«Volzhskagroprompuskonaladka» LLC

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Appraisal report

on research work: «RAH reconstruction in a boiler No. 1 with application of heat high efficiency exchange elements of enhanced type. Start and adjustment works»

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1. Introduction.

The work was carried according to the contract No.60 dated October 11, 2008 between Volzhskagroprompuskonaladka» LLC and «VoTGK» OJSC.

The works were performed in accordance with activity confirmed by the license Д 667092 dated December 12, 2005.

In the report you can see the tests results of the boiler БКЗ-420-140-НГМЗ No.1 at Samara CHP-plant after carried out replacement of standard heat exchange elements by the packed high-performance heat exchange elements of enhanced type.

During the boiler start-up, start and adjustment works for regulation of peripheral and radial RAH seals were executed. Measurements of the temperature increase of flue gases behind RAH during period of load increase were carried out.

During the tests for determining aerodynamic and heat engineering parameters of RAH with the packaged high-performance heat exchange elements of enhanced type, static pressure measurements before and after RAH A and B were carried out in order to compare them with the guarantee obligations of the manufacturer «Northern Interindustry Company «The Alternative» Ltd.

4. CONDITIONS OF CARRIED OUT TESTS.

4.1 The tests for determining aerodynamic parameters of new heat exchange elements were carried out at load of 380- 425 tons/hour.

4.2 During carried out tests, boiler gas-flow controller was switched to hand control.

5.3 The tests were carried out while air dampers in the burners and valves of "Amax" system at gas pipes to the burners being in the fully open position.

5.4 Uniformity of distribution of gas across burners was controlled according to the indices of manometers fixed according to the position and figures of the computer installed on the control panel of the boiler.

5.5 Critical excess of air were determined by reduction of air consumption for burning before appearance of chemical underburning (according to Testo devices - 20÷40 ppm corresponds to 25÷50 mg/m^3 or 0.002÷0.004 turnover rate percentage).

5.6 Feed water temperature in carried out tests was 245 °C.

5.7 The tests were carried out after stabilization of boiler operation mode. The stabilization criteria of newly set mode was the superheated steam temperature and flue gas temperature behind the boiler. The duration of the balance tests was 3 hours.

5.8 During start-up, seals adjustment and determination of equipment indexes before boiler performance run-up were carried out.

5. TESTS RESULTS.

The tests were divided into two stages:

I- stage – boiler start-up;

II- stage – balance tests.

In the tests the following parameters were determined:

- recirculation gases distribution across the burners and boiler sides at different loads;

- optimum dampers position before distribution boxes while operating at one gas recirculation fan;

- the modes of stable gas burning in every burner while inletting recirculation gases into blow air;

- aerodynamic resistance of gas and air path sectors;

Safety of superheater parts operation was assessed.

Balance tests were carried out to determine aerodynamic parameters of enhanced type of heat exchange elements of RAH.

Tests to determine aerodynamic parameters of heat exchange elements were carried out with load of 380 - 425 tons/hour. For comparative analysis of received tests parameters of gas and air path resistance reduction to comparable conditions was performed. According to the methods described in [8] calculations were arranged according to the following formula:

$$\Delta h_{test}^{reduced} = \Delta h_{test} * \left[\frac{B_c * \alpha_c * (1 + r_c)}{B_{test} * \alpha_{test} * (1 + r_{test})} \right]$$

где Δh_{test} – tests value of the path sector, *кgf/ m*^{2};

B_c, B_{test} – calculated and test fuel consumption, nm^3 /hr;

α_c, α_{test} – calculated and test average volume of flue gases at load of 1 nm^3/hr;

r – recirculation gases content, %;

n – index depending on the path sector characteristics.

RAH resistance indices are as follows:

Resistance of gas and air path sectors	**Unit measure**	**According to aerodynamical calculations of Barnaul Boiler Plant**	**According to calculations of the new heat exchange elements produced by «Northern Interindustry company «The Alternative» Ltd**	**Tests results**
RAH resistance by air	кgf/m^2	**94**	**95.2**	**95**
RAH resistance by gas	кgf/m^2	**52.2**	**97.8**	**89.4**

In such a manner, calculated data given by «Northern Interindustry Company «The Alternative» Ltd are close to tests results:

The comparative analysis of performance of heat exchange elements installed in other boilers (hot end has an enamel coating) showed the following:

The boiler No.5 (Resolution of SENTKO in 2006) – In 2005, the replacement of heat exchange elements of hot and cold ends was executed and half of the faggots with 0.7 mm thickness of enamel sheet (designed) and half of the faggots with 0.55 mm thickness of enamel sheet (experimental) in the cold end were installed.

Resistance of gas and air path sectors	**Unit measure**	**Tests results**
RAH resistance by air	кgf/m^2	**100**
RAH resistance by gas	кgf/m^2	-

The temperature of flue gases at rated load was 118/123 $^{\circ}$C.

The boiler No.2 (Resolution of SENTKO in 2007) - In 2007 the replacement of heat exchange elements of hot and cold ends was executed. Heat exchange elements of cold end have 0.5 mm thickness of enamel sheet.

Resistance of gas and air path sectors	**Unit measure**	**Tests results**
RAH resistance by air	кgf/m^2	**145**
RAH resistance by gas	кgf/m^2	-

The temperature of flue gases at rated load was 105/102 °C.

6. TECHNICAL AND ECONOMICAL INDICES OF THE BOILER OPERATION.

Boiler gross efficiency at rated load is 94.43% (α_{test} -1.05).

Temperature of flue gases at rated load is 114 and 108 °C by A and B sides.

C_{NOx} normative value is provided by operation of 1 gas recirculation fan, r_{rec} at rated load is 7.5%. Normative value of boiler gross efficiency at rated load equals 93.0% (α_{test} -1.05, r_{rec} -11%) while the temperature of flue gases equals 138°C.

As a result heat exchange elements replacement made it possible to increase the boiler gross efficiency by 1.43 % in comparison with the rated value that resulted in saving of 2 million m^3 of natural gas with boiler performance for 4000 hours at nominal parameters.

Summary table for operation results of ВКЗ-420 boiler No.1

№	Parameter	Dimension	Test 1	Test 2
1	2	4	5	6
1	Steam capacity (board)	tons/hour	425	380
2	Density	кg/m^3	39.317	38.999
3	Steam capacity (real)	tons/hour	426	379
4	Temperature of superheated steam	°C	557	557
5	Pressure of superheated steam	кgf/cm^2	138	137
6	Steam pressure in the drum	кgf/cm^2	157	156
7	Heat content in superheated steam	кcal/кg	822.3	822.5
8	Feed water temperature	°C	245	245
9	Feed water pressure	кgf/cm^2	195	195
10	Heat content in feed water	кcal/кg	239	238.5
Fuel				
11	Natural gas consumption (board)	m^3/h*10	29.5	26,5
12	Natural gas consumption (fixed)	m^3/h *10	31.08	27.71
13	Calorific power of gas	кcal/m^3	9170	9170
14	Barometric pressure	mm w.c.	755	750
15	Gas temperature	°C	0	0
16	Gas pressure before control valve	кgf/m^2	0.72	0.7
17	Gas pressure behind control valve	кgf/m^2	0.385	0.29
Air, flue gases				
18	Air pressure before: regenerative air heater РВП-3А	кgf/m^2	670	
19	regenerative air heater РВП-В	кgf/m^2	660	
20	Air pressure behind: regenerative air heater РВП -3А	кgf/m^2	575	
21	regenerative air heater РВП-3В	кgf/m^2	575	
22	Hot air temperature: A	°C	333	
23	B	°C	338	
24	Outer air temperature	°C	4	4
25	Air temperature before: calorifer-A	°C	22	
26	calorifer-B	°C	24	
27	Air temperature behind: calorifer-A	°C	26	
28	calorifer-B	°C	28	
29	Speed of air fan		2	2
30	Flue gas temperature behind steam superheater A	°C	498	
31	Flue gas temperature behind steam superheater B	°C	505	
32	Flue gas pressure before RAH A	кgf/m^2	60	30
33	Flue gas pressure before RAH B	кgf/m^2	60	35
34	Flue gas pressure behind RAH A	кgf/m^2	-30	-40
35	Flue gas pressure behind RAH A	кgf/m^2	-32	-35

Analysis of flue gases

In control cross section (on the left)				
36	Excess air coefficient		1.05	1.05
In control cross section (on the right)				
37	Excess air coefficient		1.04	1.05
In cross section behind RAH (on the right)				
38	Excess air coefficient		1.22	1.21
39	Temperature of released gases	°C	114.9	107.6
In cross section behind RAH (on the left)				
40	Excess air coefficient		1.22	1.21
41	Temperature of released gases	°C	107.8	104.6
Technical and economic parameters				
58	Heat loss with released gases	%	5.08	4.90
59	Heat loss through cladding	%	0.49	0.5
60	Boiler gross efficiency	%	94.43	94.60