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Water is an effective additive to fuel oil to reduce the concentration of soot in the gas phase

Damira Sambaeva[1], Mirlan Moldobaev[2*], Kubat Kemelov[2], Zarlık Maimekov[2]

[1]Kyrgyz Mining and Metallurgical Institute Named after academician U. Asanaliev, Bishkek, Kyrgyz Republic, dsambaeva@gmail.com, ORCID: 0000-0002-9834-341X
[2]Kyrgyz-Turkish Manas University, Department of Environmental Engineering, Bishkek, Kyrgyz Republic, mirlan.moldobaev@manas.edu.kg, ORCID: 0000-0002-8710-5643, kubat.kemelov@manas.edu.kg, ORCID: 0000-0001-7375-6325, zarlyk.maymekov@manas.edu.kg, ORCID: 0000-0002-9117-262X

ABSTRACT

Soot is one of the products of incomplete combustion of hydrocarbon fuels. It has the property of adsorption of active and carcinogenic substances on the surface of soot particles. In this regard, in burner equipment of medium and small power, it is required to develop and implement effective environmental measures to reduce emissions of soot particles. In this paper, the fuel oil-water-air system at a wide temperature range (T=500-3000K) was studied and the ratio of gas-liquid flows (water content in fuel oil 5-15%) at the maximum entropy of the system and the formation of soot in flue gases was revealed. To reduce the concentration of soot in flue gases, a fuel oil-water emulsion was used. The particle sizes of the fuel oil-water emulsion were determined by sedimentation analysis. It is shown that they have a polydisperse character (diameter from 8.96 to 59.02 µm). The water content in fuel oil during the preparation of fuel oil-water emulsion in the boiler room was controlled by a capacitive sensor. The water flow was automatically maintained by an ejector-dosing device. The thermodynamic parameters of the system (entropy, enthalpy, internal energy) were calculated and their comparative characteristics were obtained. The concentration distribution of hydrogen, carbon, nitrogen, sulfur and oxygen containing molecules, particles and condensed phases in the gas phase has been established. During the combustion of the fuel oil-water emulsion, the concentration of soot in the gas phase decreased due to an increase in hydrogen-containing particles in the gas phase, i.e. an increase in the H/C ratio, as well as a change in the concentration of condensed carbon (mol/kg): (fuel oil without water $C_{(c)} = 63.3$ mol/kg); fuel oil with water: 5% H_2O, $C_{(c)} = 54.96$; 10% H_2O, $C_{(c)} = 50.45$; 15% H_2O, $C_{(c)} = 46.3$. It is noted that the H/C ratio in the case of burning fuel oil -water emulsion is 2.26 times higher. A technological scheme for the preparation and combustion of fuel oil in the form of fuel oil-water emulsions in industrial boilers of the E-1/9-M(3) type of the Bridge Construction Detachment of the Kyrgyz Railway, Bishkek, has been developed. It has been established that when burning fuel oil-water emulsions in boiler units, the soot content in flue gases is reduced by 75% due to the developed contact surface of the interacting phases and more complete combustion of particles of fuel oil-water emulsions.

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**Corresponding Author*

1. Introduction

One of the atmospheric polluting components of hydrocarbon fuel combustion products are soot particles, which are highly stable and, therefore, capable of long-term preservation in ambient conditions [1-11]. This feature, as well as the possibility of adsorption of active and carcinogenic substances on the surface of soot particles, requires the development and implementation of effective environmental measures to reduce soot particle emissions, especially in medium and low power combustion equipment [12–20]. The formation and burnout of soot (change $C_{(c)}$ and H/C) during the combustion of hydrocarbon fuels should be considered as a set of extremely complex physicochemical, heat and mass transfer processes, which require systematic scientific research and the implementation of environmental measures on their basis [16]. Taking into account the above circumstances, the paper considers the sources of pollution of the environment with technogenic soot, the processes of conversion of technogenic soot with water of fuel oil-water emulsions in a wide range of temperature changes and ratios of gas-liquid flows (5-15% of water in fuel oil).

2. Materials and methods

Experimental determination of the soot concentration in flue gases was carried out by sampling solid particles from the chimney of E-1/9M type boilers based on the Visit 01-L/LR multifunctional gas analyzer and the UG-2 type portable gas analyzer according to the standard methods 5506 and 5515 "NIOSH Manual of Analytical Methods" [2]; determination of the particle size of the fuel oil-water emulsion was carried out by the method of sedimentation analysis [21,22]; determination of the water content in the fuel oil-water emulsion was carried out by a capacitive sensor [16]; thermodynamic modeling of the process of burning fuel oil in the form of fuel oil-water emulsions at various ratios of gas-liquid flows, temperatures and the calculation of the concentration of carbon, hydrogen, oxygen, nitrogen and sulfur-containing particles, molecules and condensed phases in the gas phase was carried out at the maximum entropy of the system based on the software package "Terra" [23]. The development and making up of a basic technological scheme for the preparation and combustion of fuel oil-water emulsions took place in boiler units of the E-1 / 9M type of the Bridge Construction Detachment of the Kyrgyz Railway, Bishkek.

3. Results and discussion

The results of furnace practice show that the initial fuel oil contains from 3 to 5% of water, due to heating it with live steam in order to impart fluidity [12-14]. In this case, water in fuel oil has a lens distribution. Such a layered distribution of fuel oil -water does not lead to the formation of polydisperse inverse emulsions. In this case, water in fuel oil has a lens distribution. Such a layered distribution of fuel oil -water does not lead to the formation of polydisperse inverse emulsions. Taking into account these circumstances, an increase in the efficiency of the use of heating fuel oil in the boiler house was achieved by modifying it in the form of fuel oil-water emulsions (**FWE**). Accordingly, the model system is first considered: fuel oil-water-air at 5%, 10% and 15% of the content of fuel oil contaminated wastewater. Therefore, the following average composition of gas-liquid flows (%) was adopted in the calculations: fuel oil C (84.8) – H (11.2) – S (2.0) – N (0.5) – O (1.5); water (**10**) and air N (10.05) – O (2.67).

Table 1 shows the equilibrium concentrations of molecules, particles and the condensed phase formed during the oxidation of the fuel oil -water-air system at CH_2O=10% and within the limits of the theoretical fuel combustion temperature (T=2000 K).

Table 1. *Equilibrium concentrations of molecules, particles, and condensed phase (mol/kg) formed in the gas phase during the oxidation of a fuel oil-water emulsion. Water content in fuel oil 10%, T=2000 K, P=0.1 MPa*

$O = 0.15 \cdot 10^{-9}$	**$H = 0.088$**	$S_2 = 0.0068$	$S_2O = 0.39 \cdot 10^{-9}$
$H_2O = 0.64 \cdot 10^{-3}$	$S = 0.002$	$SO_2 = 0.38 \cdot 10^{-11}$	$SOH = 0.35 \cdot 10^{-9}$
$S_4 = 0.68 \cdot 10^{-11}$	$SO = 0.15 \cdot 10^{-6}$	$HSO = 0.25 \cdot 10^{-10}$	$NO = 0.94 \cdot 10^{-9}$
$SH = 0.039$	$H_2S = 0.321$	$N_2 = 2.96$	$N_2H_2 = 0.71 \cdot 10^{-11}$
$H_2SO = 0.4 \cdot 10^{-11}$	$N = 0.11 \cdot 10^{-7}$	$NH_3 = 0.20 \cdot 10^{-3}$	$C_2 = 0.13 \cdot 10^{-9}$
$NH = 0.18 \cdot 10^{-6}$	$NH_2 = 0.12 \cdot 10^{-5}$	**$C = 0.18 \cdot 10^{-8}$**	$C_2O = 0.13 \cdot 10^{-7}$
$NS = 0.34 \cdot 10^{-5}$	**$C_{(c)} = 50.45$**	**$CO_2 = 0.18 \cdot 10^{-4}$**	$CH_3 = 0.63 \cdot 10^{-3}$
$C_3 = 0.16 \cdot 10^{-8}$	**$CO = 6.64$**	$CH_2 = 0.14 \cdot 10^{-5}$	$C_2H_3 = 0.19 \cdot 10^{-4}$
$C_3O_2 = 0.17 \cdot 10^{-9}$	$CH = 0.88 \cdot 10^{-8}$	$C_2H_2 = 0.04$	$C_3H = 0.39 \cdot 10^{-4}$
$CH_4 = 0.017$	$C_2H = 0.49 \cdot 10^{-5}$	$C_2H_6 = 0.90 \cdot 10^{-7}$	$C_4H = 0.12 \cdot 10^{-8}$
$C_2H_4 = 0.21 \cdot 10^{-3}$	$C_2H_5 = 0.47 \cdot 10^{-7}$	$C_3H_8 = 0.10 \cdot 10^{-11}$	$C_6H_6 = 0.37 \cdot 10^{-10}$
$C_3H_4 = 0.36 \cdot 10^{-8}$	$C_3H_6 = 0.35 \cdot 10^{-10}$	$C_5H_6 = 0.94 \cdot 10^{-11}$	$CH_2O_2 = 0.2 \cdot 10^{-10}$
$C_4H_2 = 0.20 \cdot 10^{-3}$	$C_4H_4 = 0.73 \cdot 10^{-11}$	$CH_2O = 0.22 \cdot 10^{-5}$	$COS = 0.0018$
$CHO = 0.35 \cdot 10^{-5}$	$CHO_2 = 0.7 \cdot 10^{-11}$	$CS_2 = 0.02$	$C_2N_2 = 0.53 \cdot 10^{-5}$
$CH_3O= 0.1 \cdot 10^{-11}$	$CS = 0.072$	$C_2N = 0.15 \cdot 10^{-7}$	$C_2HN = 0.60 \cdot 10^{-7}$
$CN = 0.75 \cdot 10^{-5}$	$CN_2 = 0.95 \cdot 10^{-8}$	$HNC = 0.16 \cdot 10^{-4}$	$C_9HN = 0.46 \cdot 10^{-4}$
$NCO = 0.41 \cdot 10^{-10}$	$HCN = 0.21$	$C_7HN = 0.25 \cdot 10^{-3}$	$NH^{4+} = 0.18 \cdot 10^{-10}$
$C_3HN = 0.0015$	$C_5HN = 0.0011$	$SH^- = 0.49 \cdot 10^{-11}$	
$N_2C = 0.30 \cdot 10^{-5}$	$CN^- = 0.10 \cdot 10^{-10}$	$OH = 0.11 \cdot 10^{-6}$	
$CHO^+= 0.2 \cdot 10^{-11}$	$H_2 = 49.22$	$S_3 = 0.38 \cdot 10^{-6}$	

During the oxidation of a fuel oil-water emulsion, the formation of active particles and molecules in the gas phase (mol / kg) was established: hydrogen and oxygen containing - O, H, H_2, OH, H_2O, OH; sulfur containing - S_2, S_3, S_4, SO, SO_2, S_2O, SH, H_2S, HSO, SOH, H_2SO, CS, CS, COS, SH^-; nitrogen containing - N, N_2, NO, NH, NH_2, NH_3, N_2H_2, NS, NH_2, NCO, CN, HCN, HNC, C_2HN, C_3HN, C_5HN, C_7HN, C_9HN, N_2C, CN_2, C_2N, C_2N_2, NH_4^+, CN^-; carbon containing - $C_{(c)}$, C, C_2, C, CO, CO_2, C_2O, C_3O_2, CH, CH_2, CH_3, CH_4, C_2H, C_2H_2, C_2H_3, C_2H_4, C_2H_5, C_2H_6, C_3H, C_3H_4, C_3H_6, C_3H_8, C_4H, C_4H_2, C_4H_4, C_5H_6, C_6H_6, CHO, CHO_2, CH_2O, CH_2O_2, CH_3O, CHO^+ (table 1, figure 1).

The formation of condensed carbon and other gas components (mol/kg) was established: at **5%** water content in fuel oil, $C_{(c)}$ = 54.96; H_2 = 48.96; CO = 4.56; CH_4 = 0.018; $CO_2 = 0.9 \cdot 10^{-5}$, $H_2O = 0.46 \cdot 10^{-3}$, the H/C ratio was 0.08/0.17 10^{-8}; at **10%** water content in fuel oil C(c) = 50.45; H_2 = 49.22; CO = 6.64; CH_4 = 0.017; $CO_2 = 0.18\ 10^{-4}$; $H_2O = 0.64\ 10^{-3}$; N/C 0.088/0.18 10^{-8}; at **15%** water content in fuel oil C(c) = 46.3; H_2 = 49.46; CO = 8.55; CH_4 = 0.017; $CO_2 = 0.3\ 10^{-4}$; $H_2O = 0.81 \times 10^{-3}$; N/S $0.08/0.18 \times 10^{-8}$.

It is shown that during the oxidation of the fuel oil-water-air system, the content of condensed carbon (significant change in H/C) in the gas phase decreases (mol/kg): fuel oil without water $C_{(c)}$ = 63.3 mol/kg; with water 5% H_2O, C(c) = 54.96; 10% H_2O, $C_{(c)}$ = 50.45; 15% H_2O, $C_{(c)}$ = 46.3 (Fig. 1). The H/C ratio in the case of burning fuel oil-water emulsion was 0.088/0.18 10^{-8}, i.e. The H/C is 2.26 times higher than the H/C of the fuel oil-air system.

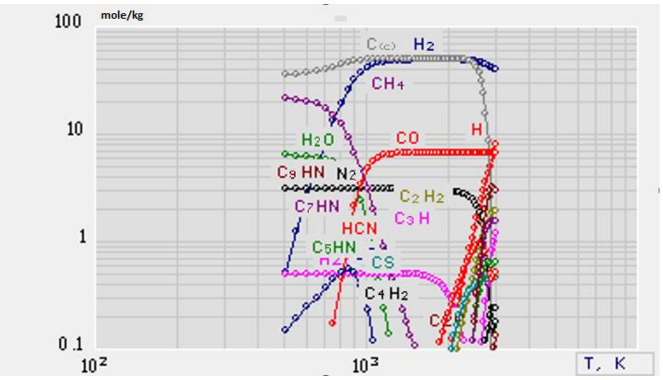

Figure 1. *Concentration distribution of particles, molecules and condensed phase (mol/kg) in the gas phase depending on the oxidation temperature of the system:* ***fuel oil -water-air****, C_{H2O}=* ***10%****, T=500-3000K, P=0.1 MPa.*

The concentration of condensed carbon in the gas phase increases with increasing temperature from 500 to 1750 K, and then decreases to zero (Table 2). Table 2. shows that combustible gases are present in the gas phase in various amounts: CO, H, H_2, CH_4, C_2H_6, C_3H_8, C_4H_{10}. Thus, the steam-oxygen conversion of fuel oil leads to the formation of a hydrogen-containing fuel gas. Therefore, the intensification of chemical processes for the conversion of hydrocarbon raw materials, in particular fuel oil into hydrogen-containing fuel synthesis gas based on the use and combustion of highly dispersed fuel oil-water emulsions, can be considered as a significant alternative to modern thermal catalytic processes for recycling liquid fuels.

Table 2. *Concentration distribution of carbon, hydrogen containing particles, molecules and condensed phase (mol/kg) in the gas phase depending on the oxidation temperature of the system: fuel oil-water-air. C_{H2O}=**10%**, T=500-3000K P=0.1MPa*

T	$C_{(c)}$	C	CO	CO_2	CH_4
500	36.18	$1{,}92\cdot10^{-22}$	$8.7\cdot10^{-5}$	0.14	21,203
750	41.78	$1.92\cdot10^{-22}$	0.17	0.44	15.12
1000	49.48	$1.92\cdot10^{-22}$	4.74	0.23	3.06
1250	50.52	$1.0\cdot10^{-20}$	6.54	0.07	0.44
1500	50.76	$1.0\cdot10^{-15}$	6.63	0	0.10
1750	50.74	$3.81\cdot10^{-12}$	6.64	0	0.037
2000	50.45	$1.8\cdot10^{-9}$	6.64	$1.9\cdot10^{-5}$	0.017
2250	49.50	$2.1\cdot10^{-7}$	6.64	$6.6\cdot10^{-6}$	0.009
2500	44.27	$1.0\cdot10^{-5}$	6.64	$2.8\cdot10^{-6}$	0.005
2750	15.77	0	6.64	$1.4\cdot10^{-6}$	0.003
3000	0	0	6.64	$9.4\cdot10^{-7}$	0.001
T	**H**	**H_2**	**C_2H_6**	**C_3H_8**	**C_4H_{10}**
500	$2{,}83\cdot10^{-20}$	0,52	$3{,}34\cdot10^{-05}$	$5{,}63\cdot10^{-10}$	$1{,}37\cdot10^{-14}$
750	$7.2\cdot10^{-12}$	13.4	0.0001	$9.55\cdot10^{-9}$	$6.89\cdot10^{-13}$
1000	$1.08\cdot10^{-7}$	41.7	$4\cdot10^{-5}$	$1.85\cdot10^{-9}$	$1\cdot10^{-13}$
1250	$2.58\cdot10^{-5}$	48.3	$4.1\cdot10^{-6}$	$1.1\cdot10^{-10}$	$3.8\cdot10^{-15}$
1500	$9.5\cdot10^{-4}$	49.06	$7.6\cdot10^{-7}$	$1.4\cdot10^{-11}$	$3.3\cdot10^{-16}$
1750	0.012	49.2	$2.2\cdot10^{-7}$	$3.3\cdot10^{-12}$	$5.8\cdot10^{-17}$
2000	0.088	49.2	$9\cdot10^{-8}$	$1\cdot10^{-12}$	$1.5\cdot10^{-17}$
2250	0.40	48.9	$4.36\cdot10^{-8}$	$4\cdot33^{-13}$	$5.26\cdot10^{-18}$
2500	1.35	47.7	$2.2\cdot10^{-8}$	$1.8\cdot10^{-13}$	$1.9\cdot10^{-18}$
2750	3.57	44.0	$1.1\cdot10^{-8}$	$6.8\cdot10^{-14}$	$5.8\cdot10^{-19}$
3000	8.04	40.0	$3.8\cdot10^{-9}$	$1.5\cdot10^{-14}$	$9.0\cdot10^{-20}$

Calculation and comparison of thermodynamic parameters of the system: fuel oil-air and fuel oil-water-air (Table 3) was carried out. It is shown that in the fuel oil-water-air system the entropy value is higher, correspondingly, there are more particle interactions.

Table 3. *Comparative characteristics of the thermodynamic parameters of the system: fuel oil-air and fuel oil-water-air*

	System	
Temperature, K	**Fuel oil -Air** 500-750	**Fuel oil -Water-Air** 500-950
Thermodynamic parameters:		
Entropy S, kJ/(kg K)	*2,49-3,28*	*7,44-11,49*
Enthalpy I, kJ/kg	*(-498) – (-94,7)*	*(-3252) – (-162)*
Internal energy U, J/kg	*(-510) – (-125)*	*(-3307) – (-452)*
Prandtl number (Pr= γ/D)	*0,68-0,59*	*0,69-0,47*
Proportion of condensed phase (z)	*0,79-0,78*	*0,41-0,54*

The values of enthalpy and internal energy are negative within the temperature range from 500 to 750 K for the fuel oil-air system, and for the fuel oil-water-air system from 500 to 950 K, therefore, in the second system there are more chemical transformations. The Prandtl number for the fuel oil-water-air system is lower and more prone to dilution; in systems, the proportion of the condensed phase (z) is 0.79/0.41 at 500 K and 0.78/0.54 at 950 K, respectively, the formation of condensed carbon (C_c) is 2 times less in the fuel oil-water-air system. Thus, the thermodynamic parameters also showed the efficiency of using the fuel oil-water-air system in the processes of reducing gas emissions, including soot in boiler plants.

The results of thermodynamic modeling of the fuel oil-water-air system showed that the physical and chemical basis for the oxidation of fuel oil-water emulsions is the effective organization of the combustion process of the gas-vapor mixture due to microcrushing of the fuel mixture, i.e. in fact, on the replacement of the traditional catalyst - water inverse emulsions (water in fuel oil), leading to the acceleration of chemical processes by increasing the contact surface of the interacting phases. Taking into account the above circumstances, microcrushing of a mixture of fuel oil and waste water was achieved in the developed rotary pulsation apparatus (RPA) [16,24-26]. The resulting inverted emulsions in RPA had a polydisperse character with particle sizes from 8.92 to 75.12 μm (Table 4) and they were introduced in the boiler house of the Bridge Construction Detachment of the Kyrgyz Railway, Bishkek.

The processes of preparation and combustion of fuel oil-water emulsion, as noted above, were tested according to the developed basic technological scheme in boiler units of the E-1/9M type of the Bridge Construction Detachment of the Kyrgyz Railway, Bishkek (Fig. 2). Fuel oil after passing through the fuel oil heater, coarse and fine filters, is pumped to the rotary pulsation apparatus (RPA). Water from the tank enters to the RPA and, based on a mixture consisting of 90% fuel oil and 10% water, polydisperse fuel oil-water emulsions are formed and they are sent to the combustion zone. The flow rates in pipelines are controlled by valves and check valves. Technical characteristics of the installation: electric motor, kW (rpm) - 4.0 (1500); fuel oil consumption 0.1-0.15 m^3/hour; water consumption 0.01 - 0.015 m^3/hour; water temperature and FWE 40 - 45°C (dashed line in the scheme: the path of the fuel oil-water emulsion).

Table 4. *Distribution of particles of water-oil emulsion: H=0.04m,* ρ_K*=775 kg/*m^3*,* ρ_{H_2O}*==1000 kg/*m^3*,* ρ_{E+K}*=820 kg/*m^3*,* η_{E+K}*=2.46·*10^{-3} *Pa· s, K=2.5·*10^{-3} *m/s*

Time, min	Sediment mass, mg	amount of precipitation over time,%	settling rate m/s	particle radius, µm	particle radius, µm
3	5	22,73	0,012	29,51	59,02
5	9	18,18	0,0091	22,79	45,57
8	12	12,63	0,0072	18,07	36,14
11	14	9,10	0,0061	15,41	30,82
15	16	9,09	0,0053	13,20	26,40
20	18	9,09	0,0046	11,43	22,86
30	19,5	6,82	0,0037	9,33	18,66
40	20	2,27	0,0032	8,08	16,16
50	20,5	2,27	0,0029	7,23	14,46
70	21	2,27	0,0024	6,11	12,22
90	21,5	2,28	0,0021	5,39	10,78
110	22	2,27	0,0019	4,87	9,75
130	22	0	0,0018	4,48	8,96

Measurements and calculation of concentrations of pollutants in flue gases were carried out in the processes of combustion of fuel oil (Table 5) and fuel oil-water emulsions (Table 6) taking into account the parameters of the chimney: H=18m, D=0.5m, the volume of the gas-air mixture Vg.cm =0.889 m^3/s, flue gas temperature td.g.=220ºC, particle settling velocity F=1, wind speed ν=5.0 m/s. It should be noted here that in this work only soot was studied, and the gas components of boiler houses were considered in [16].

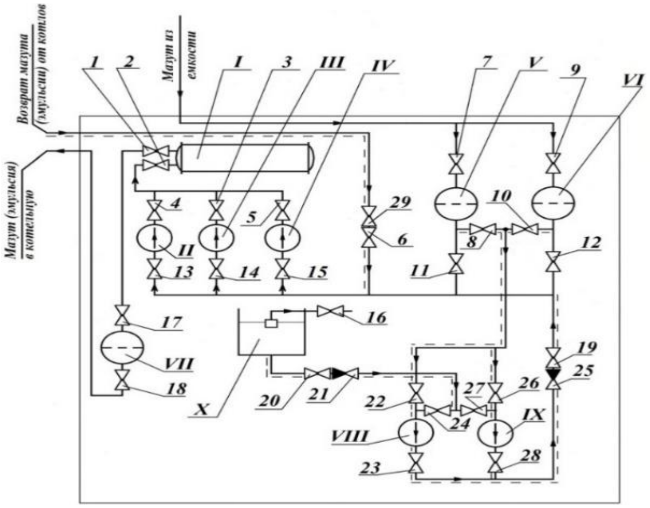

Figure 2. *Principal technological scheme for the preparation and combustion of a water-oil emulsion in boiler units of the E-1/9-M type (3): I - fuel oil heater; II, III, IV - coarse filters; V, VI, VII - fine filters; VII, IX - rotary-pulsation devices; X- water tank; 1-20, 22-24, 26-29-valves; 21, 25 - check valves.*

Table 5. *Fuel oil combustion and calculation of pollutant concentrations in the gas phase*

Components of gas emissions	MPC, mg/m^3	The amount of substances emitted into the atmosphere		The sum of maximum surface concentrations (MAC shares) created by source emissions
		max., g/s	Total, t/year	
CO	3,0	0,071	2,242	0,00356
NO_x	0,085	0,069	2,186	0,12205
SO_2	0,5	0,444	14,016	0,13351
C_xH_y	1,5	1,067	33,638	0,10695
soot	**0,15**	**0,046**	**1,458**	**0,04611**

Table 6. *Fuel oil-water combustion and calculation of pollutant concentrations in the gas phase*

Components of gas emissions	MPC*, mg/m^3	The amount of substances emitted into the atmosphere		The sum of Maximum Ground Level Concentration (MGLC) shares) created by source emissions
		max, g/s	Total, t/y	
CO	3,0	0,021	0,673	0,00145
NO_x	0,085	0,023	0,729	0,04953
SO_2	0,5	0,427	13,455	0,12299
C_xH_y	1,5	0,391	12,334	0,04901
soot	**0,15**	**0,012**	**0,364**	**0,02005**

MPC - Maximum Permissible Concentration
MGLC - Maximum Ground Level Concentration

The results of the studies show that in reverse type emulsions (water in fuel oil), when water in the form of tiny droplets with a diameter of 10-100 microns is evenly distributed throughout the mass of fuel oil, it contributes to a more efficient process of burning liquid fuel, reducing soot formation and reducing the content of harmful substances in emissions (Table 7).

Table 7. *Reducing the concentrations of pollutants in the flue gases of E-1/9M type boilers based on the combustion of fuel oil-water emulsions*

Components of gas emissions	Amount of harmful substances						
	Fuel oil			MWE			Reduction of gas emissions
	mg/m^3	g/s	t/y	mg/m	g/s	t/y	
SO_2	500	0,44	14,0	480	0,42	13,4	4,06
NO_x	78	0,06	2,18	26	0,02	0,72	66,67
CO	80	0,07	2,24	24	0,02	0,67	70,00
C_xH_y	1200	1,06	33,6	440	0,39	12,3	63,33
soot	**52**	**0,04**	**1,45**	**13**	**0,01**	**0,36**	**75,00**

An increase in the efficiency of combustion of a fuel oil-water emulsion in comparison with fuel oil is explained by the phenomenon of microexplosion [13–16]. Its essence lies in the fact that due to the large difference in the boiling points of water (100°C) and fuel oil (300°C), each drop of the inverse emulsion during the thermal effect increases in volume under the action of the water vapor formed inside, and then breaks into pieces. Intra-furnace crushing of droplets in boiler units, caused by microexplosions, sharply increases the reaction surface and improves the mixing of fuel with air. Accordingly, the water-oil emulsion droplets burn faster than the original fuel oil droplets. An increase in the concentration of active radicals (O, H, OH) in the combustion zone, due to the introduction of aqueous additives into liquid fuel, has a positive effect on the increase in the burnout rate of emulsions.

4. Conclusion

The fuel oil-air, fuel oil-water-air systems were studied at a wide range of temperature changes (T = 500-3000 K) and the ratio of gas-liquid flows (5-15% of water in fuel oil) at the maximum entropy of the system and a change in the concentration of condensed carbon and the ratio H/C, i.e. soot formation in flue gases. The particle sizes of the fuel oil-water emulsion were determined by sedimentation analysis and they have a polydisperse character. The water content in fuel oil during the preparation of fuel oil-water emulsion in the boiler room was controlled by a capacitive sensor. The water flow was automatically maintained by an ejector-dosing device.

Thermodynamic modeling of the system: fuel oil-air, fuel oil-water-air has been carried out. The thermodynamic parameters of the system (entropy, enthalpy, internal energy) are calculated and their comparative characteristics are obtained. The concentration distribution of hydrogen, carbon, nitrogen, sulfur and oxygen containing molecules, particles and condensed phases in the gas phase has been established. During the combustion of the fuel oil-water emulsion, the concentration of soot in the gas phase decreased due to an increase in hydrogen-containing particles in the gas phase, i.e. an increase in the H/C ratio, as well as a change in the concentration of condensed carbon (mol/kg): (fuel oil without water $C_{(c)}$ = 63.3 mol/kg); fuel oil with water: **5%** H_2O, $C_{(c)}$ = 54.96; **10%** H_2O, $C_{(c)}$ = 50.45; **15%** H_2O, $C_{(c)}$ = 46.3. The H/C ratio in the case of burning fuel oil-water emulsion is 2.26 times higher.

A technological scheme for the preparation and combustion of fuel oil in the form of fuel oil-water emulsions in industrial boilers of the E-1/9-M (3) type of the Bridge Construction Detachment of the Kyrgyz Railway, Bishkek, has been developed. It is shown that when burning fuel oil-water emulsions in boilers, the soot content in flue gases is reduced by 75% due to the developed contact surface of the interacting phases and more complete combustion of particles of oil-water emulsions.

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