A thermal computation program of process steam boilers obtained with reusable equipments and plants

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Abstract: - This paper presents a process steam boiler dimensioned by means of two computer programs. The first computer program entitled “thermal computation of the chamber furnace of boiler” provides the utilization of the Boltzmann criterion. This computer program consists in determination of the radiant heat exchange surface. By means of this computer program, there were also made simulations in the imposed conditions of utilization of reusable furnace and different fuel types (natural gas, heavy fuel or refinery gas). The second computer program entitled “thermal computation of the heat exchangers” allows dimensioning of the different convective heated surfaces of boiler which are placed after the chamber furnace (convective vaporizer, steam superheater, eonomizer and water preheater). By means of this computer program, there were also made simulations in the imposed conditions of utilization of reusable convective heat exchangers. Comparing the results of functional parameters determined by measurements with computation results, satisfactory convergence is found.

Key-Words: - boiler, chamber furnace, computer program, heat exchanger.

1 Introduction

In the '90s Romania, the movement to a market economy meant for the petrochemical plants the scrapping of some technological lines. The steam supply of these plants was done from the thermal plants of high capacity. At the same time with the reduction of steam requirements of the petrochemical plants, the thermal plants could no longer mantain the steam deliveries at the needed paramenters and for the established price. As a result, the thermal plants had no other solution but to import steam boilers that had the disadvantage of high costs. This aspect, along with the possibility of using some deallocated technological lines lead to the idea of building some technological steam boilers. The new technological steam boilers have been achieved for smaller costs – 35% smaller. The deallocated installments, used in achieving the new technological steam boilers were: tubular furnace, heat exchangers, pumps, combustion outdoor fans, exhausters etc.

Design of the new steam boiler necessitates the following activities:

- Establishment of the designing theme for the new process steam boiler according to technological requirements;
- Identification of deallocated equipments having the minimum resistance and which can be used within a new process steam boiler;
- Establishment of the thermodinamic diagram and conception of some solutions for connection of the different equipments in work at the process steam boiler;
- Design of the process steam boiler in which are included the reusable equipments from deallocated plants.

Design of this steam boiler implies many thermal computation variants. For these thermal computation variants, two computer programs are used. The first computer program entitled “thermal computation of the chamber furnace of boiler” provides the utilization of the Boltzmann criterion. This theory and design have been developed by professor A.M.Gurvich [1,2,3]. The second computer program entitled “thermal computation of the heat exchangers” allows dimensioning of the different convective heated surfaces of boiler which are placed after the chamber furnace of boiler (convective vaporizer, steam superheaters, eonomizers and air preheater).This is an original computer program which can be used for any heat exhanger putted after the furnace chamber of steam boiler:

- convective vaporizer;
- steam superheater;
- economizer;
- water preheater [4].

2 Thermal computation of chamber furnace of boiler

Design of the new process steam boiler implies from thermal computation point of view, the heat exchanger by radiation dimensioning according to the existent chamber furnace. This is exemplified for a steam boiler of 20t/h.

The computer program "thermal computation of the chamber furnace of boiler" computes the flame parameters depending on the used fuel type and the heat transfer according to the value of Boltzmann criterion.The listing obtained by means of the computer is presented in Table 1.

Table 1 Thermal computation of the chamber furnace of boiler.

No	Features	Symbol	U.M.	Value
	Inlet data			
1	Composition of fuel: Carbon dioxide	CO_2	m^3N/ m^3N	0.025
2	Carbon oxide	CO	m^3N/ m^3N	0.0
3	Hydrogen	H_2	m^3N/ m^3N	0.0
4	Hydrogen sulfide	H_2S	m^3N/ m^3N	0.0
5	Methane	CH_4	m^3N/ m^3N	0.94
6	Acetylene	C_2H_2	m^3N/ m^3N	0.0
7	Ethane	C_2H_6	m^3N/ m^3N	0.004
8	Propane	C_3H_2	m^3N/ m^3N	0.0
9	Propane	C_3H_8	m^3N/ m^3N	0.001
10	C_4H_8	C_4H_8	m^3N/ m^3N	0.0
11	Butane	C_4H_{10}	m^3N/ m^3N	0.0
12	Pentane	C_5H_{12}	m^3N/ m^3N	0.0
13	Nitrogen	N_2	m^3N/ m^3N	0.03
14	Oxygen	O_2	m^3N/ m^3N	0
15	Fuel Flow	DC	m^3N/h	1900
16	Inlet air excess coefficient	ALFI	-	1.1
17	Outlet air excess coefficient	ALFE	-	1.1
18	Input air temperature	TAI	ºC	20
19	External efficiency of the firebox of steam boiler	ETA	-	0.98
20	Ambient temperature	TAM	ºC	20
21	Low calorific power	PCI	kJ/ m^3N	31806
22	Caloric capacity of the fuel	CC	$kJ/(m^3N$ ºC)	1.8
23	Fuel temperature	TC	ºC	20
24	Dissociation loses	qd	-	0.99
25	Covered geometric surface of the furnace of steam boiler	Sp	m^2	73
26	Geometric surface of the furnace of steam boiler	Sg	m^2	88.8
27	Pipes pitch	t	mm	200
28	Outer diameter of the pipes	d	mm	100
29	Distance from pipes to wall	e	mm	150
30	Burner height	Ha	m	1
31	Furnace height	Hf	m	5
32	Light side emissivity coefficient	m	-	0.3
33	Furnace pressure	p	bar	1
34	Furnace volume	Vf	m^3	52.4
	Outlet data			
35	Inlet flue gases flow rate	DGAI	m^3N/h	21115.22
36	Outlet flue gases flow rate	DGAE	m^3N/h	21115.22
37	Combustion air flow rate	DA	m^3N/h	19209.52
38	Inlet air heat	QA	W	138431.69
39	Inlet heat with fuel	QC	W	16805764
40	Volumetric load	qv	W/m^3	323362.51
41	Surfacing load	qs	W/m^2	232112.27
42	Inlet exhaust gases temperature	TGI	ºC	1725.74
43	Mean caloric capacity of the inlet gases	CPI	$kJ/(m^3N$ ºC)	1.6572
44	Outlet exhaust gases temperature	TGE	ºC	1014.1
45	Mean caloric capacity of the outlet gases	CPE	$kJ/(m^3N$ ºC)	1.5487
46	Heat included in the inlet gases	QGI	W	16774754
47	Heat included in the outlet gases	QGE	W	9211749.9
48	Radiant heat	Qr	W	13262567
49	Furnace efficiency	ETAF	-	0.43537

3 Thermal computation of heat exchangers

The computer program entitled "thermal computation of the heat exchangers" allows dimensioning of the different convective heated surfaces of boiler which are placed after the chamber furnace of boiler (convective vaporizer, steam superheaters, eonomizers and water preheater) [4].

The input data are obtained, for each heat echanger from the antecedent heat exhanger, according to the thermal circuit diagram, presented in figure 1, as the side of combustion gases as well as the side of the heated fluid. The thermal computations are made in order to use as many deallocated equipments.

For the variant of rating, the listings obtained by means of the computer, are presented in Table2, Table 3, Table 4 and Table 5, as follows.

Figure 1 Thermal circuit for the process steam boiler of 20 t

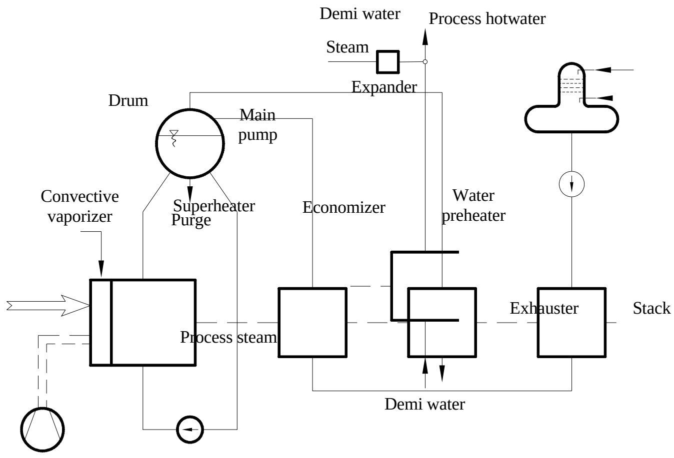

Table 2. Thermal computation of the convective vaporizer

No	Notation	Symbol	U.M.	Value
	Inlet data Composition of fuel			
1	Carbon dioxide	CO_2	m^3N/ m^3N	0.025
2	Carbon oxide	CO	m^3N/ m^3N	0.0
3	Hydrogen	H_2	m^3N/ m^3N	0.0
4	Hydrogen sulfide	H_2S	m^3N/ m^3N	0.0
5	Methane	CH_4	m^3N/ m^3N	0.94
6	Acetylene	C_2H_2	m^3N/ m^3N	0.0
7	Ethane	C_2H_6	m^3N/ m^3N	0.004
8	Propane	C_3H_2	m^3N/ m^3N	0.0
9	Propane	C_3H_8	m^3N/ m^3N	0.001
10	C_4H_8	C_4H_8	m^3N/ m^3N	0.0
11	Butane	C_4H_{10}	m^3N/ m^3N	0.0
12	Pentane	C_5H_{12}	m^3N/ m^3N	0.0
13	Nitrogen	N_2	m^3N/ m^3N	0.03
14	Oxygen	O_2	m^3N/ m^3N	0
15	Fuel Flow	DC	m^3N/h	1900
16	Fluid Flow	DA	kg/h	21000
17	Inlet fluid temp.	TAI	º C	198
18	Outlet fluid temp.	TAE	º C	200.4
19	Heat exchanger efficiency	ETA	-	0.97
20	Air excess coefficient to burner	ALF	-	1.1
21	Ambient temperature	TAM	ºC	10
22	Inlet exhaust gases temperature	TGI	ºC	1014
23	Steam title	x	-	0.31
24	Latent heat of vaporization	r	kJ/kg	1947.8235
25	Inner diameter of pipe	DI	m	0.1
26	Outer diameter of pipe	DE	m	0.108
27	Pipe length by one passing	LT	m	5.4
28	Height tube plate	LV	m	0.3
29	Length tube plate	LO	m	1.4
30	Spacing between pipes on vertical	PV	m	0.2
31	Spacing between pipes on horizontal	PO	m	0.2
32	Vertical distance to the wall	DV	m	0.05
33	Horizontal distance to the wall	DO	m	0.05
34	Passes number	NTR	-	12
35	Pressure	p	bar	15
36	Saturation temperature	TS	ºC	200.4
37	Thickness of salts layer	GS	m	0.0005
38	Thickness of soot layer	GF	m	0.0005
39	Soot thermal conductivity	LAF	W/(m ºC)	0.1
40	Salt thermal conductivity	LAS	W/(m ºC)	1
41	Steel thermal conductivity	LAMDAO	W/(m ºC)	50
42	**Outlet data** Inlet exhaust gases flow	DGAI	m^3N/h	21115.22
43	Outlet exhaust gases flow	DGAE	m^3N/h	21115.22
44	Mean caloric capacity of the inlet gases	CPI	kJ/ (m^3N ºC)	1.5483
45	Mean caloric capacity of the outlet gases	CPE	kJ/ (m^3N ºC)	1.4879
46	Heat included in the inlet gases	QGI	W	9208474
47	Heat included in the outlet gases	QGE	W	5516820
48	Outlet exhaust gases temperature	TGE	ºC	632.15
49	Mean temperature difference	DTMED	ºC	604.14
50	Mean temperature of gases	TMG	ºC	803.34
51	Mean temperature of fluid	TMA	ºC	199.2
52	Absorbed heat of water	QA	W	3580904.2
53	Pipes number on a line by one vertical passing	NV	-	1
54	Pipes number on a line by one horizontal passing	NO	-	7
55	Gas flow section	SG	m^2	3.4776
56	Fluid flow section	SA	m^2	0.05498
57	Gas velocity	WG	m/s	6.6497
58	Gas velocity	WA	m/s	4.1635
59	Gas convection heat transfer coefficient	ALFACG	W/(m^2 ºC)	37.5939
60	Fluid convection heat transfer coefficient	ALFACA	W/(m^2 ºC)	83062.09
61	Thickness of gases layer	LG	m	0.327429
62	Radiation coefficient	ALFARG	W/(m^2 ºC)	16.8498
63	Convection heat transfer coefficient from gases	ALFAG	W/(m^2 ºC)	54.4438
64	Overall heat transfer coefficient	KL	W/(m^2 ºC)	13.0036
65	Overall heat transfer coefficient	KM	W/(m^2 ºC)	39.7986
66	Length of the device	LA	m	5.4263
67	Heat transfer surface	S	m^2	148.2219
68	Necessary heat transfer surface	SN	m^2	148.9305
69	Water pressure losses	PA	N/m^2	239495.2
70	Gas pressure losses	PGA	N/m^2	40.60

Table 3 Thermal computation of the steam superheater

No	Notation	Symbol	U.M.	Value
	Inlet data			
1	Composition of fuel: Carbon dioxide	CO_2	m^3N/ m^3N	0.025
2	Carbon oxide	CO	m^3N/ m^3N	0.0
3	Hydrogen	H_2	m^3N/ m^3N	0.0
4	Hydrogen sulfide	H_2S	m^3N/ m^3N	0.0
5	Methane	CH_4	m^3N/ m^3N	0.94
6	Acetylene	C_2H_2	m^3N/ m^3N	0.0
7	Ethane	C_2H_6	m^3N/ m^3N	0.004
8	Propane	C_3H_2	m^3N/ m^3N	0.0
9	Propane	C_3H_8	m^3N/ m^3N	0.001
10	C_4H_8	C_4H_8	m^3N/ m^3N	0.0
11	Butane	C_4H_{10}	m^3N/ m^3N	0.0
12	Pentane	C_5H_{12}	m^3N/ m^3N	0.0

13	Nitrogen	N_2	m^3N/m^3N	0.03
14	Oxygen	O_2	m^3N/m^3N	0
15	Fuel Flow	DC	m^3N/h	1900
16	Fluid Flow	DA	kg/h	20200
17	Inlet fluid temperature	TAI	º C	200.4
18	Outlet fluid temperature	TAE	º C	250
19	Heat exchanger efficiency	ETA	-	0.98
20	Air excess coefficient to burner	ALF	-	1.1
21	Ambient temperature	TAM	ºC	10
22	Inlet exhaust gases temperature	TGI	ºC	632
23	Inner diameter of pipe	DI	m	0.034
24	Outer diameter of pipe	DE	m	0.038
25	Pipe length by one passing	LT	m	4.1
26	Height tube plate	LV	m	0.2
27	Length tube plate	LO	m	1.2
28	Spacing between pipes on vertical	PV	m	0.06
29	Spacing between pipes on horizontal	PO	m	0.085
30	Vertical distance to the wall	DV	m	0.03
31	Horizontal distance to the wall	DO	m	0.03
32	Passes number	NTR	-	4
33	Pressure	Pres	bar	14
34	Thickness of salts layer	GS	m	0.0005
35	Salt thermal conductivity	LAS	W/(m ºC)	1
36	Thickness of soot layer	GF	m	0.0005
37	Soot thermal conductivity	LAF	W/(m ºC)	0.1
38	Steel thermal conductivity	LAMDAO	W/(m ºC)	50
39	**Outlet data** Inlet exhaust gases flow	DGAI	m^3N/h	21115.22
40	Outlet exhaust gases flow	DGAE	m^3N/h	21115.22
41	Mean caloric capacity of the inlet gases	CPI	kJ/ (m^3N ºC)	1.4877
42	Mean caloric capacity of the outlet gases	CPE	kJ/ (m^3N ºC)	1.4745
43	Heat included in the inlet gases	QGI	W	5514858.8
44	Heat included in the outlet gases	QGE	W	4781979.0
45	Outlet exhaust gases temperature	TGE	ºC	552.9
46	Mean temperature difference	DTMED	ºC	345.0
47	Mean temperature of gases	TMG	ºC	570.2
48	Mean temperature of fluid	TMA	ºC	225.2
49	Absorbed heat of water	QA	W	718222.2
50	Pipes number on a line by one vertical passing	NV	-	2
51	Pipes number on a line by one horizontal passing	NO	-	14
52	Gas flow section	SG	m^2	2.738
53	Fluid flow section	SA	m^2	0.02542
54	Gas velocity	WG	m/s	6.6148
55	Steam velocity	WA	m/s	27.3693
56	Gas convection heat transfer coefficient	ALFACG	W/(m^2 ºC)	68.38
57	Steam convection heat transfer coefficient	ALFACA	W/(m^2 ºC)	207.668
58	Thickness of gases layer	LG	m	0.11967
59	Radiation coefficient	ALFARG	W/(m^2 ºC)	7.6489
60	Convection heat transfer coefficient from gases	ALFAG	W/(m^2 ºC)	76.035
61	Overall heat transfer coefficient	KL	W/(m^2 ºC)	4.5807
62	Overall heat transfer coefficient	KM	W/(m^2 ºC)	40.501
63	Length of the device	LA	m	4.057
64	Heat transfer surface	S	m^2	51.94
65	Necessary heat transfer surface	SN	m^2	51.39
66	Water pressure losses	PA	N/m^2	22043.8
67	Gas pressure losses	PGA	N/m^2	90.81

Table 4 Thermal computation of economizer

No	Notation	Symbol	U.M.	Value
	Inlet data			
1	Composition of fuel : Carbon dioxide	CO_2	m^3N/m^3N	0.025
2	Carbon oxide	CO	m^3N/m^3N	0.0
3	Hydrogen	H_2	m^3N/m^3N	0.0
4	Hydrogen sulfide	H_2S	m^3N/m^3N	0.0
5	Methane	CH_4	m^3N/m^3N	0.94
6	Acetylene	C_2H_2	m^3N/m^3N	0.0
7	Ethane	C_2H_6	m^3N/m^3N	0.004
8	Propane	C_3H_2	m^3N/m^3N	0.0
9	Propane	C_3H_8	m^3N/m^3N	0.001
10	C_4H_8	C_4H_8	m^3N/m^3N	0.0
11	Butane	C_4H_{10}	m^3N/m^3N	0.0
12	Pentane	C_5H_{12}	m^3N/m^3N	0.0
13	Nitrogen	N_2	m^3N/m^3N	0.03
14	Oxygen	O_2	m^3N/m^3N	0
15	Fuel Flow	DC	m^3N/h	1900
16	Fluid Flow	DA	kg/h	21000
17	Inlet fluid temp.	TAI	º C	105
18	Outlet fluid temperature	TAE	º C	198
19	Heat exchanger efficiency	ETA	-	0.99
20	Air excess coefficient	ALF	-	1.1
21	Ambient temperature	TAM	ºC	10
22	Inlet exhaust gases temperature	TGI	ºC	552.9
23	Inner diameter of pipe	DI	m	0.034
24	Outer diameter of pipe	DE	m	0.038
25	Pipe length by one passing	LT	m	4.1
26	Height tube plate	LV	m	0.2
27	Length tube plate	LO	m	1.2
28	Spacing between pipes on vertical	PV	m	0.06
29	Spacing between pipes on horizontal	PO	m	0.085
30	Vertical distance to the wall	DV	m	0.03
31	Horizontal distance to the wall on Horizontal	DO	m	0.03
32	Passes number	NTR	-	16
33	Pressure	Pres	bar	15
34	Thickness of salts layer	GS	m	0.0005
35	Salt thermal conductivity	LAS	W/(m ºC)	1
36	Thickness of soot layer	GF	m	0.0005
37	Soot thermal conductivity	LAF	W/(m ºC)	0.1
38	Steel thermal conductivity	LAMDAO	W/(m ºC)	50
39	**Outlet data** Inlet exhaust gases flow	DGAI	m^3N/h	21115.22
40	Outlet exhaust gases flow	DGAE	m^3N/h	21115.22
41	Mean caloric capacity	CPI	kJ/ (m^3N	1.4745

	of the inlet gases		ºC)	
42	Mean caloric capacity of the outlet gases	CPE	kJ/ (m^{3}N ºC)	1.4283
43	Heat included in the inlet gases	QGI	W	4781979.0
44	Heat included in the outlet gases	QGE	W	2466462.3
45	Outlet exhaust gases temperature	TGE	ºC	294.4
46	Mean temperature difference	DTMED	ºC	263.5
47	Mean temperature of gases	TMG	ºC	415.1
48	Mean temperature of fluid	TMA	ºC	151.5
48	Absorbed heat of water	QA	W	2270362.5
50	Pipes number on a line by one vertical passing	NV	-	2
51	Pipes number on a line by one horizontal passing	NO	-	14
52	Gas flow section	SG	m^2	2.738
53	Fluid flow section	SA	m^2	0.02542
54	Gas velocity	WG	m/s	5.3978
55	Gas velocity	WA	m/s	0.266
56	Gas convection heat transfer coefficient	ALFACG	W/(m^2 ºC)	61.05
57	Fluid convection heat transfer coefficient	ALFACA	W/(m^2 ºC)	2470.14
58	Thickness of gases layer	LG	m	0.11967
59	Radiation coefficient	ALFARG	W/(m^2 ºC)	3.9979
60	Convection heat transfer coefficient from gases	ALFAG	W/(m^2 ºC)	65.054
61	Overall heat transfer coefficient	KL	W/(m ºC)	4.908
62	Overall heat transfer coefficient	KM	W/(m ºC)	43.40
63	Length of the device	LA	m	3.916
64	Heat transfer surface	S	m^2	207.76
65	Necessary heat transfer surface	SN	m^2	198.45
66	Water pressure losses	PA	N/m^2	1216.95
67	Gas pressure losses	PGA	N/m^2	214.47

Table 5 Thermal computation of water preheater

No	Notation	Symbol	U.M.	Value
	Inlet data			
1	Composition of fuel : Carbon dioxide	CO_2	m^{3}N/ m^{3}N	0.025
2	Carbon oxide	CO	m^{3}N/ m^{3}N	0.0
3	Hydrogen	H_2	m^{3}N/ m^{3}N	0.0
4	Hydrogen sulfide	H_2S	m^{3}N/ m^{3}N	0.0
5	Methane	CH_4	m^{3}N/ m^{3}N	0.94
6	Acetylene	C_2H_2	m^{3}N/ m^{3}N	0.0
7	Ethane	C_2H_6	m^{3}N/ m^{3}N	0.004
8	Propane	C_3H_2	m^{3}N/ m^{3}N	0.0
9	Propane	C_3H_8	m^{3}N/ m^{3}N	0.001
10	C_4H_8	C_4H_8	m^{3}N/ m^{3}N	0.0
11	Butane	C_4H_{10}	m^{3}N/ m^{3}N	0.0
12	Pentane	C_5H_{12}	m^{3}N/ m^{3}N	0.0
13	Nitrogen	N_2	m^{3}N/ m^{3}N	0.03
14	Oxygen	O_2	m^{3}N/ m^{3}N	0
15	Fuel Flow	DC	m^{3}N/h	1900
16	Fluid Flow	DA	kg/h	14000
17	Inlet fluid temp.	TAI	º C	105
18	Outlet fluid temperature	TAE	º C	167
19	Heat exchanger efficiency	ETA	-	0.98
20	Air excess coefficient	ALF	-	1.1
21	Ambient temperature	TAM	ºC	10
22	Inlet exhaust gases temperature	TGI	ºC	294.4
23	Inner diameter of pipe	DI	m	0.034
24	Outer diameter of pipe	DE	m	0.038
25	Pipe length by one passing	LT	m	4.1
26	Height tube plate	LV	m	0.2
27	Length tube plate	LO	m	1.2
28	Spacing between pipes on vertical	PV	m	0.06
29	Spacing between pipes on horizontal	PO	m	0.085
30	Vertical distance to the wall	DV	m	0.03
31	Horizontal distance to the wall on Horizontal	DO	m	0.03
32	Passes number	NTR	-	21
33	Pressure	Pres	bar	13
34	Thickness of salts layer	GS	m	0.0005
35	Salt thermal conductivity	LAS	W/(m ºC)	1
36	Thickness of soot layer	GF	m	0.0005
37	Soot thermal conductivity	LAF	W/(m ºC)	0.1
38	Stainless steel thermal conductivity	LAMDAO	W/(m ºC)	35
39	**Outlet data** Inlet exhaust gases flow	DGAI	m^{3}N/h	21115.22
40	Outlet exhaust gases flow	DGAE	m^{3}N/h	21115.22
41	Mean caloric capacity of the inlet gases	CPI	kJ/ (m^{3}N ºC)	1.4283
42	Mean caloric capacity of the outlet gases	CPE	kJ/ (m^{3}N ºC)	1.4013
43	Heat included in the inlet gases	QGI	W	2462599.2
44	Heat included in the outlet gases	QGE	W	1432956.2
45	Outlet exhaust gases temperature	TGE	ºC	173.9
46	Mean temperature difference	DTMED	ºC	95.3
47	Mean temperature of gases	TMG	ºC	231.1
48	Mean temperature of fluid	TMA	ºC	136.5
48	Absorbed heat of water	QA	W	1009050.5
50	Pipes number on a line by one vertical passing	NV	-	2
51	Pipes number on a line by one horizontal passing	NO	-	14
52	Gas flow section	SG	m^2	2.738
53	Fluid flow section	SA	m^2	0.02542
54	Gas velocity	WG	m/s	3.955
55	Gas velocity	WA	m/s	0.1774
56	Gas convection heat transfer coefficient	ALFACG	W/(m^2 ºC)	53.04
57	Fluid convection heat transfer coefficient	ALFACA	W/(m^2 ºC)	1751.4
58	Thickness of gases layer	LG	m	0.11967
59	Radiation coefficient	ALFARG	W/(m^2 ºC)	1.977
60	Convection heat transfer coefficient from gases	ALFAG	W/(m^2 ºC)	55.41
61	Overall heat transfer coefficient	KL	W/(m ºC)	4.33
62	Overall heat transfer coefficient	KM	W/(m ºC)	38.29
63	Length of the device	LA	m	4.158
64	Heat transfer surface	S	m^2	272.69
65	Necessary heat transfer surface	SN	m^2	276.53
66	Water pressure losses	PA	N/m^2	718.75
67	Gas pressure losses	PGA	N/m^2	191..84

4 Experimental results

The steam boiler of 20t/h which is shown in Figure 2, it was made by changing of a tubular furnace and utilization of some components, as e.g.: combustion air fan, deaerator, drum, exhauster, convective vaporizer, economizer, pumps, which were taken up from technological deallocated lines [4].

By the experimental results obtained at putting into service is shown in Table 6, the steam flow, steam pressure and steam temperature, according to the fuel flow and exhaust gases temperature to chimney. Therefore, it is relieved a good concordance between these obtained results experimentally and the values of these parametres which were computed by means of the computer programs above mentionated.

Table 6. Values of some parameters obtained by working of the process steam boiler with a steam flow of 20t/h

No	Natural gas flow	Combustion air flow	Steam flow	Steam temperature	Exhausted gases temperature
	m^3N/h	m^3N/h	t/h	ºC	ºC
0	1	2	3	4	5
1	1220	12450	12.5	238	147
2	1340	13700	13.7	240	151
3	1530	15630	16.2	244	159
4	1725	17650	18.6	247	168
5	1810	18400	19.4	249	172
6	1890	19200	20.1	251	177

5 Conclusions

Computer programs of thermal computation of furnace of boiler and heat exchangers located after the furnace of boiler were used in dimensioning of some process steam boilers obtained with reusable equipments.In this paper, it is exemplified the process steam boiler dimensioning of 20t/h, for which the obtained experimental results are in a good concordance with other obtained by the utilization of the dimensioning mathematical models.

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