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Study for Decreasing Emissions in the Flue Gas from Fuel Combustion of Steam andHot Water Boilers of Thermal Power Plant and Heating Plants of Mongolia

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Abstract: This paper mainly describes the current situation of the main thermal energy sources and some experimental results of total suspended particles (TSP) control equipments of reconstructed steam boilers and new hot water boilers.

Coal-fired power plants provide the majority of power generation for Mongolia. In 2014, coal consumption of the three main thermal power plants (TPP) in Ulaanbaatar is 4.824 million tons and all 7 TPPs — 5.97 million tons. The TSP, SO_2, NOx emissions from these power plants in Ulaanbaatar are 13.977, 37.328, and 11.331 tons, respectively. Therefore, more stringent emission standards on TSP, SO_2, CO and NOx are urgently needed to reduce current emissions to acceptable levels.

We tested TSP control equipments of TPPs and heating plants for determining TSP or fly ash concentration in the flue gas and these removal efficiencies. As a result average efficiency of the electrostatics precipitators' is 96.8-99%, wet scrubbers with Venture tubes — 85-90%, and dry cyclones — 45-60%, which were lower than their designed value. But flyash removal efficiency of bag filters is 99.7-99.9%. Comparison bag filter efficiency with ash collector (packet cyclone-centrifugal force) of the steam boilers No. 1 and No3 of TPP#2 in Ulaanbaatar more 54.3% and fly ash average concentration in the flue gas is lower 72.5 times [1].

In order to reduce pollutants concentration in the combustion product polluting the environment it is important to improve the operation regime of the main equipments and ash collectors of the Thermal energy sources as well. There is an urgent need ecological friendly renovation of thermal energy sources and to introduce an advanced combustion technology, use the options measures and reduce TSP concentration in the discharging smog.

Key words: steam boiler, hot water boiler, TSP, fly ash, ESP, bag filter, mechanical collector, efficiency

1. Introduction

Coal-fired power plants provide the majority of power generation for Mongolia. In 2014, the total power generation of Mongolia reached 5392.0 million kWh, with 96.3% from coal-fired power plants. There are seven main coal-fired power plants in Mongolia with a total installed capacity of 1024.3 MW. The central energy system (CES), with 95% of share in the total installed capacity is the largest energy supply system in Mongolia, including five thermal power plants (TPP), one transmission network, four distribution networks, supplying power to the cities of Ulaanbaatar, Darkhan, Erdenet and the centers of 13 provinces. Total installed capacity of the CES is 964.3 MW. Three large sized power plants, including TPP2, TPP3 and TPP4 located in Ulaanbaatar, account for 92% of the total installed capacity in the CES.

Coal-fired power plants provide the majority of power generation for Mongolia. In 2014, coal consumption of the three main power plants in Ulaanbaatar is 4.824 million tons and all seven TPPs — 5.97 million tons. The TSP, SO_2, NOx emissions

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from these power plants in Ulaanbaatar are 13.977, 37.328, and 11.331 tons, respectively. Therefore, more stringent emission standards on TSP, SO_2, CO and NOx are urgently needed to reduce current emissions to acceptable levels.

Construction of boiler furnace depends on fly ash in the flue gas. Approximately 90 percent of the ash from a pulverized-coal-fired boiler is carried through the boiler as fly ash, and about 50 percent of that is less than 10 microns in size. There are three principal types of equipment used to remove ash from the flue gases before they are discharged from the stack.

Thermal Power Plants and Heating plants use electrostatics (ESP), dry and wet collectors for removing of the particulate matter from flue gas. Most advanced TSP control equipments used to control TSP emissions from power and heating plants are ESP and bag filter house. The overall (mass) collection efficiencies for ESP can exceed 99.9%, and efficiencies in excess of 99.5% are common. Bag filter houses often are capable of 99.9% removal efficiencies.

Mechanical collectors use a combination of centrifugal, inertial, and gravitational forces to remove fly ash from the flue gas. Mechanical collectors are used primarily in the industrial market to remove material having carbon from the flue gas (for example, as a result of wood or bark burning) and to reinject it into the boiler. This not only improves the emissions but also improves the boiler efficiency.

Mechanical dust collectors can be utilized if the emission requirements are 0.129 kg/GJ or greater and if fewer than 25 percent of the particles are under 10 microns.

For this reason mechanical dust collectors have limited application when emission requirements must be met, and therefore an electrostatic precipitator or a bag filter house must be used to meet the more stringent requirements. However, where applicable, the mechanical dust collector should receive careful consideration, as its capital cost is about one-eighth that of an electrostatic precipitator or bag filter- house.

Approximately 80 percent of the ash from a pulverized-coal-fired boiler is carried through the boiler as fly ash, and about 50 percent of that is less than 10 microns in size. This requires the use of electrostatic precipitators to handle the fly ash.

In an electrostatic precipitator, dust-laden flue gas is distributed uniformly between rows of discharge electrodes and grounded collecting plates. A high-voltage DC current is applied to the electrodes which causes the dust particles to become ionized and then to be attracted to the grounded collecting plate. These collected particles are periodically removed from the plates by a rapping system which generates vibrations and causes the collected dust to fall into the hoppers.

Because the gas velocities through an ESP are very low (approximately 1.52 m/s), the draft loss is minimal, at about 12.7 mm of water gauge through the precipitator, as compared to mechanical collectors and, as we will see later, to bag filter houses.

The bag filter house is another method of removing particulates from flue gases. The decision on whether to have a fabric filter or an electrostatic precipitator is one of the most important decisions that a plant operator must make, as the consequences have to be lived with for the life of the plant.

Bag filter houses remove more than 99.9 percent of the fly ash from the flue gas, and for low-sulfur coals, where the ash has a high resistivity; they are preferred in many cases over electrostatic precipitators. Of course, careful evaluation of each collecting device is required to determine the proper equipment for the application. This evaluation would consider such areas as maintenance costs, power costs, draft loss, bag replacement costs, etc. Fabric filters operate at high pressure drops as compared to precipitators (152.24 mm of water as opposed to 12.7 mm), which is a highly important consideration as it increases power costs.

2. Test Results of Ash Collectors

We determined TSP concentration in the combustion products (flue gas) of the steam and hot water boilers by Gravimetric filter in the experiment. Temperature of exhaust gas is measured by Digital thermometer TX1001. After determining TSP concentration we calculated efficiency of ash collectors.

Efficiency of ash collector, %

$$\eta_{ac} = \frac{G_{in} - G_{out}}{G_{in}} \cdot 100 = \frac{c_{in}^{fa} - c_{out}^{fa}}{c_{in}^{fa}} \cdot 100$$

Here: G_{in}, G_{out} — fly ash mass before and after ash collector, kg/s; $c_{in}^{fa}, c_{out}^{fa}$ — concentration of fly ash in the flue gas before and after ash collector, mg/m^3.

Percentage of fly ash in the flue gas after ash collectors, %

$$\delta = \frac{G_{out}}{G_{in}} \cdot 100 = 1 - \eta_{ac}$$

2.1 Test Results of Electrostatic Precipitator

At the present time only Thermal Power Plant No4 in Ulaanbaatar and TPP in Ukhaa khudag used electrostatic precipitators.

Maximum efficiency is obtained by automatic control of the high voltage. The voltage is maintained at the maximum value without excessive sparking between the discharge electrodes and collecting plates. When correctly sized and operated, these collectors can remove more than 99.9 percent of the fly ash from the flue gases. However, the size of an ESP depends upon a characteristic of ash known as the resistivity. This determines the susceptibility of the fly-ash particles to the influence of the electrostatic field.

Fly ash resulting from burning coal with a high sulfur content has a low resistivity and therefore is more easily collected, requiring a smaller precipitator than one designed to collect fly ash from a coal having a low sulfur content. Therefore the proper sizing of a precipitator is dependent upon knowing the various types of coal which will be used over the life of the plant. Otherwise the precipitator might be too small if it were designed for high-sulfur coal and in the future low sulfur coal were used. Other fuels such as wood, bark, or municipal solid waste (MSW) have similar resistivity characteristics, and these must be used for the proper sizing of an ESP.

We tested TSP control equipments of steam boilers in TPP No. 4 of Ulaanbaatar for determining TSP or fly ash concentration in the flue gas at the maximum, medium and minimum capacity and these removal efficiencies.

During the test we measured flow rate, temperature of feed water and super heated steam flow rate, pressure and temperature and exhaust flue gas temperatureof steam boiler.

The testing results show in the Table 1.

Table 1 Test results of Electrostatic precipitator.

№	Characteristics	Unit	Baganuur coal			Shivee-Ovoo coal		
1	Number of boiler	-	K-7	K-8	K-1	K-5	K-6	K-5
2	Load of boiler	t/h	427 (max)	348 (medium)	240 (min)	402 (max)	335 (medium)	240 (min)
3	Heating value of coal	MJ/kg	14.62	14.97	13.93	12.18	12.89	12.69
4	Ash	%	6.9	9.6	7.4	6.1	6.7	9.6
5	Moister	%	38.4	35	39	45.7	42.3	40
6	Worked poly.	-	1,2,3,4ab	1,2,3,4ab	1,2,3,4ab	1,2,3,4ab	1, 2, 3ab	1, 2, 3, 4ab
7	Temperature of exhaust gas	°C	143	121.75	152	147.8	146.8	142.2
8	Worked Mill system	-	Mill ABCD	Mill ABCD	Mill ABCD	Mill ABCD	Mill ABCD	Mill ABCD
9	Total consumption of mills	t/h	70.4	60.2	42.8	80.5	67.1	54.4
10	Efficiency of Electrostatic precipitator	%	98.36	97.3	94.3	99.3	97	92.3

Temperature of feed water for this steam boiler was 229-235°C and it average 230°C. Super heated steam average flow rate of boiler at the minimum, medium and maximum capacity was 240 t/h, 348 t/hand 427 t/h and temperature 554-564°C with combustion Baganuur coal.Exhaust flue gas temperature from boiler at this steam capacity of steam boiler was changed between 145-150°C and it average was 146.5°C.

Temperature of feed water for this steam boiler was 228-234°C and it average 230°C. Super heated steam average flow rate of boiler at the minimum, medium and maximum capacity was 240 t/h, 335 t/h and 402 t/h and temperature 550-560°C with combustion Shivee-Ovoo coal.

Exhaust flue gas temperature from boiler at this steam capacity of steam boiler was changed between 140-145°C and it average was 142.5°C.

As a testing results efficiency of electrostatic precipitator of steam boilers with combustion Baganuur coal was 94.3-99.3% and for Shivee-Ovoo coal 93.3-97% and average efficiency 97.1%.

2.2 Test Results of Dry Collectors

Dry ash collector is use usually with low and medium capacity boilers, outdated technology and so is relatively low compared to other methods of efficiency. Mechanical collectors consist of multitube units which remove the fly ash by centrifugal action. The gases flow downward through the spinner vanes in the annular space between the outer and inner tubes. Then the gases reverse direction and flow up through the inner tube and out of the collector.

The combination of centrifugal force created by the spinning of the gases and the action of gravity when the flow is reversed separates the dust particles, and they fall through the bottom end of the outer tube into the hopper.

Exhaust flue gas temperature from boiler at this steam capacity of steam boiler No. 1 was changed between 140-145°C and it average was 141.5°C. The testing results show in the Table 2.

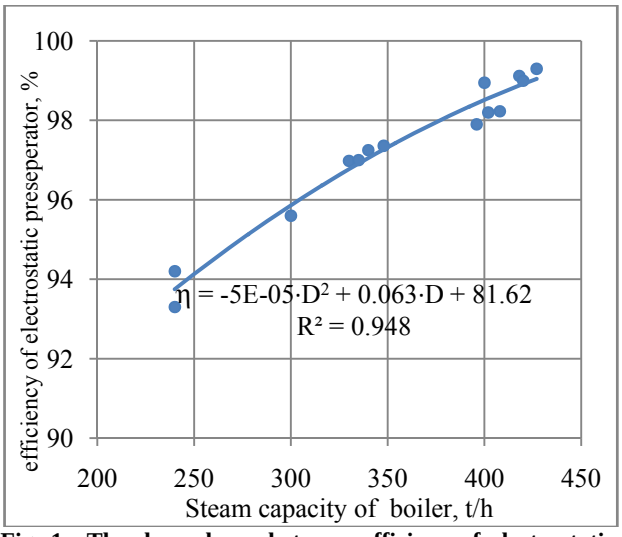

Fig. 1 The dependence between efficiencyof electrostatic preseperator andsteam capacity ot steam boilers.

Table 2 Efficiency of ash collector of steam boiler No. 3 [1, 2].

No	Average steam capacity [t/h]	Boiler No. 3		
		Before cyclone [g/nm^3]	After cyclone [g/nm^3]	Efficiency [%]
1	33	7.310	3.650	**50.07**
2	32	6.316	3.634	**42.47**
3	34	6.984	2.591	**62.91**
4	Average	**6.87**	**3.292**	**51.82**

The boiler No. 3 of "TPP-2" ash collector to evaluate operational performance. During the test feed water flow rate of this steam boiler was fluctuated 27.2-39.2 t/h and it average- 33.9 t/h. Temperature of feed water for this steam boiler No1 was 143-145°C and it average 143.4°C. Super heated steam flow rate of boiler No. 3 was fluctuated 30-38 t/h and it average-34.3 t/h, and its temperature 434.5-445°C and average-438.8°C.

Table 2 shows fly ash measurement results and efficiency of ash collector (packet cyclone-centrifugal force) of steam boiler type TS-35-39. Fly ash concentration in the flue gas before ash collectorof steam boiler fluctuated between 6.316 g/m^3 and 7.31 g/m^3, average 6.87 g/m^3, after ash collectorfluctuated between 2.591 g/m^3 and 3.65 g/m^3, average 3.292 g/m^{3}at the average steam capacity — 34.28 t/h.

After measuring fly ash (TSP) concentration we calculated efficiency of ash collector (packet cyclone-centrifugal force). Efficiency of ash collector of steam boiler No. 3 fluctuated between η = 42.47% and η = 62.91%, average 51.82% at the average steam capacity — 34.28 t/h. This efficiency comparison with average efficiency of other filters is 1.79-2.17 times less than test value. This ash collector ash outdated and shows the loss of ability to build long-term use is down.

2.3 Test Results of Wet Collectors

Most of the Mongolian Thermal power plants were used wet ash collectors for cleaning flue gas. But water and electricity consumption of this method was high and has a negative impact on the environment and do not meet modern requirements, such as disadvantages. The Table 3 shows some testing results of wet ash collector of steam boilers of TPP-3 in Ulaanbaatar.

Table 3 Test result of Wet ash collector.

No	Number of Samples	Boiler No 11			Boiler No 10		
		Fly ash concentration [g/nm^3]		Efficiency [%]	Fly ash concentration [g/nm^3]		Efficiency [%]
		Before Scrubber	After Scrubber		Before Scrubber	After Scrubber	
1	Channel B1	10.5142	1.5265	85.48	7.1241	0.6852	90.38
2	Channel B2	11.6297	1.718	85.22	6.941	0.696	89.9
4	Channel B3	12.3261	1.6254	86.81	6.8214	0.7514	88.9
5	Channel A1	10.1214	0.845	91.65	8.0211	2.1248	73.5
6	Channel A2	9.9434	0.558	94.38	7.3579	1.915	73.9
7	Channel A3	9.5461	0.542	94.32	7.0214	1.7251	75.4
8	Average	**10.6802**	**1.1358**	**89.64**	**7.2145**	**1.3163**	**82.0**

Fly ash concentration in the flue gas before wet ash collector of steam boiler No. 11 fluctuated between 10.121 g/m^3 and 12.326 g/m^3, average 10.68 g/m^3, after ash collector fluctuated between 0.542 g/m^3 and 1.718 g/m^3, average 1.136 g/m^3.

Efficiency of wet ash collector of steam boiler No11was 85.22-94.38% and average of 89.64%, but the efficiency of wet ash collector of steam boiler No. 10 73.5-90.38% and average of 82%. The efficiency of ash collectors of these boilers for the mean estimate 82-89.64% and average of 85.82%.

2.4 Test Results of Bag Filters

At the present bag filters newly commissioned in recent years Central heating plant (CHP) of Ouy tolgoi, and "TPP-2" Joint Stock Company has been installed in the boiler No. 1 is used. This method is commonly used in the world in recent years is environmentally friendly and high efficiency of the filter material at high temperatures can significantly increase the availability of cost-effective technology for a long time.

Bag houses are characterized according to the method used to remove the fly ash from the filter medium. To illustrate, in reverse-air collectors, the type preferred for central stations, air is pushed through the bags in the direction opposite to filtration after the compartment containing the bags is removed from service. Sometimes a mechanical shaker is installed on these units to help remove dust. Pulse-jet bag houses are often used on industrial boilers and rely on a short burst of compressed air directed down through the filter bag to dislodge fly ash into the hopper below.

The principal advantage of filters over precipitators is that coal sulfur content (resistivity) does not influence the collection efficiency. Another benefit of reverse-air filters is that their compartmented design permits maintenance while the unit is operating.

During the test feed water flow rate of this steam boiler type TS-35-39 was fluctuated 32-35 t/h and it average — 32.91 t/h. Table 4 show fly ash

measurement results and efficiency of bag house of steam boiler type TS-35-39.

Exhaust flue gas temperature from boiler at this steam capacity of steam boiler No1 was changed between 150-160°C and it average was 151.6°C.

Fly ash concentration in the flue gas before bag filter of steam boiler No1 fluctuated between 1.775 g/m^3 and 2.53 g/m^3 and average 2.067 g/m^3 at the average steam capacity- 32.25 t/h. Fly ash concentration in the flue gas after bag filter of steam boiler No. 1 fluctuated between 0.039 mg/m^3 and 0.049 g/m^3 and average 0.0425 g/m^3 at the average steam capacity — 32.25 t/h.

During the test fluidized bed temperature of the furnace at medium capacity of boiler type DHFX29-2.0/130/70-M was fluctuated 766.87-799.07°C and it average 782.91°C for A side (753.32-783.79°C and average 768.22°C for B side) and heat capacity of boiler — 15.85-17.55 MW and it average — 16.45 MW. The Table 5 shows testing results of bag filters of hot water boilers in the Central heating plant of Oyu Tolgoi.

Table 4 Efficiency of bag house of steam boiler type TS-35-39 [1, 2].

No	Average steam capacity [t/h]	Boiler No. 1		
		Before bag house [g/nm^3]	After bag house [g/nm^3]	Efficiency [%]
1	33	2.530	0.039	**98.45**
2	33	2.051	0.043	**97.91**
3	33	1.912	0.039	**97.97**
4	30	1.775	0.049	**97.22**
Average	**32.25**	**2.067**	**0.0425**	**97.89**

Table 5 Efficiency of bag house of hot water boilers [3, 4].

No	Hot water boiler 7 MW				Hot water boiler 29 MW			
	Average heat capacity [MW]	Before bag filter [g/nm^3]	After bag filter [g/nm^3]	Efficiency [%]	Average heat capacity [MW]	Before bag filter [g/nm^3]	After bag filter [g/nm^3]	Efficiency [%]
1	4.34	43.237	0.0629	**99.85**	16.45	2.53	0.0277	**98.91**
2	3.6	9.418	0.00952	**99.99**	27.44	3.019	0.0081	**99.73**
3	7.13	36.12	0.617	**98.29**	16.45	9.77	0.0091	**99.91**
4	7.13	10.737	0.0103	**99.9**	14.4	12.356	0.173	**98.64**
5	-	-	-	**-**	29.6	3.89	0.0041	**99.9**
6	**-**	**24.88**	**0.175**	**99.51**	**-**	**6.31**	**0.068**	**99.22**

Fluidized bed temperature of the furnace at maximum capacity of boiler was 884.02-904.50°C and it average 895.82°C for A side (874.40-895.97°C and it average 887.29°C for B side) and heat capacity of boiler — 21.42-27.46MW or average — 25.35 MW.

Fluidized bed temperature of the furnace at minimum capacity of hot water boiler type SHFX7-2.0/130/70-M was fluctuated 993.87-1012.74°C and average was 1001.58°C for A side (991.43-1010.98°C and it average 1000.31°C for B side) and heat capacity of boiler — 2.47-3.69 MW and it average — 3.6 MW during testing period (Table 6). Fluidized bed temperature of the furnace at medium capacity of boiler#1 was fluctuated 956.23-1012.85°C and it average was 981.30°C for A side (957.42-1015.93°C and average 983.82°C for B side) and heat capacity of boiler — 4.13-4.55 MW and it average — 4.34 MW.

Fluidized bed temperature of the furnace at maximum capacity of boiler#1 was 971.72-1167.12°C and it average 1076.00°C for A side (1020.27-1167.82°C and it average — 1088.90°C for B side) and heat capacity of boiler — 6.04-7.54 MW or average — 7.13 MW.

Table 6 TSP average concentration in the exhausting flue gas comparison to MNS standard "MNS 6298: 2011".

Boiler No	Heat load	Sampling point	Date	C [mg/m^3]	C [mg/nm^3]	Standard value [mg/nm^3]	Comparison to Standard value
TPP#2 in Ulaanbaatar							
K-1	Max	After Bag house	2014.08.19	43.0	68.2	200	65.9 % less than standard value
K-3	Max	After ash collector (packet cyclone)	2014.08.30	3292	4947.2	200	24.74 times more
Central Heating Plant in Oyu Tolgoi							
K-1	Medium	After Bag house	2013.12.28	62.9	93.2	200	53.40 % less than standard value
K-2	Max	After Bag house	2014.01.14	10.3	16.0	200	91.98% less than standard value
K-3	Max	After Bag house	2014.01.12	4.1	6.0	200	97.01% less than standard value
K-4	Max	After Bag house	2014.01.09	8.1	10.7	200	94.64 % less than standard value

Efficiency of bag house of hot water boiler DHFX29-2.0/130/70-Mfluctuated between η = 98.64% and η = 99.91%, average 99.22% at the average capacity, 99.73 % at the maximum capacity.

Efficiency of bag house of hot water boiler SHFX7-2.0/130/70-M fluctuated between η = 98.29% and η = 99.99%, average 99.51% at the average capacity, 99.9% at the maximum capacity.

3. Comparison of Test Results of Ash Collectors

We tested TSP control equipments of TPPs and heating plants for determining TSP or fly ash concentration in the flue gas and these removal efficiencies. As a result average efficiency of the electrostatics precipitators' is 96.8-99%, wet scrubbers with Venture tubes — 85-90%, and dry cyclones — 45-60%, which were lower than their designed value. But flyash removal efficiency of bag filters is 99.7-99.9%.

As a testing result fly ash (TSP) average concentration in the combustion product of coal after bag filter of steam boiler No1 type TS-35-39 is 68.2 mg/nm^3 and lower 65.9%, and after ash collector of steam boiler No. 3 in Ulaanbaatar is 4947.2 mg/nm^3 and 23.74 times more than the national standard "MNS 6298: 2011".

Comparison bag filter efficiency with ash collector (packet cyclone-centrifugal force) of the steam boilers No. 1 and No. 3 of TPP#2 in Ulaanbaatar more 45.73% and fly ash average concentration in the flue gas is lower 72.5 times.

From comparison bag filter efficiency with ash collector (packet cyclone-centrifugal force) more 52.3% at the maximum steam capacity.

Fly ash (TSP) average concentration in the combustion product of coal after bag filter of CFB hot water boilers SHFX7-2.0/130/70-M is 53.40% and 91.98%, and DHFX29-2.0/130/70-M boilers 6.0-10.7 mg/nm^3 and lower 94.64-97.01% than the national standard "MNS 6298: 2011".

4. Conclusion

(1) As a testing result the average efficiency of Electrostatic precipitators of steam boilers TPP-4 fluctuated between η = 98.36% and η = 99.3% and average 98.83% at the maximum capacity.

(2) As a testing result the average efficiency of bag house of steam boiler type TS-35-39 of TPP #2 in Ulaanbaatar fluctuated between η = 97.2% and η = 98.45% at the 31.27 t/h capacity and will reach 99.7% at the steam capacity 34 t/h and fly ash average concentration in the combustion product of coal after

bag filter was 68.2 mg/nm^3 and lower 65.9% than the national standard "MNS 6298: 2011".

(3) The average efficiency of bag house of hot water boilers DHFX29-2.0/130/70-Mfluctuated between 99.73-99.9% at the maximum capacity and fly ash average concentration in the combustion product of coal after bag filter was 6.0-10.7 mg/nm^3 and lower 94.64-97.01% than the national standard "MNS 6298: 2011".

(4) The average efficiency of bag house of hot water boilers SHFX7-2.0/130/70-M was 98.3-99.9% at the maximum capacity and fly ash average concentration in the combustion product of coal after bag filter was 16.0-93.2 mg/nm^3 and lower 53.4-92.0% than the national standard "MNS 6298: 2011".

(5) The average efficiency of packet cyclone of steam boiler No. 3 type TS-35-39 of TPP #2 in Ulaanbaatar fluctuated between η = 42.47% and η = 62.9%, average 45.73% at the maximum steam capacity and fly ash average concentration in the combustion product of coal after ash collector (packet cyclone) 4947.2 mg/nm^3 and 23.74 times more than the national standard "MNS 6298: 2011".

(6) Comparison bag filter efficiency with ash collector (packet cyclone-centrifugal force) of the steam boilers No. 1 and No. 3 of TPP#2 in Ulaanbaatar more 54.3% and fly ash average concentration in the flue gas is lower 72.5 times.

References

[1] J. Tseyen-Oidov, O. Batbayar, A. Tumenbayar and B. Battor, Testing results of bag filter type LCMD-1870 of steam boiler TS-35-39, *Energy & Engineering* 2/132 (2015) 16-17. (in Mongolian)

[2] J. Tseyen-Oidov, A. Tumenbayar and Ts. Amarjargal, Final report of test of ash collectors of steam boilers of TPP-2 in Ulaanbaatar, 2014, p. 39.

[3] J. Tseyen-Oidov, A. Tumenbayar and Ts. Amarjargal, Final report of test of CEF hot water boilers of Central Heating Plant in OYU TOLGOI, 2014, p. 154.

[4] J. Tseyen-Oidov and Ts. Amarjargal, Some testing results of bag filter of hot water boilers, *Energy & Engineering* 3/133 (2015) 16-18. (in Mongolian)