1).

Models for controlling of heating flow

Task of the control system is to calculate necessary heating flows forward for four hours from measured and calculated data. Those heating flows are calculated for all blocks (A, B, C) and for two sides (coking side and machine side). Therefore are necessary 6 models for battery (Figure 1.).

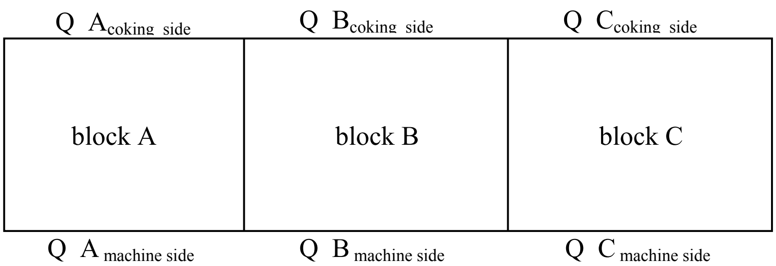

Fig.1. Scheme of coking plant.

[1] *Marek Laciak, Karol Kostúr:* Department of Applied Informatics and Process Control, Technical University of Kosice Kosice, Slovak Republic Marek.Laciak@tuke.sk, Karol.Kostur@tuke.sk
(Recenzovaná a revidovaná verzia dodaná 19.11.2003)

Structure of models for control

Models for control of heating flow in coke plant emanate from regression approach. Regression model is based on linear equations (1), where in iteration loops are calculated dependent variables Ex – heating flow for block and side.

$$Ex(k+1) = a_{10} + a_{11} \cdot x_1(k) + a_{12} \cdot x_2(k) + \ldots + a_{1n} \cdot x_n(k) + a_{1n+1} \cdot v_1(k) + \ldots a_{1n+m} \cdot v_m(k+1) \quad (1)$$

where: Ex(k+1) – dependent variable in step k+1, $x_i(k)$ – independent variable in step k, $v_i(k+1)$ – required values for step time k+1, a_i – regression parameters of model.

In between measured values, which are inputs in models belongs:
- heating flow from last four hour,
- measured temperature,
- count of expelled chambers, etc.

Inputs in model are also required variables – required temperature for next four hours and planed count of expelled chambers.

Model No. 1

The initial model was designed for calculating heating flows and its formula is following:

$$Q_i(k+1) = a_0 + a_1 \cdot Q_i(k) + a_2 \cdot G_i(k) + a_3 \cdot T_i(k) + a_4 \cdot pvk_i + a_5 \cdot T_i^r(k+1) + \\ + a_6 \cdot Q_i(k-1) + a_7 \cdot T_i(k-1) + a_8 \cdot Q_i(k-2) \quad (2)$$

where: a – parameters of model, Q_i – heating flow, T_i – measuring temperature, pvk_i – count of expelled chambers after last four hours, T_i^r – required temperature for next four hours.

Coking process has long warm inertia. Therefore the model count with heat flow from paste eight hours.

Model No. 2

Model No.2 was expanded by count of expelled chambers calculated from pushing plan and its formula is following:

$$Q_i(k+1) = a_0 + a_1 \cdot Q_i(k) + a_2 \cdot G_i(k) + a_3 \cdot T_i(k) + a_4 \cdot pvk_i + a_5 \cdot T_i^r(k+1) + \\ + a_6 \cdot Q_i(k-1) + a_7 \cdot T_i(k-1) + a_8 \cdot Q_i(k-2) + a_9 \cdot pvk_i^r(k+1) \quad (3)$$

where: pvk_i^r – count of expelled chambers calculated from pushing plan.

Model No. 3

Model No 3 is in comparison with model No.2 expanded by two parameters. First parameter is required temperature for next eight hours and planning count chambers for following four hour.

$$Q_i(k+1) = a_0 + a_1 \cdot Q_i(k) + a_2 \cdot G_i(k) + a_3 \cdot T_i(k) + a_4 \cdot pvk_i + a_5 \cdot T_i^r(k+1) + \\ + a_6 \cdot Q_i(k-1) + a_7 \cdot T_i(k-1) + a_8 \cdot Q_i(k-2) + a_9 \cdot pvk_i^r(k+1) + a_{10} \cdot T_i^r(k+2) + \\ + a_{11} \cdot pvk_i^r(k+2) \quad (4)$$

Model parameters adaptation is designed on principle of FIFO buffer. Little by little oldest data are pushed out from buffer by new data. New parameters for all models are calculated after each update. For whole battery exist six buffers, one for each side per block. Quality of models is depending from correct input data and buffer length, from which parameters are calculated.

Results models for variant buffer

Research for models was oriented to length of buffer. In table 1 are presented results of all models for buffer length n=70, 80, 90, 100, 110. Results are presented as average relative deviation (5).

$$\overline{Q}_{relative} = \frac{\sum_{i=1}^{n} \frac{abs\left(Q_i^{measur} - Q_i^{model}\right)}{T_i^{model}} \cdot 100}{n} \quad [\%] \quad (5)$$

From results in table 1 it can by apparently clear, that the best results for precision are those, where length of buffer n=100. Model No.3, where is expanded by required temperature for next eight hours and planning chambers count for next four hours, achieve lowest deviation.

Tab.1. Results models for variant buffer.

	N	**70**	**80**	**90**	**100**	**110**
$Q_{relativ}$ [%]	Model No.1	14,32	14,12	6,88	6,86	7,02
	Model No.2	13,62	13,13	6,55	6,62	6,62
	Model No.3	12,37	12,48	5,46	5,69	6,03

Conclusion

The models for controlling of heating flows are part of the whole control system for coking plant. In this paper are presented results of research on buffer length, which have strong influence to model precision. The best results where achieved with buffer length n=90 or 100.

References

KOSTÚR, K.: Control System of Coking Plant. Metallurgy, 2/2002, 2002. pp. 121-124. ISSN 0543-5846

PÁSTOR, M. and KOSTÚR, K.: Modelling flow in industry furnace. In: Proceedings of Řízení procesu 2002, 2002-1. pp. 182. ISBN 80-7149-452-1

PÁSTOR, M. and KOSTÚR, K.: Gas flow modelling in tube system of coke-owen battery. Acta Metallurgica Slovaca, 4/2002, 2002-2. pp.129-134. ISSN 1335-1532