Evaluation of scale formation in waterwall heated surfaces

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Abstract. This paper presents the possibility of forecasting assessments of the speed and the time of formation of depositions in the evaporator-tube elements of double-drum boilers. The values of thermal flow in the wall region of tank screens of boiler furnace are obtained, besides the velocity values of scaling metal corrosion products are obtained. Conclusions about the ability of forecasting unnominal situations and emergency risks dependent with damage to the screen surface heating pipes are made.

1 Introduction

Water is known to be the most common heat-transport medium in steam boilers. It can be explained by several factors. First of all water possess high values of heat storage capacity, density, heat conductivity and viscosity. All this allows achieving fairly high coefficients of heat exchange. Secondly, water is a preferable heat transport medium since it is cheap.

But given all its advantages water has some disadvantages. The major disadvantage is that water actively causes corrosion. It results in certain problems when it is used as a heat transport medium, for instance, corrosion of metal of various equipment of the boiler and consequent deterioration of the boiler's reliability.

Various impurities present in water including corrosion products can deposit not only in the inner surface of heated pipes but also in some other equipment that will result in the significant reduction of reliability and cost effectiveness of the boiler and even of the steam and water pipes of the whole power plant in general.

2 Description of the model and the object of research

The study is devoted to investigation of the process of scale formation and corrosion of inner heated surfaces since they require special attention.

The intensity of the above process is correlated with the quality of the boiler water, i.e. contents of impurities and their quantity. This correlation explains the strictly regulated content of each impurity both of feed water and boiler water and the lower content of impurities is, the higher pressure of the heat transport medium is.

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Thus the quantitative content of impurities is to be lower than the required one to prevent the deposit of these impurities on inner surfaces of pipes of various heating surfaces such as superheaters, condensers, various desuperheaters etc. Due to the above requirements it is necessary to clean the primary water to provide the required quantitative parameters which can be achieved by the following: filtration, natural settling, ionization, coagulation, decarbonization etc. And in order to support the sufficient quality of the boiler water, the boiler is continuously blown off.

This article studies the boiler of DKVR-20-13 GM.

The specific feature of this boiler is the availability of two drums (upper and lower) which are aimed for different tasks. The upper drum is used for steam separation and feed water supply. The lower drum is used for sludge settlement and feeding of saline parts (loop with remote cyclone separators). The feed water is supplied to the upper drum through two feeding lines and from there it is supplied to the lower drum through low heated pipes of the convection tube bank. Furnace waterwalls are fed by non-heated pipes from the lower and upper drums: the front waterwall is fed by water from down-take pipes of the upper drum and the rear waterwall is fed by water from down-take pipes of the lower drum. The steam and water mixture from the waterwalls and risers is supplied to the upper drum. All boilers of this type are provided by internal steam separators in the upper drum.

The scale formation is the most probable in the parts of the drums connected to remote cyclone separators due to the high content of salt in the boiler water.

3 Results and discussion

The study is based on the correlation of the deposit formation rates of A [1]:

$$A_i = k \cdot C_i \cdot q^n, \quad (1)$$

where k – factor of proportionality; C_i – impurity concentration, mg/dm^3; q – heat flow, W/m^2; n = 1, 2, 3.

Impurities such as hardness salts (Ca and Mg) and steel corrosion products (Fe) are the most common in the feed water. In these cases the rate of n can vary from 1 to 3.

In order to study this correlation (1) the burning process going on in this boiler was simulated with the use of FIRE 3D with the nominal capacity of [2,3]. For this purpose six waterwall pipes were selected along the total length of the lateral panel, and heat flow values were numerically calculated for them in the near-wall region for all their height. The heat flow values are presented in Table 1.

In order to visualize the obtained results the heat flow curves were built up for each pipe and they are presented on Fig.2.

Table 1. Heat flows q (kW/m^2) in near-wall part of the lateral waterwall of DKVR-20 boiler.

Pipe	**No. 1**	**No. 2**	**No. 3**	**No. 4**	**No. 5**	**No. 6**
X, m / Y, m	0.096	0.4808	1.3256	1.536	2.1704	2.3816
0.14	847.3	849.3	827.2	810.5	733.7	702.2
1.13	739.2	783.9	823.5	814.9	749.4	718.1
1.47	694.9	751.3	817.0	812.8	756.2	726.4
1.84	655.9	717.1	802.2	802.1	754.5	726.4
2.20	608.6	670.1	764.8	767.6	727.6	701.4

2.45	567.8	627.7	722.9	726.9	691.7	667.1
2.63	534.7	592.7	685.7	690.5	658.8	635.6
2.85	490.1	544.4	632.2	637.5	610.8	589.9
3.08	439.3	488.9	569.7	575.6	554.8	536.6
3.30	386.8	431.9	506.3	512.8	498.2	482.8
3.51	334.4	375.2	445.3	452.6	444.3	431.7
3.72	283.5	320.9	389.0	397.4	395.3	385.2
3.95	228.1	262.3	330.8	340.6	345.2	338.0
4.28	155.9	186.5	262.8	274.6	287.4	283.8
4.61	104.4	129.2	211.0	224.4	242.8	242.0
4.93	78.7	97.2	174.1	187.5	208.4	209.4
5.26	68.9	83.8	149.6	161.8	182.5	184.4
5.42	67.6	81.3	141.3	152.8	172.8	174.8

Values of X and Y are geometrical coordinates of the estimated area which plane coincides with the plane of the waterwall pipes location and the point of reference is the lower point of the left lateral waterwall.

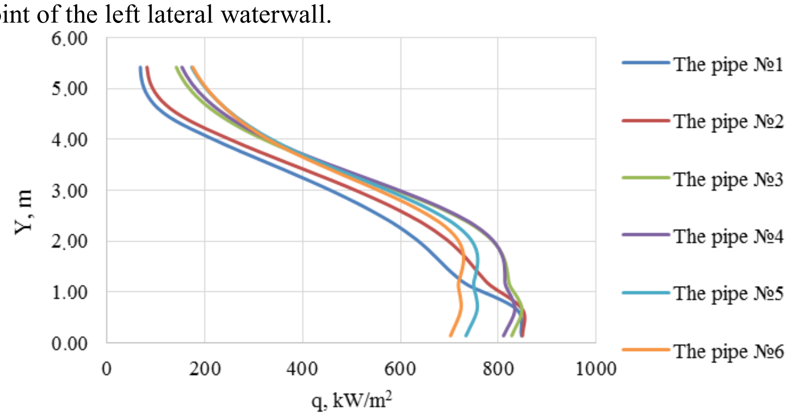

Fig. 1. Heat flow curves in the near-wall region of the lateral waterwall of DKVR-20 boiler.

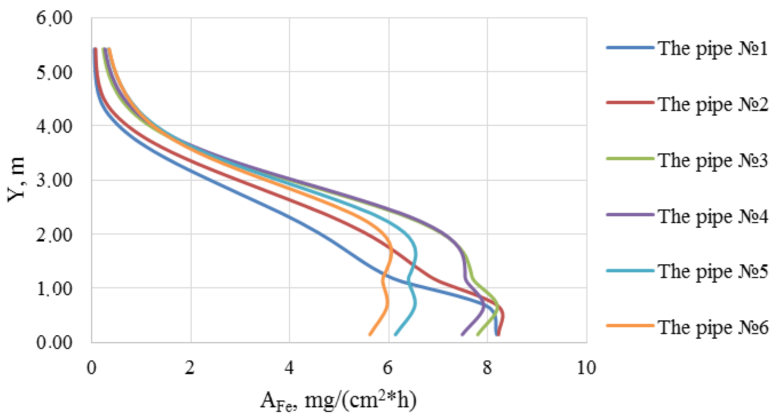

Fig. 2. The curve of deposit formation rate of ferrous corrosion products in the pipes of the lateral waterwall of DKVR-20 boiler.

Figure 2 shows the estimated deposit formation rate from which one can conclude that the maximum scale formation rate coincides with the level of burners' location, and the area of maximum deposit formation is located there.

4 Conclusions

The final purpose of this study is to predict the time of failure free operation of boilers, i.e. to define the time till formation of critical volume of deposits of various impurities. Results of this study allow predicting non-routine events and failure risks related namely to the damage of pipes within waterwall heating surfaces.

References

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