MEASUREMENT OF PARAMETERS THAT DEFINES BURNERS OPERATION OF HOT WATER BOILERS

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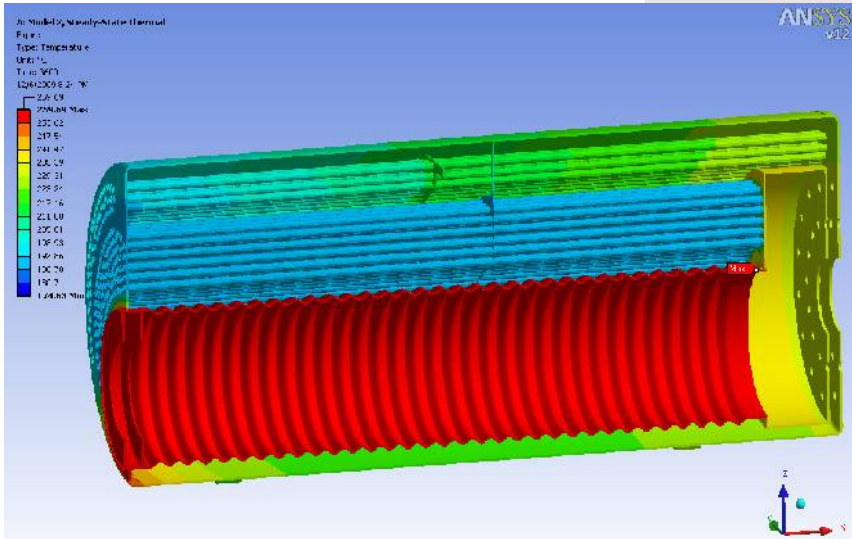
Content

Introduction

- In recent years, intensive research work is dedicated to energy savings, air pollution and fuel savings.
- Research for this purpose has shown that efficiency of boilers, such as fossil fuel fired industrial boilers or in thermal power plant , represents a very important parameter.
- Any improvement of boiler efficiency leads to energy savings and economic viability of primary energy use.
- Research shows that boiler efficiency increases by 5% during complete combustion process compared to the process with incomplete combustion.

Introduction

- **Hot water boiler represents an object in which the thermal energy produced by combustion of organic fuels, through the heat surfaces transfer on the working fluid.**
- **As a working fluid are commonly used water or water vapor.**
- **In hot water fire-tubes boilers flue gases flow through pipes around which flows the hot water in the cylindrical shell that is closed at the ends.**

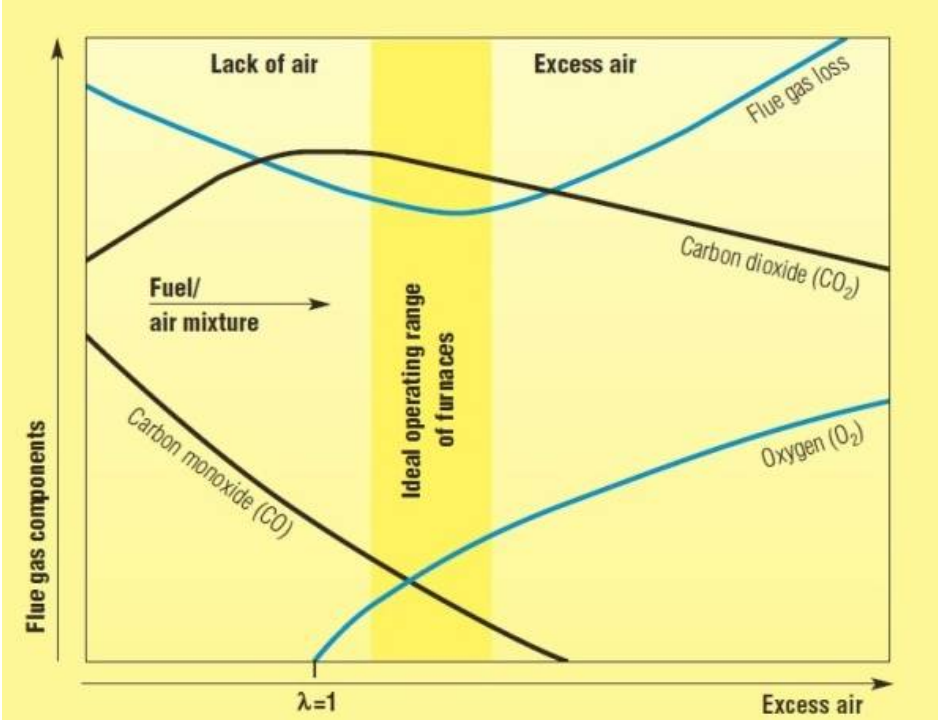


Introduction

- The paper presents an analysis of measured results of combustion process of hot water boilers that use fuel oil and natural gas, as a function of the boiler load.
- The paper focuses on parameters that should be controlled in flue gas and determination of their specific limits in order to have combustion process with the highest coefficient of utilization while meeting environmental requirements at the same time.
- The measurement was carried out on the hot water boilers manufactured by " Djuro Djaković" - Slavonski Brod with 5.37 MW and 16.5 MW capacity within the Heating plant of city of Niš.

Parameters that defines complete combustion process

- **Optimization of combustion process in order to obtain rationally fuel consumption refers to:**
  - Controlled combustion (to obtain amount of heat required for the process);
  - Burning of fuel with the highest level of efficiency;
  - The least possible environmental pollution.



Parameters that defines complete combustion process

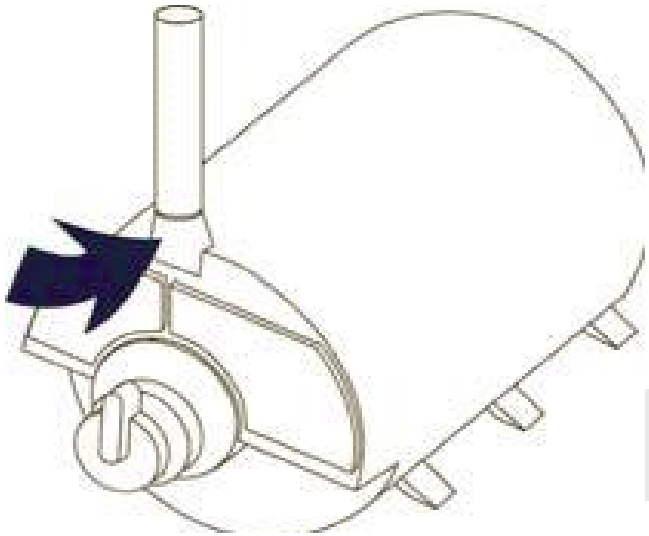
- Theoretically, combustion process will always be complete, if amount of oxygen that is brought into the process is greater than, or at least equal to, the minimum of the required amount of oxygen for complete combustion.
- Also, one of the influential parameters affecting the quality of combustion process is the burning rate.
- Burning rate must be equal to the velocity of propagation of the mixture in order to have steady flame and quality combustion.
- The maximum combustion rate occurs at stoichiometric conditions, while with increase of excess air or with deficit of air, burning rate decreases.
- Coefficient of excess air has the greatest impact on the efficiency.

Measurement of combustion parameters in dependence of boiler load

- The quality of combustion can be evaluated from the composition of the flue gases.
- Therefore, in well-guided and operated combustion chambers composition of flue gases is continuously controlled by means of special measuring instruments.
- The most favorable ratio of excess air is the one in which the lowest heat losses occurs.
- The highest content of CO_2 in flue gas is not favorable, because it is often accompanied by carbon monoxide CO.

Measurement of combustion parameters in dependence of boiler load

- The measuring device used, is a digital instrument for measuring temperature, relative humidity, velocity of differential gas with associated accessories and printer Testo 350M produced by Testo GmbH.
- It can measure the contents of O_2, CO_2, NO, NO_2, temperature of flue gases, ambient temperature, complete with accessories, printers and measuring probes, with the ability to archive data and suitable software.



Measurement of combustion parameters in dependence of boiler load

- **The measurement was carried out on hot water boilers manufactured by "Djuro Djaković Slavonski Brod" with capacity of 5,37 MW and 16,5MW within the Heating plant in the city of Niš**

	Boiler 1	Boiler2
Manufacture:	"Djuro Djaković" - Slavonski brod	"Djuro Djaković" - Slavonski brod
Type:	Optimal 800	Optimal 2500
Maximum capacity of boiler:	5,37 MW	16,96 MW
Permitted maximum overpressure:	12,5 bar	16,2 bar
Operating pressure:	12,5 bar	15,7 bar
Temperature of hot water at inlet:	90°C	100°C
Temperature of hot water at outlet:	130°C	160°
Amount of water in boiler:	10,845 m^3	40 m^3
Boiler efficiency:	87%	91%

	Boiler 1	Boiler2
Manufacture:	"SAACKE" - Germany	"SAACKE" - Germany
Type:	SKVJG 55-18	SKVG-A 82
Nominal capacity:	6,6 MW	17,3 MW
Fuel:	Fuel oil, gas	Fuel oil, gas

Measurement of combustion parameters in dependence of boiler load

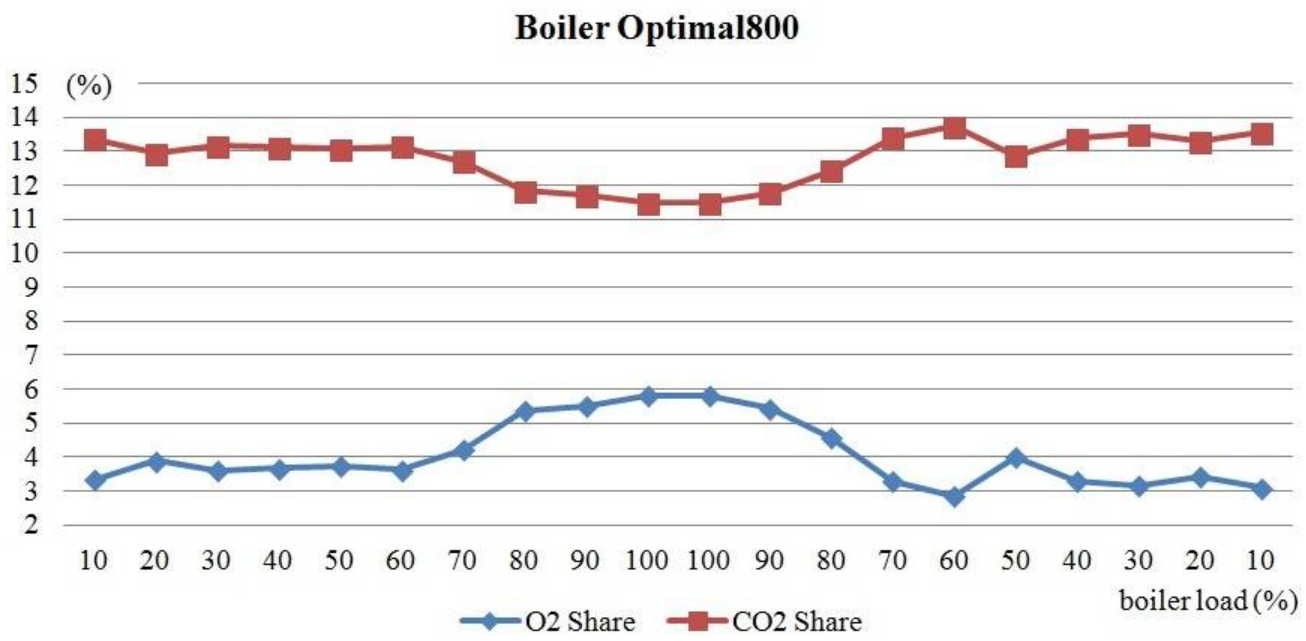


Figure. The Share of O2 and CO2 in flue gases depending of the boiler load for boiler Optimal 800

Measurement of combustion parameters in dependence of boiler load

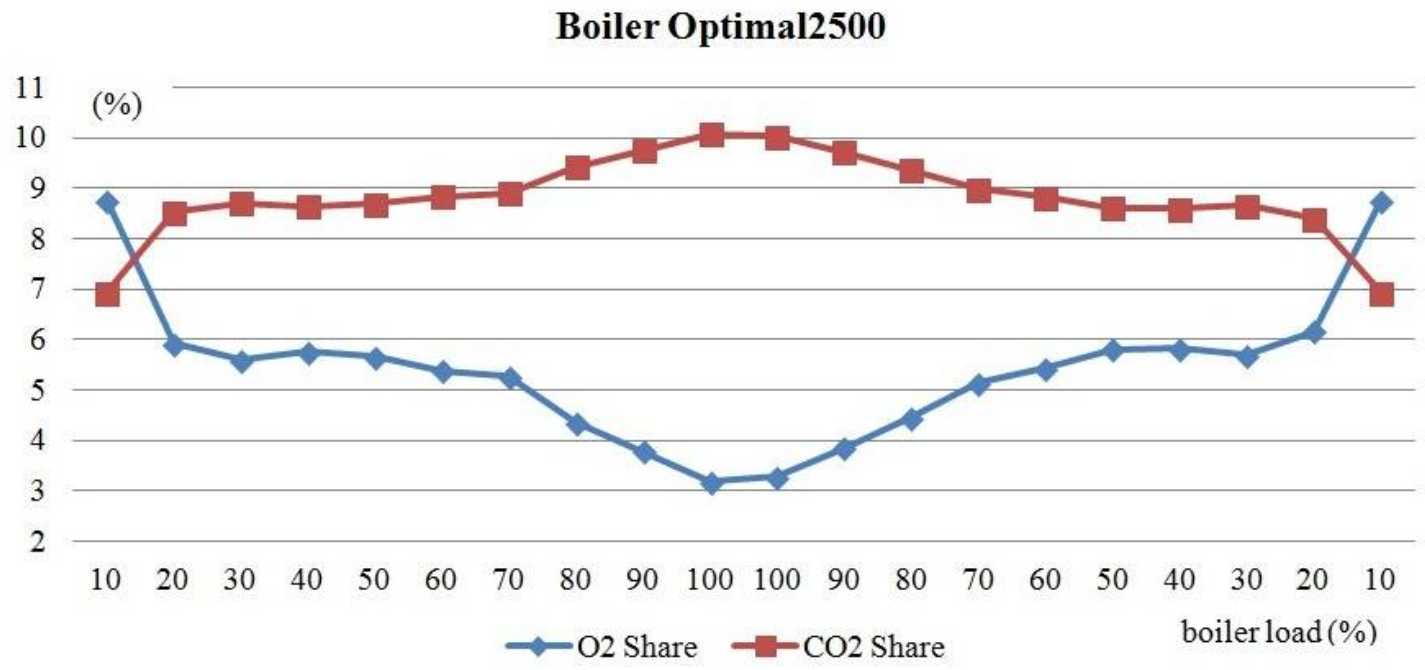


Figure. The Share of O2 and CO2 in flue gases depending of the boiler load for boiler Optimal 2500

Measurement of combustion parameters in dependence of boiler load

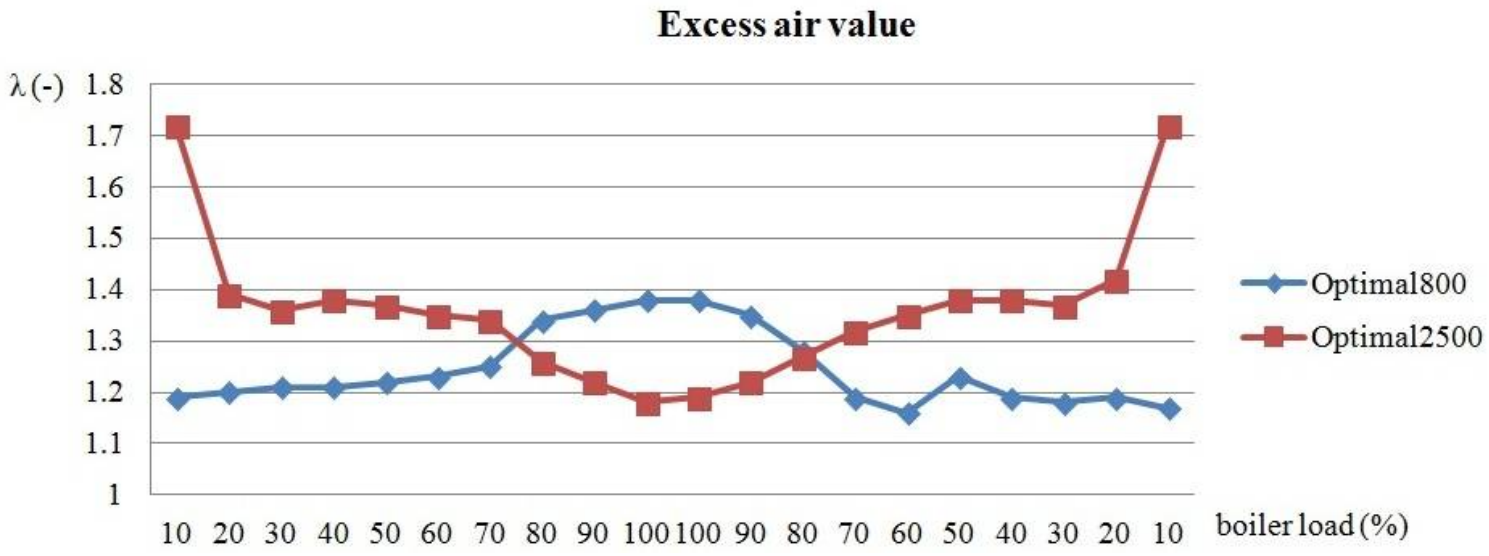


Figure. Excess air value λ depending of the boiler load for boilers Optimal 800 and Optimal 2500

Measurement of combustion parameters in dependence of boiler load

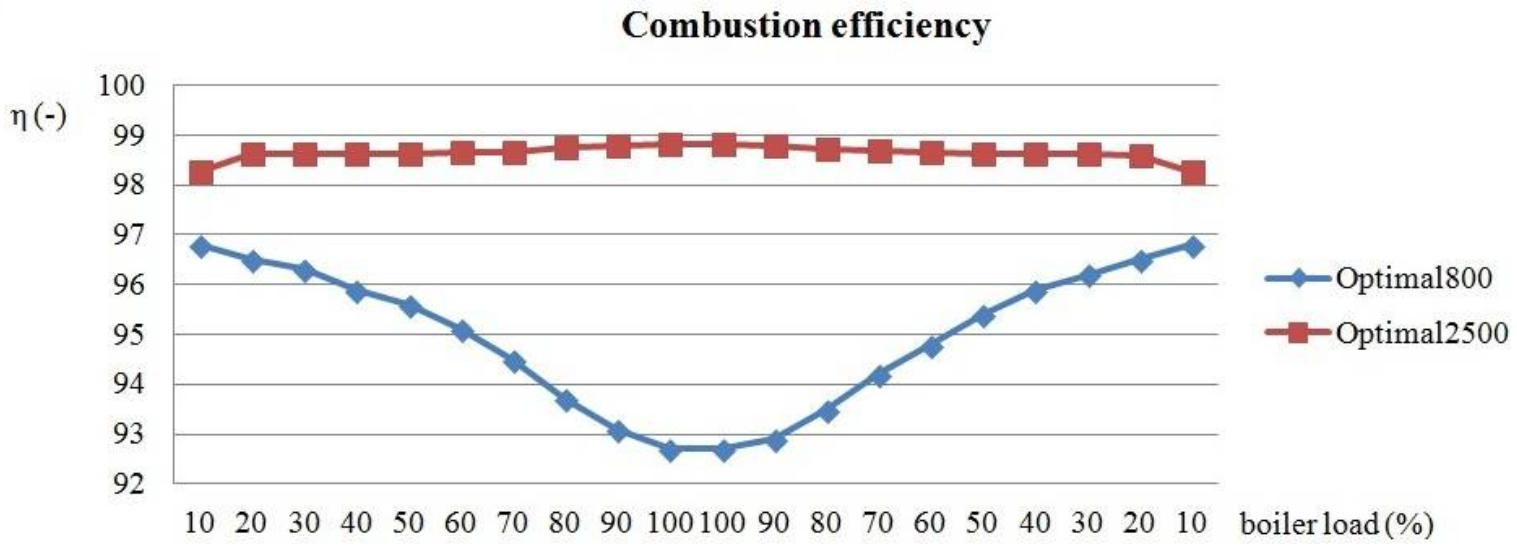


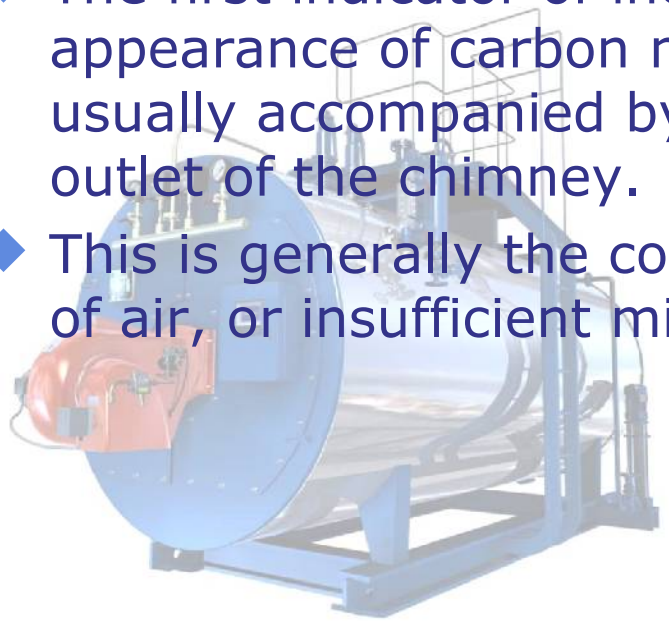
Figure. Combustion efficiency η depending of the boiler load for boilers Optimal 800 and Optimal 2500

Measurement of combustion parameters in dependence of boiler load

Boiler load	Boiler Optimal 800 - fuel oil combustion						Boiler Optimal 2500 - natural gas combustion					
	O_2 Share	CO_2 Share	CO Share	NO Share	NO_x Share	Flue gas temp.	O_2 Share	CO_2 Share	CO Share	NO Share	NO_x Share	Flue gas temp.
%	%	%	mg/m^3	mg/m^3	mg/m^3	°C	%	%	mg/m^3	mg/m^3	mg/m^3	°C
10	3.34	13.37	0	1050	1102	91.8	8.76	6.93	0	161	169	106
20	3.89	12.95	0	998	1048	96.3	5.93	8.54	0	150	158	107.4
30	3.61	13.17	0	932	978	100.9	5.61	8.72	0	154	162	110.5
40	3.67	13.12	0	923	969	109.2	5.76	8.64	0	164	172	119
50	3.73	13.08	0	901	946	117	5.67	8.69	0	168	176	130.1
60	3.63	13.15	0	904	949	126.2	5.39	8.85	0	166	174	139.4
70	4.22	12.71	0	960	1008	136	5.27	8.91	0	173	181	146.3
80	5.37	11.84	0	983	1033	143.5	4.35	9.43	0	171	179	156.1
90	5.51	11.73	1.452	1006	1056	154.3	3.79	9.75	0	170	179	160.2
100	5.82	11.49	2.964	1004	1054	159.8	3.19	10.09	0	173	182	164.3
100	5.82	11.49	2.962	1008	1058	158.3	3.28	10.04	0	172	181	169.3
90	5.44	11.78	1.446	1005	1055	157.9	3.85	9.72	0	171	180	166
80	4.57	12.44	0	997	1046	153.6	4.46	9.37	0	171	180	159.2
70	3.29	13.41	0	954	1002	148.7	5.14	8.99	0	172	181	151.3
60	2.86	13.74	0	900	945	139.1	5.44	8.82	0	166	174	145.1
50	3.99	12.88	0	903	948	117.8	5.81	8.61	0	168	177	132.1
40	3.31	13.39	0	913	958	112	5.82	8.6	0	167	176	125.1
30	3.16	13.51	0	915	961	104.4	5.7	8.67	0	152	160	117.4
20	3.42	13.31	0	983	1032	97.7	6.17	8.4	0	155	162	111.7
10	3.1	13.56	0	1039	1091	92.6	8.76	6.93	0	161	169	106

Conclusion

- For effective use of fuel, natural gas or fuel oil, as well as heat that is produced during its combustion, it is necessary to control the combustion process by analyzing the combustion products.
- It is enough to determine the content of the flue gases (the share of CO_2, O_2 and CO).
- The first indicator of incomplete combustion is the appearance of carbon monoxide in the flue gases, which is usually accompanied by darker color of the flue gas at the outlet of the chimney.
- This is generally the consequence due to insufficient amount of air, or insufficient mixing of natural gas with air.



Conclusion

- Today exploitation of hot water boilers shows that there is a large number of boilers, especially smaller ones, without gas analyzer.
- Even where the analyzers were built they are usually not used.
- Taking into account the economic effects that are achieved by monitoring the combustion process and affordability of flue gas analyzers which are available on the market today, every industrial boiler or boiler in thermal power plant should be equipped with exhaust gas analyzer.
- It is particularly important that organizations that perform the process of adjustment of the combustion process use combustion products analyzers.

Thank you!