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3.4 Analysis of mode-adjustment tests of boiler ТПП-312А

The main purpose of the work was to conduct testing and adjustment tests of the boiler ТПП-312А in the operational range of loads and adjusting the mode maps of the boiler and vacuum cleaners during its transfer to solid fuel combustion, which differs from the design general and specific. The results of mode-adjustment tests with determination of: dependence of influence of steam productivity on mode, and economic indicators of boiler operation are given; dependence of the optimal coefficient of excess air on steam production; the magnitudes of air intake into individual elements and the gas path as a whole; determining the mode of operation of the dust system. Compiled mode map of the boiler and vacuum cleaner. The suggestions for increasing the efficiency and reliability of the boiler are given.

Keywords: boiler, coal, fuel, liquid sniffer, cold air, heat losses, gross boiler efficiency.

Introduction

According to Presidential Decree No. 37/2017 “On the decision of the National Security and Defense Council of February 16, 2017 “On urgent measures to neutralize the threats to the energy security of Ukraine and strengthen protection of critical infrastructure”, to perform the repair schedule of the main equipment of thermal power plants there was a need for regime-commissioning trials boiler ТПП-312А of TPP in the operational range of loads and adjustment of the mode maps of the boiler and vacuum cleaners when transferring it to solid fuel combustion, which differs from the design general and specific properties.

Boiler type ТПП-312А direct-flow, dust-coal, liquid-liquid, single-hull, U-shaped layout, with intermediate steam overheating. The boiler operates in a monoblock with a K-300-240-2 ХТГЗ turbine rated at 300 MW [139].

Methods of testing. The test was carried out according to a commonly accepted method [139] and agreed by the Work Program of Testing.

The boiler test and debug tests included preparatory work and debug experiments.

Mode-adjusting experiments included determination of air intakes in the fuel and gas path of the boiler, determination of the optimal value of the coefficient of excess air in the section, characteristics of the steam and gas-air tracts of the boiler, as well as experiments on the determination of the optimal values of the operating parameters, heat losses and boiler efficiency. The processing of test results was performed according to [139, 140, 142, 143].

Methods of measurements. Measurements of the basic parameters of the boiler operation were carried out with the help of staff control equipment. The temperatures, pressures, costs, electrical power of the turbogenerator, the temperatures along the boiler's gas-air path were measured by standard control devices [144-149]. The flue gases for gas analysis were extracted from the cross section of the gas duct in front of the water economizer (mode cross section) and after the smoke smokes (balance cross section) and were performed with a tared TESTO-340 gas analyzer.

To determine the air intake in the sections of the gas tract, gas analysis was performed in cross sections by regenerative air heaters. Samples of solid fuels for determination of ash content, humidity and caloric content were carried out from the feeders of raw coal. Dust samples to determine fineness of grinding and humidity were taken from dust leaks under cyclones.

Samples of ash for the determination of combustible (mechanical non-combustible) were collected from flue gases with the help of regular port installations from the gas line in front of the water economizer.

The solid fuel consumption of the boiler was determined by the inverse balance. Characteristics of solid fuels, dust specimens, as well as the content of combustible fuels were carried out by the staff of the coal laboratory of TPP.

Test conditions. The auxiliary equipment that provides the preparation and supply of fuel to the fuel and the hydroelectric removal system were designed for the operation of the boiler on the screenings of gas coal «ГСШ». Non-project fuel characteristics are as follows: $Q^w{}_l$ = 5524 kcal / kg; W^w = 16.4%; A^w = 11.1%; V = 41.7% (dry ashless mass).

The quality of this coal at the yield of volatiles and the calorific value of coal corresponds to the domestic coal of the gas group. In the conditions of TPP, it is impossible to allocate a separate site for the storage of non-project fuel, so storage was performed only on one side of the coal warehouse, from where it was fed for burning.

During the mode-adjusting experiments, the average quality characteristic of solid fuel was as follows: Q^w_l = 5265 kcal / kg; W^w = 12.2%; A^w = 19.1%; V = 41.7% (by working mass).

Test results. Mode-adjusting experiments were carried out in the load range of the block 65.0-100% of the nominal, which corresponds to the steam capacity of the boiler 638,0-951,0 t/hr when burning solid fuel.

Carry out mode experiments to determine the need and amount of illumination by another type of fuel. It is experimentally established that when burning coal with Q^w_l = 5265 kcal / kg, excess air close to the optimum and satisfactory condition of the burners in the range of loads of the block 65-100% of nominal, provides a satisfactory escape of liquid pellets without illumination with natural gas.

Determination of air intakes in fuel and boiler gas ducts. The air intake in the fuel, resulting in a rated load, is approximately 5.0%, which complies with the requirements [142].

Rated to the nominal load air intake in the gas path from the water economizer and to the exit of the smokestacks are 41.7%, with an allowable value of 35% according to requirements [142]. The parcels mentioned parcels are distributed as follows:

- in water economizer, gas pipeline and regenerative air heater (RAH) - 26,0%;
- from RAH and electrostatic precipitators with adjacent gas ducts - 15.7%.

The total air intake in the convective mine, the gas duct and the RAH increase the amount of gases passing through the RAH, which leads to an increase in the temperature of the exhaust gases, excess air in the exhaust gases, the power consumed by smoke smokes, that is, to reduce the efficiency of the boiler.

Airflows through the lower seals of the RAH and aspirations in the filters with adjacent gas ducts reduce the temperature of the exhaust gases, increase the excess air in them and practically do not change the heat loss with the exhaust gases, and lead to a decrease in the efficiency of the boiler only due to the consumption of smoke and vents.

Determination of the optimal value of the fineness of grinding coal (R_{90}). Taking into account the tests performed at burning of similar coal at TPP [140], experiments to determine the optimal fineness of grinding (R_{90}) were not performed and accepted according to the recommendations [140] and the regime map. The fineness of grinding coal (R_{90}) during the experiments was 24 - 25%.

Determination of the optimal value of the coefficient of excess air in the section. The optimal excess air in the regime section was selected from the conditions of the absence of products of chemical unburned (CO) in the flue gas, the minimum content of combustible in the removal and satisfactory melting of the slag.

The optimum excess air in the mode section at a boiler load of 100% of the nominal is 1.15, at a load of 80% is 1.2, and at a load of 65% is 1.22.

With excess air below the optimum by 0.03-0.04, the products of chemical unburned (CO) appear and the content of combustible in the carry-on (losses with mechanical unburned) increases. The dependence of the optimal excess air on the steam capacity of the boiler is shown in Fig. 1.

The total relative consumption of feed water for injection to the overhead steam superheater (II injection) and to the high-pressure convective steam superheater (CSS) (III injection) in the operating range of loads is 10.7-13.6% of the consumption of superheated steam.

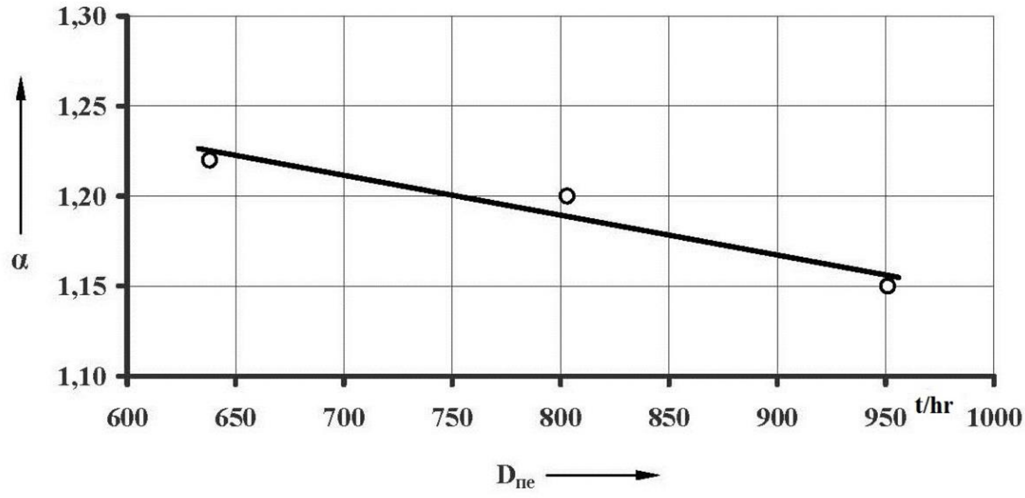

Fig. 1. Dependence of the optimal coefficient of excess air on the steam capacity of the boiler.

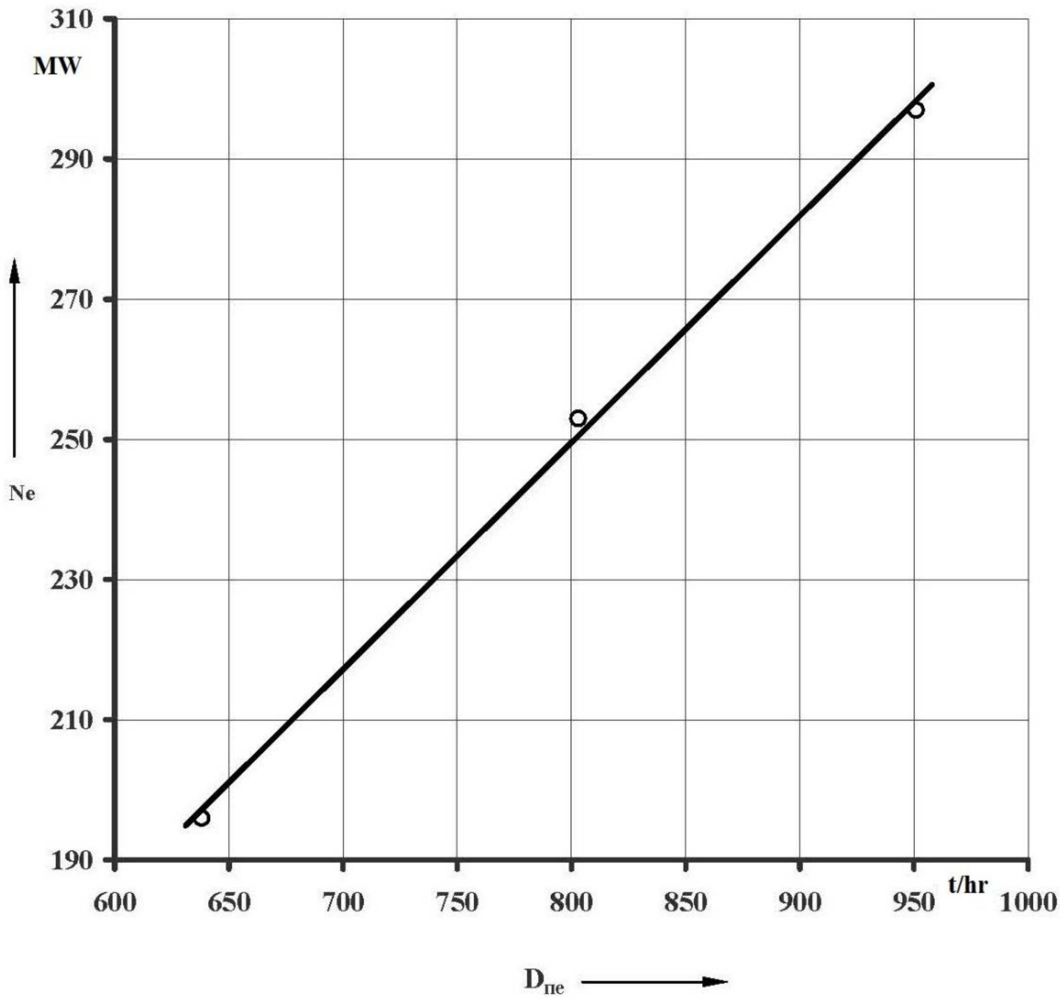

Fig. 2. Dependence of electrical load of the unit on its steam capacity.

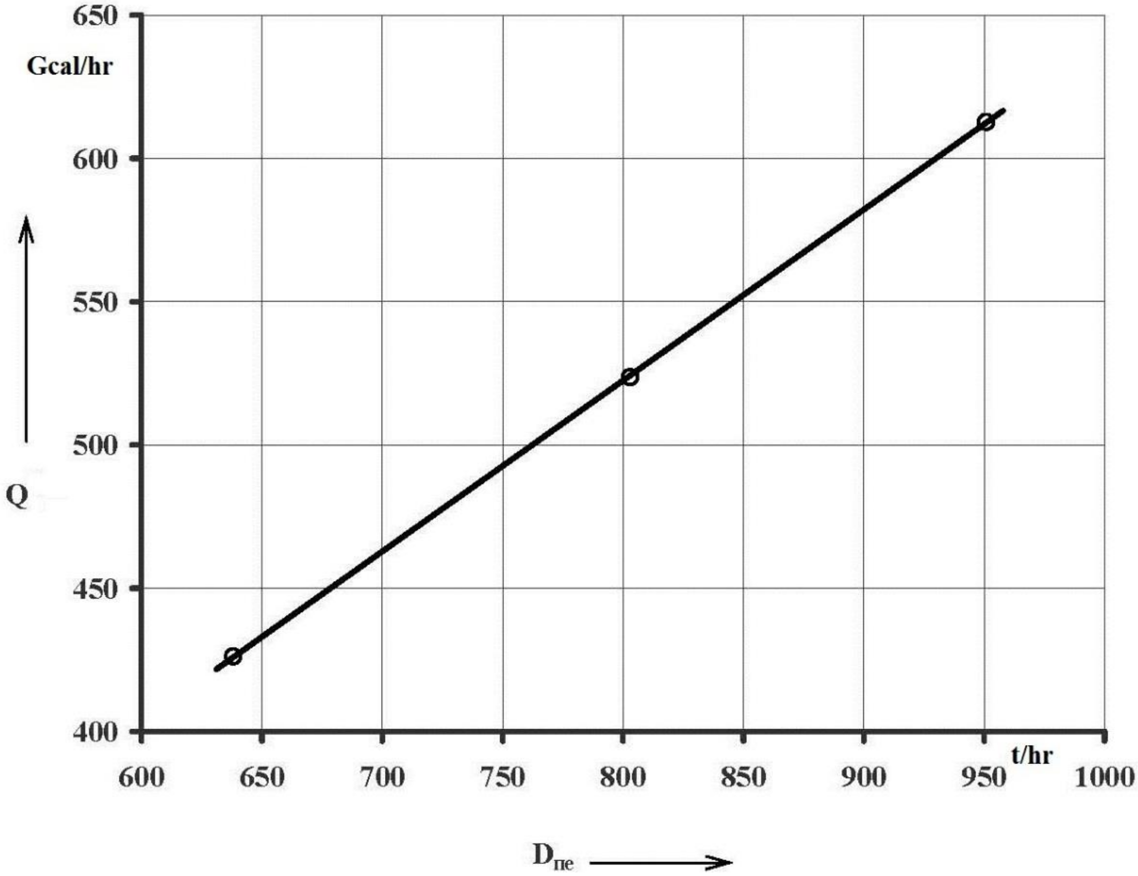

Fig. 3. The dependence of the heat capacity of the boiler on its steam capacity.

The secondary steam temperature at the boiler was maintained at ~545 °C. Figures 2, 3 show the dependencies that relate the electrical load and heat output of the boiler to the consumption of superheated steam.

Mode map of the boiler and dust system. According to the results of the tests, a mode map of the boiler was prepared when burning solid fuel (Table 1). The mode map is made for the condition of the equipment, which took place during the period of testing, in the range of boiler loads 65-100% of the nominal (load unit 196 - 287 MW) and included in the operation of the high-pressure heater. In the case of measures to seal the furnace and gas pipelines, reconstruction of individual heating surfaces, significant changes in the quality of coal and the like, the mode map must be corrected.

Table 1

Mode map of the boiler ТПП-312А and its dust system.

№	Name of the parameter	Unit of measurement	Electrical load			Remarks
			200	250	300	
1	Steam capacity of the boiler	t/hr	638,0	803,0	951	
2	Consumption of nutritious water	t/hr	568	710	820	
3	Feeding water temperature	°C	243	256	265	
4	Temperature of superheated steam	°C	545			
5	Pressure of superheated steam	kg/cm^2	250			
6	The temperature of cold preheat steam in front of the boiler	°C	285	292	300	
7	Pressure of cold preheat steam in front of the boiler	kg/cm^2	25	31	37	
8	Steam temperature of hot boiler overheating	°C	545			
9	Ambient temperature to the built-in latch	°C	415	420	425	not more 430
10	Steam temperature for the overheating steam superheater (up to III injection)	°C	520	525	525	not more 525
11	O_2 content of flue gases	%	3,8	3,5	2,8	not lower 2,5
12	Dilution at the top of the fuel	kg/m^2	2 -5			
13	Dilution for convective superheater	kg/m^2	14-18	18-20	20-24	not more 35
14	Resistance is a regenerative air heater	kg/m^2	75-80	85-90	120-130	
15	The temperature of the gases in the rotary chamber	°C	790-810	820-840	850-880	not more 920
16	Flue gas temperature	°C	162	164	166	
17	Air temperature to regenerative air heater	°C	30			
18	Secondary air temperature	°C	335	345	355	
19	Secondary air pressure in front of the burner	kg/m^2	100	130	160	
20	The position of the secondary air vents in front of the burner: - central - peripheral	%	 100 10 – 15	 100 10 – 15	 100 10 – 15	
21	Number of operating dust extractors	pcs.	12 – 14	14 – 16	14 – 16	
22	Number of dust systems in operation	pcs.	2	2	2	
23	Dilution in front of the mill	kg/m^2	70-90	70-90	70-90	
24	Mill resistance	kg/m^2	200-240	200-240	200-240	
25	The temperature of the mixture over the mill	°C	70-80			not more 90
26	O_2 content per mill fan	%	14,5-15,5			not more 16
27	Pressure in the pressure head mill fan	kg/m^2	260-290			not more 300
28	Moisture dust in the hopper	%	1,0-1,5			R_{90}=24-25
29	Dust level in the hopper	m	3,5 -4,5			

The mode map is made when burning solid fuel with the following characteristics: $Q^w{}_l$ = 5265 kcal / kg; V = 40.0%, $Q^w{}_l$ = 12.0-14.0%; A^w = 18.0-20.0%.

Conclusions

Based on the work done, we can draw the following main conclusions:

In the boiler load range of 65-100% of nominal (unit capacity 196-297 MW), the combustion of solid fuel without natural gas illumination ensures stable long-term operation of the boiler with nominal parameters and satisfactory liquid beet yield.

The air intake in the boiler furnace, reduced to nominal load, is 5%, which complies with the requirements [142].

Air aspirations into the gas path of the boiler in the section "water economizer - exhaust", reduced to nominal load, make 47% at the rate of 35% according to [142].

When burning only solid fuel in quality (Q, A, W, V), which was during the mode-setting experiments, the optimal fineness of grinding of coal on a residue on a sieve of 90 microns can be considered 24-25%.

The optimum excess air in the mode section at boiler loads of 65%, 80% and 100% of the nominal is 1.22, 1.2 and 1.15 respectively.

At boiler loading, ~ 100% of the boiler's gross efficiency when burning solid fuel is 88.7% at an estimated 89.72% at rated load and burning only solid fuel.

The consumption of solid fuel is calculated according to the inverse balance at the same time is 131,2 t/hr.

When boiler load is 65% of nominal boiler gross efficiency, when burning solid fuel is 87.58%.

Consumption of solid fuel calculated on the reverse balance at a load of 65% of the nominal is 92.4 t/hr.

A mode map has been developed according to which the boiler operation mode can be maintained.