

## **RESEARCH-AND-PRODUCTION FIRM «GRADIENT-C»**

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### **APPRAISAL REPORT on the results of replacement of heat exchange elements of cold and hot ends in two regenerative air heaters PBII-54 of TFM-84A boiler No.5 at Balakovo CHP-plant-4**

In autumn 2006, in TFM-84A boiler No.5 at Balakovo CHP-plant-4 (branch of «Volzhskaya TGC» OJSC) during major repair period the heat exchange elements of cold and hot ends in two regenerative air heaters PBII-54 were replaced by the new surface of heating of the upgraded heat exchange elements. The developer, manufacturer & supplier of the new heat exchange elements is «Northern Interindustry Company «The Alternative» Ltd (Severodvinsk city).

In December 2006, thermotechnical tests of the regenerative air heater with the improved heat exchange elements type were executed when burning natural gas. The tests were carried out by research-and-production firm «Gradient-C» of Saratov State Technical University with participation of «Northern Interindustry Company «The Alternative» and Balakovo CHP-plant-4 representatives. The aim of the tests was empirical data acquisition on heat exchange and aerodynamic resistance of the improved heat exchange elements in real-life operation environment as well as determining the technical and economic efficiency of fulfilled modernization.

Design characteristics of the observable heat exchange elements: double-sided heating surface of the heat exchange elements (per one RAH) is equal to: cold part - 3142 m, hot part - 7917 m<sup>2</sup>. The heat exchange elements sheets thickness: cold part - 1.2 mm, hot part - 0.7 mm. Total heat exchange elements height: cold part - 600 mm, hot part - 1200 mm. Equivalent diameter of the heat exchange elements: cold part - 11.98 mm, hot part - 10.16 mm.

According to the approved program of thermotechnical tests, experiments took place when burning natural gas in a boiler in the range of performance load of the boiler from 210 t/h to 410 t/h.

During the tested range of load the following parameters of RAH and boiler performance as a whole were fixed (after modernization took place):

- 1) Cold air temperature at RAH inlet - 9 °C;
- 2) Hot air temperature at RAH outlet - from 226 °C to 236 °C;
- 3) Flue gas temperature at RAH inlet - from 257 °C to 291 °C;
- 4) Flue gas temperature at RAH outlet - from 79 °C to 89 °C;
- 5) Excess air coefficient at RAH outlet - from 1.58 to 1.32;
- 6) Air suction in RAH - from 0.25 to 0.21;
- 7) Gross efficiency of the boiler - from 93.9% to 94.7%;
- 8) Calculated fuel consumption (when the lowest heat of burning  $Q=8000 \text{ kcal/ Nm}^3$ ) - from 17400 to 33100 Nm<sup>3</sup>/h.
- 9) RAH resistance by air, kg/m<sup>2</sup> - from 47 to 136;
- 10) RAH resistance by gas, kg/m<sup>2</sup> - from 75 to 167.

All the results of thermotechnical tests are shown in the report about research works. Calculations of thermotechnical indices of the boiler and RAH were carried out according to the recommendations /points 1 and 2 of the literature list/.

Empirical data processing has shown that numerical values of excess air coefficients in released gas and air suction in RAH are close to normative values /point 1 of the literature list/. When changing air suction in

RAH from 0.21 to 0.25, coefficient of using RAH heating surface is in the range of values 0.9-0.8 and is well coordinated with recommendations of the thermal design norms of boiler units /point 1 of the literature list/.

We should point out that when average annual boiler load is 345 t/h, then released gas temperature after the boiler after installation of RAH heat exchange elements of improved type is 78 °C. It's 57 °C less in relation to the data of the boiler performance prior to carried out modernization (temperature of released gas T=135 °C - Balakovo CHP plant-4 data for taken conditions, see Table).

*Thus, the results of RAH tests have confirmed great thermal effectiveness of intensified heat exchange elements of improved type produced by «Northern Interindustry Company «The Alternative» Ltd and the method recommended before for determining heat-emission coefficients of examined heat exchange elements /point 2 of the literature list/.*

After received results of thermotechnical tests, in compliance with the recommendations of point 3 of the literature list, assessment of technical and economic effectiveness of fulfilled modernization on installing the improved heat exchange elements in regenerative air heater PBII-54 was carried out. It's assumed that integral effect (clear capitalized profit) and costs self-repayment period when replacing RAH heat exchange elements are the effectiveness criteria.

When assessing technical and economic efficiency of fulfilled modernization, the example of replacing the existing heat exchange elements of regenerative air heater PBII-54 of TFM-84A boiler by the new heating surface of the heat exchange elements with geometry features of the heat exchange elements of cold and hot ends, according to the type design, is considered to be a comparable variant. Such replacement variant was considered to be **the variant of STANDARD replacement**. Double-sided surface of the heat exchange elements heating (per one RAH) is equal to: cold part - 3504 m<sup>2</sup>, hot part - 7848 m<sup>2</sup>. The heat exchange elements sheets thickness: cold part - 1.2 mm, hot part - 0.63 mm. Total heat exchange elements height: cold part - 600 mm, hot part - 1200 mm. Equivalent diameter of the heat exchange element: cold part - 10.24 mm, hot part - 10.0 mm.

This is the typical variant of the heat exchange elements and it's manufactured by the enterprises of Russia and Belarus.

Technical and economic calculations are made for average annual boiler load D =345 t/h (steam parameters P=130 kgf/cm<sup>2</sup>, t=550 °C) when the average annual boiler's run equal to 3500 h/year. The fuel burnt in the boiler is natural gas. Natural gas price in year 2006: 1414.32 roubles per 1000 normal m<sup>3</sup> (data of Balakovo CHP plant-4).

The cost of manufacture and delivery of 2 sets of heat exchange elements for regenerative air heater PBII-54 for the comparable variants is based on the prices existing in the end of year 2006. The cost of assembling works on replacing the heat exchange elements of two regenerative air heaters PBII-54 is based on data of Balakovo CHP plant-4 (autumn, 2006).

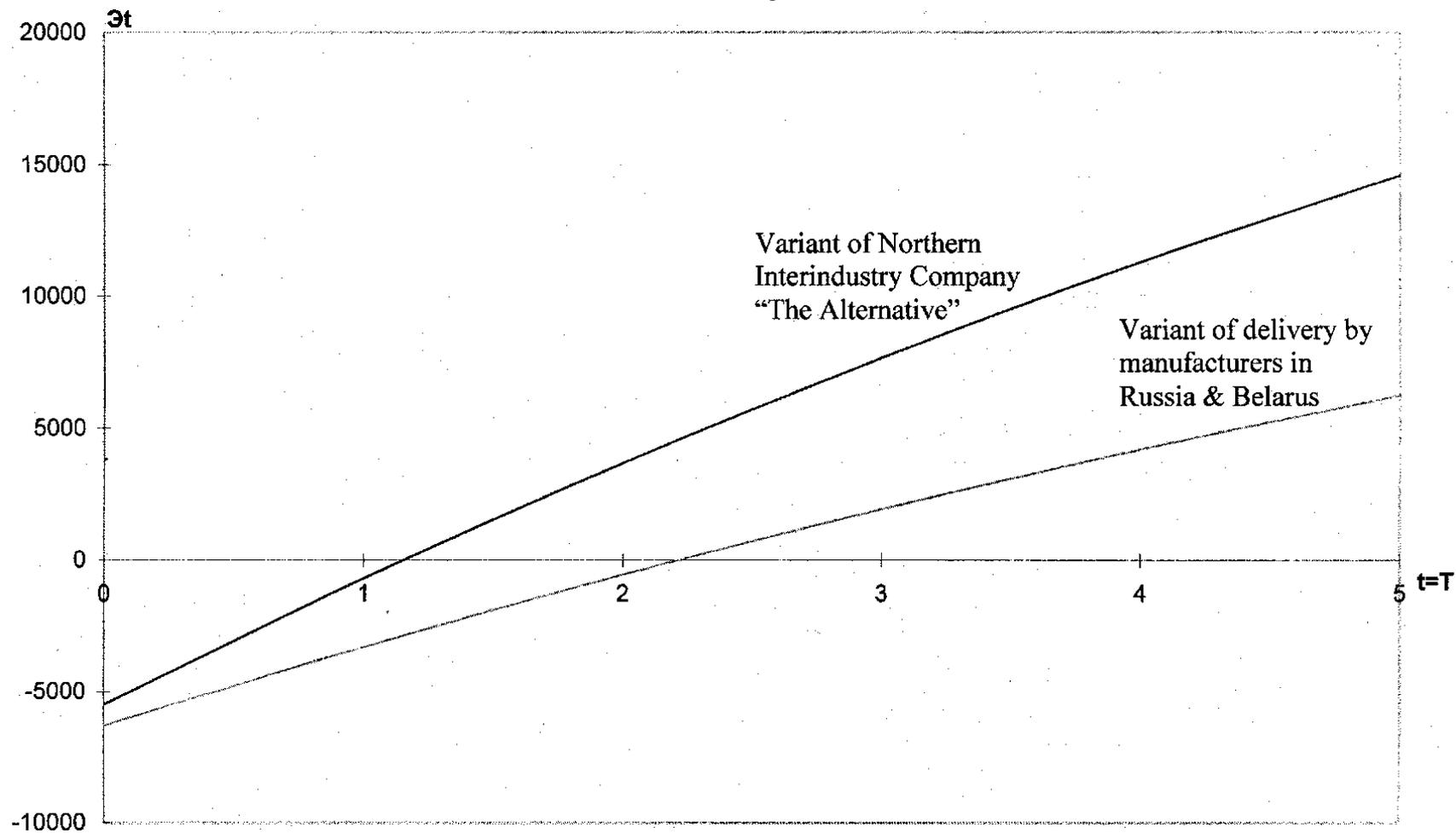
The results of fulfilled technical and economic comparable analysis are presented **in the table**.

You can see in the table that natural gas consumption in the variant with improved type of heat exchange elements is 400 normal m<sup>3</sup>/h less than in the variant of scheduled replacement and is 1070 normal m<sup>3</sup>/hr less than in the basic variant.

Period of capital investment recoupment in the variant with the heat exchange elements produced by «Northern Interindustry Company «The Alternative» is ~ **1.14** years, and in the variant of the standard replacement ~ **2.22** years.

*Thus, technical & economic comparison results of the heat exchange elements replacement variants in regenerative air heater PBII-54 for TFM-84A boiler No.5 at Balakovo CHP-plant-4 indicate considerable advantage of the heat exchange elements produced by «Northern Interindustry Company «The Alternative» Ltd in comparison with the standard one.*

**DIAGRAM FOR THE DETERMINATION OF PAY-BACK PERIOD FOR THE CONSIDERED  
REPLACEMENT VARIANTS OF HEAT EXCHANGE ELEMENTS FOR REGENERATIVE AIR  
HEATER PБП-54**



Parameters	Comparable variants		
	<i>BASIC VARIANT - existing state (before major repair)</i>	<i>VARIANT STANDARD EXCHANGE ELEMENTS- Manufacturers: enterprises in Russia and Belarus</i>	<i>OF HEAT NEW VARIANT- replacement by the enhanced type heat exchange elements Manufacturer: «Northern Interindustry Company «The Alternative»</i>
Gas temperature at RAH inlet, °C	293	279	279
Cold air temperature, °C	10	7	7
Hot air temperature, °C	170	215	228
<b>Flue gases temperature, °C</b>	<b>135</b>	<b>100</b>	<b>78</b>
Lowering temperature of released gases in relation to the basic variant, °C	0	35	57
Boiler efficiency, %	91.3	93.45	94.8
Calculated consumption of natural gas, normal m <sup>3</sup> /h	28910	28240	27840
Annual fuel economy, thousand normal m <sup>3</sup> /year	0	2345	3745
Cash value due to fuel economy after the heat exchange replacement (in relation to the basic variant per year), thousand RUR	0	3316.6	5296.6
Capital investment connected with the heat exchange elements manufacture and delivery, thousand RUR, VAT inclusive		5990.64	5184.768
Capital investment connected with the heat exchange elements dismantling and mounting, thousand RUR, VAT inclusive		322.047	322.047
Total capital investment, thousand RUR		6312.687	5506.815
Integral effect (net present value) per 5 years after replacing heat exchange elements of regenerative air heater PBII-54, thousand RUR	—	6259.7	14571.4
<b>Period of capital investment recoument in total, year</b>		<b>2.22</b>	<b>1.14</b>

*Taking into account high thermotechnical and technical and economical parameters of the improved type heat exchange elements produced by «Northern Interindustry Company «The Alternative» Ltd, we consider it would be advisable to recommend it for further wide application when carrying out RAH modernization of boiler units running on natural gas.*

#### LITERATURE

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