U.P.B. Sci. Bull., Series D, Vol. 79, Iss. 3, 2017 ISSN 1454-2358

NUMERICAL SOLUTION FOR THE EQUATION SYSTEM THAT MATHEMATICALLY DESCRIBES THE HEAT TRANSFER IN A ROTATING- PLATE REGENERATIVE AIR PREHEATER OF A STEAM GENERATOR

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The rotating- plate regenerative air preheaters, of Ljungström or Rothemuhler types, belong to the category of preheaters that equip modern steam generators. They are heat exchangers used to transfer heat between the flue gases and the incoming combustion air that enters the furnace across an inert material called metal filler. A disadvantage of these preheaters is the acid dew phenomenon that appears inside the preheater, leading to a decrease in the operating efficiency. This paper presents a mathematical model that simulates the preheater operation. The model is used to optimize the operation of the heat exchanger in a manner that the apparition of the acid corrosion phenomenon does not occur or is kept under control.

Keywords: rotating-plate regenerative air preheather, acid corrosion, flue gases, combustion air, metal filler, temperature points.

Nomenclature

RAPH	- rotary air preheater	
$t_{gi}(z_i,\varphi_i)$	- flue gases temperature	^oC
$t_{ar}(z_r,\varphi_r)$	- combustion air temperature	^oC
$t_{ui}(z_i,\varphi_i)$	- metal filler temperature during heating	^oC
$t_{ur}(z_r,\varphi_r)$	- metal filler temperature during cooling	^oC
z_i, z_r	- cylindrical coordinates	m
φ_i, φ_r	- cylindrical coordinates	rad
ω	- angular velocity of the rotor in rotation	rad/s
w_g	- flue gases velocity in passing through the cold zone of the RAPH	m/s
w_a	- velocity of the combustion air in passing through the cold zone of the RAPH	m/s
h	- rotor height	m

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α_g, α_a - convection heat transfer coefficient from gases to metal filler, respectively from the metal filler to air $kW/(m^2.K)$

S_s - specific surface m^2/m^3

v_g, v_a - metal filler porosity m^3/m^3

c_g, c_a - gas specific heat and air specific heat $kJ/m^3.K$

δ_u - metal filler density kg/m^3

c_u - specific heat of metal filler $kJ/(kg.K)$

φ_{it} - the full angle of the heating zone in the preheater rotation rad

φ_{rt} - the full angle of the cooling zone in the preheater rotation rad

Subscript

g- gas; a- air; i- heating; r- cooling

The quantities are expressed with reference to the normal state: 273,16 K; 0,1013 MPa

1. Introduction

Rotary air preheater is one of the most important energy recovery systems in the steam power plant (e.g. Ljungström type was invented in 1920, in Sweden, by Frederick Ljungström). The main function of the heat exchanger is to primarily preheat the combustion air for a rapid and efficient combustion in the furnace [1]. The other function is to save the energy, not only from the viewpoint of fuel consumption but also for the protection of global environment [4]. Those preheaters have some disadvantages including the formation of the acid dew phenomenon inside it. This phenomenon leads to a decrease of the efficiency in preheater operation. The final part of the rotor, which is more exposed to degradation by acid corrosion, is analyzed.

The mathematic model presented in the paper is performed using the MathCAD and it is original. The model allows the operator to find the important temperature points in the air preheater which represents a justified approach by the experimental data in the science literature.

The main purpose of the paper is the optimization of the preheater in such a manner that the acid dew phenomenon disappears or is kept under control, depending on the obtained temperature points.

In this study, the mathematical model is similar to the models usually found in the literature. The preheater mathematical model is based on the following simplified assumptions [2]:

1. Heat transfer between the exchanger and the environment is negligible. There are no thermal energy sources within the exchanger.

2. The velocity and temperature of each fluid at the inlet are uniform over the flow cross section and are constant with time.

3. The thermal properties of both fluids and wall material are constant, irrespective of time and position.

4. The temperature across the wall thickness is uniform at cross section and the wall thermal resistance is treated as zero.

2. The numerical calculus of the equation system which mathematically shapes the cooling of the flue gases and heating the metal filler of the studied air preheater

2.1. The metal filler heating

The variations in space of the flue gases heat content from a volume element of the filler (in the cooling period of the flue gases and the heating of the metal), lead to the following differential equation system, which mathematically shapes the thermal regime of the analyzed system.

The heating of the metal filler system is as follows:

$$w_g \frac{\partial t_{gi}(z_i,\varphi_i)}{\partial z_i} + \omega \frac{\partial t_{gi}(z_i,\varphi_i)}{\partial \varphi_i} = -a \cdot \left[t_{gi}(z_i,\varphi_i) - t_{ui}(z_i,\varphi_i)\right]; \qquad (2.1)$$

$$\omega \frac{\partial t_{ui}(z_i,\varphi_i)}{\partial \varphi_i} = b \cdot \left[t_{gi}(z_i,\varphi_i) - t_{ui}(z_i,\varphi_i)\right]; \qquad (2.2)$$

The 2nd order partial derivatives are approximated according to the finite difference method.

The temperatures variation of the flue gases with the preheater height z_i is:

$$\frac{\partial t_{gi}(z_i,\varphi_i)}{\partial z_i} = \frac{t_{gi}(z_i,\varphi_i) - t_{gi}(z_{i-1},\varphi_{i-1})}{z_i - z_{i-1}}; \qquad (2.3)$$

The temperature variation of the flue gases with the preheater angle φ_i is:

$$\frac{\partial t_{gi}(z_i,\varphi_i)}{\partial \varphi_i} = \frac{t_{gi}(z_i,\varphi_i) - t_{gi}(z_{i-1},\varphi_{i-1})}{\varphi_i - \varphi_{i-1}}; \qquad (2.4)$$

The temperature variation of the metal filler with the preheater angle φ_i is:

$$\frac{\partial t_{ui}(z_i,\varphi_i)}{\partial \varphi_i} = \frac{t_{ui}(z_i,\varphi_i) - t_{ui}(z_{i-1},\varphi_{i-1})}{\varphi_i - \varphi_{i-1}}; \qquad (2.5)$$

The following notations were done to facilitate the resolution of the system calculus: $a = \frac{\alpha_g S_s}{v_g c_g}$ 1/rad; $b = \frac{\alpha_a S_s}{v_g c_g}$ 1/rad; $m = z_i - z_{i-1}$; $x = \varphi_i - \varphi_{i-1}$; $w_g = v$;

$A = v \cdot x + \omega \cdot m + a \cdot m \cdot x$; $B = -a \cdot m \cdot x$; $C = v \cdot x + \omega \cdot m$; $E = -b \cdot x$; $G = \omega + b \cdot x$; $F = E \cdot B - A \cdot G$.

After the system was solved, there results the temperature of the metal filler, respectively the temperature of the flue gases, $t_{ui}(z_i, \varphi_i)$, $t_{gi}(z_i, \varphi_i)$ ^oC, with the finite difference method, on the heating side of the preheater, at any z_i and φ_i:

$$t_{ui}(z_i, \varphi_i) = \frac{E \cdot C \cdot t_{gi}(z_{i-1}, \varphi_{i-1}) - A \cdot \omega \cdot t_{ui}(z_{i-1}, \varphi_{i-1})}{E \cdot B - A \cdot G}; \quad (2.6)$$

$$t_{gi}(z_i, \varphi_i) = \frac{A \cdot B \cdot \omega \cdot t_{ui}(z_{i-1}, \varphi_{i-1}) - t_{gi}(z_{i-1}, \varphi_{i-1}) \cdot (B \cdot C \cdot E - F \cdot C)}{A \cdot F} \quad (2.7)$$

Some calculated values of the elements are taken over from the literature [9], [7]:

$$w_g,\ h,\ \varphi_{it},\ \omega,\ t_{gi}(0{,}0),\ t_{ui}(0{,}0),\ w_a,\ \varphi_{rt},\ t_{ar}(0{,}0),\ t_{ur}(0{,}0) \quad (2.8)$$

The ” j ” variable, on the heating side of the metal filler has been chosen depending on how many temperature points are intended to be calculated in the inside of the rotary air preheater. All temperatures are defined with the help of the two variables z_i and φ_i, or z_r and φ_r, presented in (1.11) and (1.12), respectively (2.10) and (2.11).

The step wherewith the preheater height increases for each calculated temperature point p, m, is:

$$p = h / j_{max}; \quad (2.9)$$

The step wherewith the preheater angle increases for each calculated temperature point pp, rad, is:

$$pp = \varphi_{it} / j_{max}; \quad (2.10)$$

The specific height for each calculated temperature point on the heating side of the metal filler is, z_i, m:

$$z_i = i \cdot p; \quad (2.11)$$

The specific angle of each calculated temperature point, φ_i, rad, on the heating side of the metal filler is:

$$\varphi_i = i \cdot pp; \quad (2.12)$$

The temperature of the metal filler, ^{o}C at z_j and φ_j, results from the equation (1.7), with the notations, parameters (see point (1.8)), and the relations (2.9)- (2.12).

$$t_{ui}(z_j,\varphi_j)=\frac{E\cdot C\cdot t_{gi}(z_{j-1},\varphi_{j-1})-A\cdot\omega\cdot t_{ui}(z_{j-1},\varphi_{j-1})}{E\cdot B-A\cdot G} \quad (2.13)$$

The temperature of the flue gases, ^{o}C, at z_j and φ_j, results from the equation (1.10), with the notations, parameters (see point (1.8)), and the relations (2.9)- (2.12).

$$t_{gi}(z_j,\varphi_j)=\frac{A\cdot B\cdot\omega\cdot t_{ui}(z_{j-1},\varphi_{j-1})-t_{gi}(z_{j-1},\varphi_{j-1})\cdot(B\cdot E\cdot C-F\cdot C)}{A\cdot F} \quad (2.14)$$

3. The numerical calculus of the equation system which mathematically shapes the heating of the combustion air and cooling the metal filler of the studied preheater

3.1. The cooling of the metal filler

The cooling of the metal filler system is [6]:

$$w_a\cdot\frac{\partial t_{ar}(z_r,\varphi_r)}{\partial z_r}+\omega\cdot\frac{\partial t_{ar}(z_r,\varphi_r)}{\partial\varphi_r}=a_r\cdot(t_{ur}(z_r,\varphi_r)-t_{ar}(z_r,\varphi_r)) \quad (3.1)$$

$$\omega\cdot\frac{\partial t_{ur}(z_r,\varphi_r)}{\partial\varphi_r}=-b_r\cdot(t_{ur}(z_r,\varphi_r)-t_{ar}(z_r,\varphi_r)) \quad (3.2)$$

The 2[nd] order partial derivatives are approximated according to the finite difference method.

The temperatures variation of the combustion air with the preheater height z_r is:

$$\frac{\partial t_{ar}(z_r,\varphi_r)}{\partial z_r}=\frac{t_{ar}(z_r,\varphi_r)-t_{ar}(z_{r-1},\varphi_{r-1})}{z_r-z_{r-1}}; \quad (3.3)$$

The temperature variation of the combustion air with the preheater angle φ_r is:

$$\frac{\partial t_{ar}(z_r,\varphi_r)}{\partial\varphi_r}=\frac{t_{ar}(z_r,\varphi_r)-t_{ar}(z_{r-1},\varphi_{r-1})}{\varphi_r-\varphi_{r-1}}; \quad (3.4)$$

The temperature variation of the metal filler with the preheater angle φ_r, in the cooling zone of the preheater is:

$$\frac{\partial t_{ur}(z_r,\varphi_r)}{\partial \varphi_r} = \frac{t_{ar}(z_r,\varphi_r) - t_{ar}(z_{r-1},\varphi_{r-1})}{\varphi_r - \varphi_{r-1}}; \tag{3.5}$$

The following notations were done to facilitate the resolution of the system calculus:

$$n = z_r - z_{r-1}; \quad p = \varphi_r - \varphi_{r-1}; \quad M = w_a \cdot p + n \cdot \omega + n \cdot p \cdot a_r;$$

$$N = -n \cdot p \cdot a_r; \quad R = w_a \cdot p + n \cdot \omega; \quad S = \omega + p \cdot b_r; \; T = -p \cdot b_r;$$

$$K = T \cdot N - M \cdot S;$$

After the system has been solved, there results the temperature of the metal filler, respectively the temperature of the combustion air, $t_{ur}(z_r,\varphi_r)$, $t_{ar}(z_r,\varphi_r)$ ^oC, with the finite difference method, on the cooling side of the preheater, at any z_r and φ_r:

$$t_{ur}(z_r,\varphi_r) = \frac{T \cdot R \cdot t_{ar}(z_{r-1},\varphi_{r-1}) - M \cdot \omega \cdot t_{ur}(z_{r-1},\varphi_{r-1})}{T \cdot N - M \cdot S} \tag{3.6}$$

$$t_{ar}(z_r,\varphi_r) = \frac{K \cdot \omega \cdot t_{ur}(z_{r-1},\varphi_{r-1}) - S \cdot T \cdot R \cdot t_{ar}(z_{r-1},\varphi_{r-1})}{K \cdot T} + \frac{S \cdot M \cdot \omega \cdot t_{ur}(z_{r-1},\varphi_{r-1})}{K \cdot T}; \tag{3.7}$$

The step wherewith the preheater height increases for each calculated temperature point, s, m:

$$s = h / j_{\max} \tag{3.8}$$

The step wherewith the preheater angle increases for each calculated temperature point, ss, rad, on the cooling side of the metal filler:

$$ss = \varphi_{rt} / j_{\max}; \tag{3.9}$$

The specific height of each calculated temperature point on the cooling side of the metal filler is, z_r, m:

$$z_r = k \cdot s; \tag{3.10}$$

The specific angle for each calculated temperature point on the cooling side of the metal filler is, φ_r, rad:

$$\varphi_r = k \cdot ss; \tag{3.11}$$

The temperature of the metal filler, ^{o}C, at z_j and φ_j results from the equation (3.6), with the notations, parameters (see point (1.8)), and the relations (3.8)- (3.17):

$$t_{ur}(z_j,\varphi_j)=\frac{T\cdot R\cdot t_{ar}(z_{j-1},\varphi_{j-1})-M\cdot\omega\cdot t_{ur}(z_{j-1},\varphi_{j-1})}{T\cdot N-M\cdot S} \tag{3.12}$$

The temperature of the combustion air, ^{o}C, at z_j and φ_j results from the equation (3.7), with the notations, parameters (see point (1.8)), and the relations (3.8)- (3.17):

$$t_{ar}(z_j,\varphi_j)=\frac{K\cdot\omega\cdot t_{ur}(z_{j-1},\varphi_{j-1})-S\cdot T\cdot R\cdot t_{ar}(z_{j-1},\varphi_{j-1})}{K\cdot T}+$$
$$+\frac{S\cdot M\cdot\omega\cdot t_{ur}(z_{j-1},\varphi_{j-1})}{K\cdot T} \tag{3.13}$$

The equations (2.1), (2.2), (3.1) and (3.2) that form the two systems were taken from [6], but the method for solving the two systems, with interests in thermal processes of a rotating air preheater, has been an original idea. This idea involved a detailed mathematic analysis on the 2^{nd} order partial derivatives method, which was greatly simplified by finding the finite elements methods. A mathematical model which simulates the operation of preheater and which treats the thermal regime of a such a heat exchanger was created based on these formulae and on this solved mode. The presented model has been created by the authors, it is new and original and its graphic form is shown in Fig. 4.4. The purpose of these calculations is presented at the ”Results” chapter.

4. Results

Mathematical modelling developed in this paper was validated on a rotating-plate regenerative air preheather, Rothemuhler type, which equipped a 510 t/h steam generator from CET Isalnita. With a fixed rotor (Rothemuhler type) or a mobile one (Ljungström type), the results can be validated, because the rotation velocity have very little influence on the temperature variation of preheater’s air and flue gases [8]. Besides, both preheater have used metal filler, which leads to similar heat exchanges. Fig. 4.1 shows a part from the corroded active zone.

Fig. 4.1. The metal filler of a worn out preheater, formed from the corroded sheet combs

For a better understanding some measurements were made at CET Isalnita. There are presented the values of some calculated elements validated with the real measurements, on the cold zone of the preheater, in its lower part. This area is very important for the corrosion of the metal and can be thought of as a separate preheater. This paper treats only this zone of the rotor. Any numerical simulation can be considered only a part of the real physical domain or system [3].

The main parameters of the 7A steam generator from CET Isalnita are:

Nominal flow: $D_n = 510 \;\; t/h$; $D_n = 141.667, \;\; kg/s$;

Nominal temperature: $t_n = 540, \, ^oC$;

Nominal pressure: $p_n = 196$ bar;

The temperature of the supplied water: $t_e' = 254 \;\; ^oC$;

The fuel used is coal (lignite) with the elemental analysis:

$C_i = 22.8$ %; $S_i = 0.74$ %; $H_i = 2.08$ %; $N_i = 0.51$%;

$W_{ti} = 41.86$ %; $O_i = 9.78$ %; $A_i = 22.23$%;

The air preheater features are: rotor diameter: $8.5 \; m$ and the height of the active area $0.25 \; m$ (it is treated only the cold zone of the preheater).

The temperature points used to find out the point on the preheater height where the acid corrosion of the metal apears, have been the filler temperatures in cold zone of the preheater, in the streaming of the flue gases $t_{ui}(1,1)$, $t_{ui}(2,2)$, $t_{ui}(3,3)$, $t_{ui}(4,4)$.

Those temperatures were measured by means of the pyrometer Powerfix HG00304. The results are presented in Table 4.1 and Fig. 4.2. The pyrometer is shown in Table 4.2.

Table 4.1.

The measurements result of the metal filler temperature point $t_{ui}(0{,}0)$, ^{o}C

Nr. Crt.	Date	Time	Temperature value $t_{ui}(0,0)$	Unit measure
1	6/22/2016	11:00	118	ºC
2	6/22/2016	11:02	119	ºC
3	6/22/2016	11:04	118	ºC
4	6/22/2016	11:06	118	ºC
5	6/22/2016	11:08	117	ºC

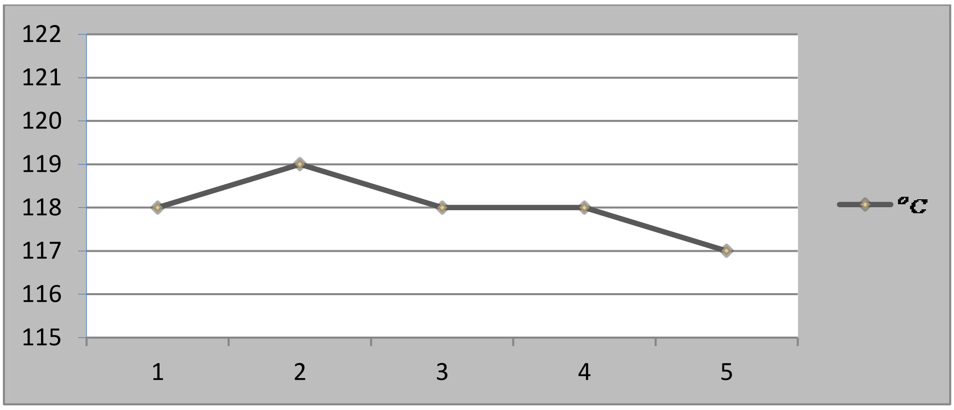

Fig. 4.2 The graphic presentation of the temperature values from Table 4.1

Table 4.2.

The pyrometer caracteristics

Technical specifications	
Measuring range	- 50 ºC up to 380 ºC (-58 ºF up to + 716 ºF)
Measurement accuracy for T > 0 ºC	± 1.5 ºC or ± 1.5 % of measurement
Measurement accuracy for T < 0 ºC	± 3 ºC or ± 3 % of measurement
Laser class:	2
The wavelength of the laser:	650 nm
Laser output power	< 1 mW
Operation temperature	0 ºC up to 40 ºC
Humidity	≤ 75 %

4.1. The numerical values calculated on the heating part of the metal filler

To get the results shown in this paper the elements below were calculated with the relations (1.9) up to (1.14):

$h = z_i = z_r = 0.25$ m; $\varphi_{it} = 3.403$ rad; $\varphi_{rt} = 2.356$ rad; $\omega = 0.3142$ rad/s; $w_g = 7.88$ m/s;

$t_{gi}(0,0) = 135\ ^oC$; $t_{ui}(0,0) = 115\ ^oC$; $t_{ar}(0,0) = 50\ ^oC$; $t_{ur}(0,0) = 115\ ^oC$.

$z_1 = 0.063$ m; $z_2 = 0.126$ m; $z_3 = 0.189$ m; $z_4 = 0.250$ m;

$\varphi_1 = 0.851$ rad; $\varphi_2 = 1.702$ rad; $\varphi_3 = 2.553$ rad; $\varphi_4 = 3.403$ rad;

Table 4.3

The numerical values calculated on the heating part of the metal filler

$t_{gi}(1,1) = 147\ ^oC$;	$t_{ui}(1,1) = 122\ ^oC$;
$t_{gi}(2,2) = 160\ ^oC$;	$t_{ui}(2,2) = 131\ ^oC$;
$t_{gi}(3,3) = 175\ ^oC$;	$t_{ui}(3,3) = 142\ ^oC$;
$t_{gi}(4,4) = 190\ ^oC$;	$t_{ui}(4,4) = 154\ ^oC$;

4.2. The numerical values calculated on the cooling part of the metal filler

To get the results, the elements below were calculated with the relations (2.9) up to (2.13):

$z_1 = 0.063$ m; $z_2 = 0.126$ m; $z_3 = 0.189$ m; $z_4 = 0.250$ m;

$\varphi_1 = 0.589$ rad; $\varphi_2 = 1.178$; $\varphi_3 = 1.767$ rad; $\varphi_4 = 2.356$ rad;

Table 4.4.

The numerical values calculated on the cooling part of the metal filler

$t_{ar}(1,1) = 62\ ^oC$;	$t_{ur}(1,1) = 123\ ^oC$;
$t_{ar}(2,2) = 78\ ^oC$;	$t_{ur}(2,2) = 134\ ^oC$;
$t_{ar}(3,3) = 98\ ^oC$;	$t_{ur}(3,3) = 143\ ^oC$;
$t_{ar}(4,4) = 122\ ^oC$;	$t_{ur}(4,4) = 156\ ^oC$;

In Figs. 4.3 and 4.4 it is presented the graph of the temperature points of the metal filler, flue gases and combustion air previously obtained.

The average values obtained by measuring with the pyrometer for steam generator load of 72 %, is approximately 118 °C An outlet temperature of the metal filler with the value of 118 °C results from calculus, using the mathematical model. If a comparison by means of a relative error between the results is made, a value of 1.7 % is obtained. Also if it is considered the measure error, the comparision result is about 2 °C. The relative error of 2 % is conservative and the two results can be considered close if one takes into account the influences that appear in the calculus of such a heat exchanger during service.

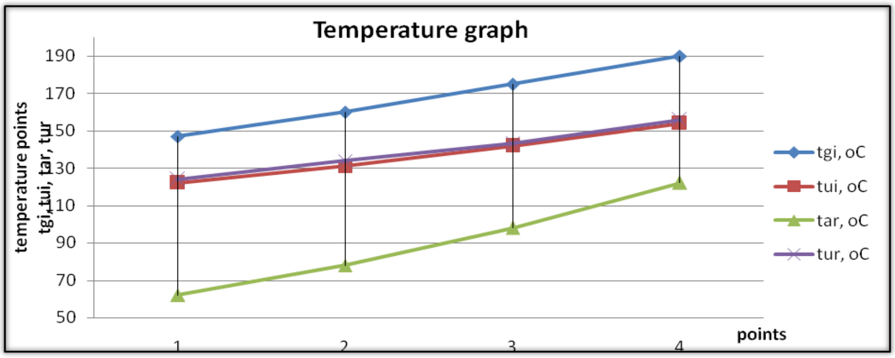

Fig. 4.3 Temperature graph, t_{gi} - flue gases temperatures, °*C*; t_{ui} - metal filler temperatures on the heating part, °*C*; t_{ar} - the combustion air temperature, °*C*; t_{ur} - metal filler temperatures on the heating part, °*C*

The calculus of the equation systems (2.1) and (2.2) on the filler heating part, respectively equations (3.1) and (3.2) on the filler cooling part, with the unknowns: $t_{ui}(z_i,\varphi_i)$ and $t_{gi}(z_i,\varphi_i)$ temperatures, respectively $t_{ur}(z_i,\varphi_i)$ and $t_{ar}(z_i,\varphi_i)$ temperatures, which if solved allows finding the practical possibilities to avoid the acid corrosion of the RAPH rotor sheet. The acid dew temperature t_{ra} $^\circ C$ was of 152 °*C*, calculated for the used fuel.

The calculations were made for the 72 % load of the steam generator. For this load $t_{ra} \approx t_{ui}(4,4) = 154$ $^\circ C$ it results that the acid dew phenomenon occurs in the cold zone, the height of the preheater at approximately 0.25 m ($250\,mm$).

The most exposed point to the acid corrosion inside the preheater is the metal filler point with the temperature $t_{ui}(1,1)$, °*C*. If the acid corrosion is avoided in this area, the entire rotor will be protected and, more exactly, this thing happens when the calculated temperature of the filler approaches to the temperature $t_{ui}(0,0)$, which is the lowest temperature of the metal filler. If the temperature is $t_{ui}(0,0) > t_{ra}$, then the acid corrosion does not appear.

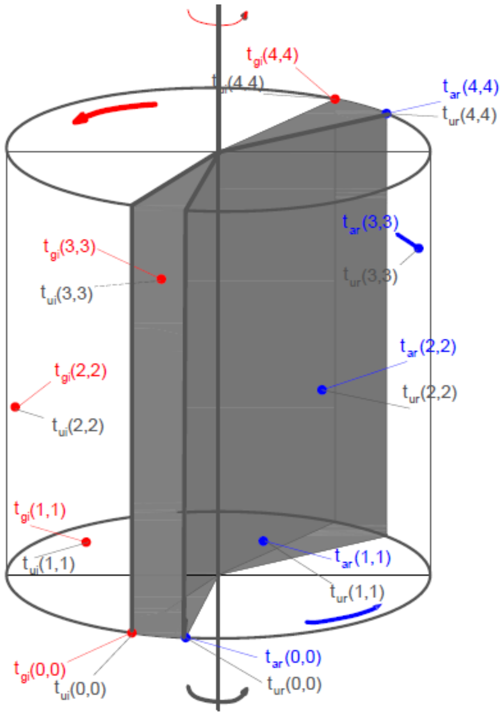

Fig. 4.4 The RAPH spatial view; t_{gi} - flue gases temperatures, °*C*; t_{ui} - metal filler temperatures on the heating part, °*C*; t_{ar} - the combustion air temperature, °*C*; t_{ur} - metal filler temperatures on the heating part, °*C*

The mathematic model presented in this paper allows the preheater operator to find the interest temperature points of the heat exchanger, that represents a justified approach by the experimental data in the science literature. Air preheaters have proved to have an important influence on the efficiency of the entire steam boiler. By means of this mathematic model the interest temperatures were calculated from the metal comb of the inside preheater depending of its height h and center angle φ, formed by preheater rotation. The temperatures were found either on the cooling part of the cooling gases or on the combustion preheating air part or on the cooling of the metal filler. There are shown the temperatures of the metal filler, the flue gases and the combustion air.

The temperature points show the manipulation of the efficiency of the preheater. The operator can optimize the preheater operation in a manner that the apparition of the sulfuric acid should not occur or be kept under control.

The main purpose was to find the point on the preheater height where the acid dew phenomenon appears, the phenomenon that destroys the heat exchanger material and methods to avoid its occurrence. Knowing this point, using the presented mathematical model, the optimum height of the final stage zone of the heat exchanger can be calculated. For example, for this area it is often used special metal filler (specially treated or from a different material which resist to corrosion as compared to other stages) with the height of 25 cm, but the acid corrosion can occur at 30 cm on the height, due to the usual load regime of the steam generator which the operator uses. In this case, when it is necessary to replace the metal filler combs, it can be considered a metal filler acquisition with a higher height for the final stage of the preheater so as the sulfuric acid will not destroy the material.

In chapter 4 the mathematical model for a real preheater was implemented. For the calculus made in chapter 4, there has been found out that for a 72 % load of the presented steam generator, the final stage of the air preheater enters an acid corrosion process, at approximately 25 cm from the gas evacuation of the heat exchanger. In this moment, the preheater operator knows whether to increase the generator load until the metal filler temperature is higher than the acid dew temperature, $t_{ui}(0,0) > t_{ra}$, from 118 $°C$ to aproximately 154 $°C$; then inside the preheater, the acid dew phenomenon does not appear.

In this exemple there were calculated only 4 filler temperatures on the heating part of the preheater. With the presented calculation model as many temperatures as desired by the operation of the preheater can be calculated, depending on the chosen step on the rotor height(z_i) and the angle of rotation (φ_i).

In nominal operation regime, as it is designed by the manufacturer, the preheater doesn’t work in acid corrosion regime; however, the things will change when the steam generator charge is in decrease and simultaneously with it the input, respectively the outlet temperatures of the flue gases are also in decrease. By means of those presented in this paper, the point on the preheater height where the sulfuric acid occurs can be accurately calculated. This phenomenon can be stopped through an optimum adjustment of the generator load or it can be brought into question the use its end stage under corrosion acid, like a sacrified component part or how the preheater can be divided into two parts, a hot part, respectively a cold part which can be changed more easily whenever needed.

There are shown some other methods for controlling or keeping under control this phenomenon. By the help of those presented in this work the rotating-plate regenerative air preheater can be manipulated/ operated with better accuracy and professionalism, situation which finally leads to lower costs, which are not negligible in exploiting this type of thermal equipment.

5. Conclusions

The aim of this paper was that of developing a scientific idea for optimizing rotating-plate regenerative air preheaters. In chapter 4 “Results”, there are minutely presented the methods for stopping or keeping under control the acid dew phenomenon which apears inside a rotating air preaheater.

In the future, this paper can represent a starting point for the researchers keen on the development of this imperfection (acid dew phenomenon) of the rotary air preheater and a totally different method against that which is used now on the market, method with absorbant substances injection in flue gases. This solution chemically removes the sulfuric acid and can be used, but involves supplementary costs, which are not at all negligible.

The thermal regime in a rotary air preheater was investigated numerically and the presented mathematical model was validated on a real case of a preheater. A model for operation simulation of the rotate air preheater was achieved.

The simulation of the preheater operation can be used in more approaches and specific problems of this preheater type. The paper provides to the specialists in this field a new approach in thermal processes analysis of an RAPH.

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