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IMPROVEMENT OF HEATING PLANT OPERATION EFFICIENT DUE TO CONTACT WASTE HEAT BOILERS AND HEAT PUMP EQUIPMENT

There had been suggested the scheme of the combined plant on the base of power – plant boiler, contact waste heat boiler and heat pump equipment. There had been determined the main factors of its operation, fuel saving and reduction in emissions of harmful substances into the atmosphere.

Key words: *boiler, contact economizer, heat pump, compressor, condenser, evaporator.*

Introduction

Nowadays, when fuel prices constantly grow, the energy efficiency is becoming more urgent and saving of fuel and energy recourses has become of top priority. Non-efficient use of fuel is observed in almost all branches of industry. It causes the necessity of importing of approximately. 5 % of the required fuel. According to the statistic data, heating supply requires almost 95 million tons of conventional fuel. Thus, the issue of efficiency improvement of fuel use must be paid special attention .

One of the efficient means of fuel economy and environment protection is the use of low temperature energy of waste heat. Highly industrial countries pay much attention to the creation and introduction of heat pump equipment (HPE), which is designed for heating, hot water supply, distillation etc. [1 – 3]. HPE's universality is also an important factor, as it may be used as heaters and coolers at the same time, transforming waste heat into conditioned heat energy, useful for heat supply. The majority of foreign and native specialists consider HPE to take the main place in low-temperature systems of heating supply. Considerable economic and ecological advantages of HPE are considered as leading –edge technology in the sphere of heat and cool supply. Unfortunately, the works on implementation of HPE are at the initial stage in our country. The spheres and scales of work of HPE use have not been determined. Nevertheless, economy of fuel in the systems for central heating supply in domestic household sector may make up 20 -30% [4].

The main reason for restraining the introduction of heat pump equipment in boilers is the absence of low temperature sources of heat. Such a source may be created due to deep utilization of combustion products heat , which are emitted into the funnel. Contact economizers (CE) with water condensation, which is held in products of combustion may be used for utilization of this heat. Such CE of the original construction with the nozzle of jalousie-type have been developed by the Department of Heat and Power Engineering in Vinnytsia National Technical University [5]. Proceeding from the above- mentioned we put forward the task to evaluate the efficiency of HPE application in boilers with CE for waste heat utilization.

Main results

Principle diagram of boiler with contact economizer and heat pump equipment is shown in fig. 1.

Temperature of combustion gases from native boilers which use natural gas, is usually 130 – 135ºC. Efficiency of boilers operation is possible to improve due to decrease in temperature of combustion gases. But to avoid vapour condensation from combustion products in funnels and gas ducts, the temperature of discharge gas must be not less then 85 – 90ºC.. Under such conditions, the discharge gases from the boiler are separated into two streams. One stream in the amount of 35 % of total gas discharge with the temperature of 130ºC flows to smoke exhauster 13. The other flow with discharge of 65% flows to contact economizer 2. In contact economizer the cold water is sprayed by nozzles 4 and as a thin film water flows on jalousie channels of nozzle 5, contacting with exhausting gases. In the result of gas cooling, the vapour which is present in combustion product, is condensed and together with cool water, which is heated from 30 to 50 ºC is collected in pallet of the CE. Cases are cooled to the temperature of 65 ºC, pass the separator 3 and flow into the suction inlet of smoke exhauster 13. In front of the smoke exhauster there is the mixture of gases with the temperature 93-95 ºC, which flow in to the funnel. From the CE pallet the water by the circulating pump 6 is pumped through the evaporator of HPE, where it is cooed up to 30 ºC and is supplied to nozzles 4. Due to the heat, which is supplied to evaporator 7, cooling agent of HPE is evaporated and its dried saturated vapour is supplied to the compressor 8, which is rotated by the electric motor 9. The condensed vapour of cooling agent is supplied to the HPE compressor 11, where it is condensed and gives heat to the water in the net, which is pumped by the pump 10. Heated net water is supplied to the consumers of heating system and hot water supply. The condensate of cooling agent is choked in the throttle valve 12 and is again supplied to the evaporator of HPE 7.

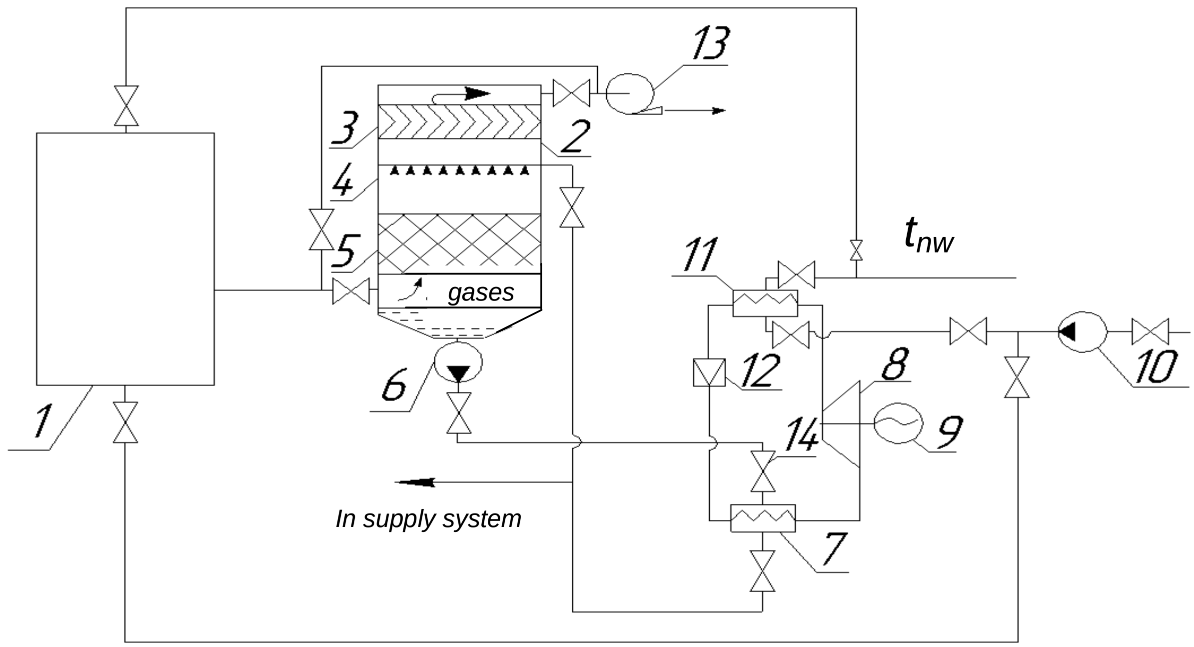

Fig. 1. Boiler flow diagram with CE and HPE : 1 – boiler; 2 – body of CE; 3 – separator (spray separator); 4 – water spray nozzles; 5 – regulative nozzle of jalousive-type; 6 –circulating pump; 7 – evaporator of HPE; 8 – compressor of HPE; 9 – electric motor; 10 –net pump; 11 – condenser; 12 – throttle valve; 13 – smoke exhauster; 14 – stop valve.

The efficiency of the suggested plant was researched with the standard boiler ПТВГ – 30 with the capacity of 34,86 MWt, Working fuel is natural gas with combustion heat in dried mass of 33,4 M J/m^3, at price 2500 Uhr per 1000 m^3 . Firing rate of fuel and discharge gas made up 1,1344 m^3/sec and 16,359 m^3/sec accordingly.

It was assumed that in heating and between-heating season the boiler works with the nominal loading. Duration of heating seasons was 4500 Hours and that of between heating seasons was 3600 hours. Price of the consumed electricity was 650 Uhr for 1 megawatt – hours. The working medium in HPE was ammonia. During the researches, temperature of net water t_{nw} on the output from the condenser of HPE was measured. Methods of calculations is developed and presented in [4, 5].

The main operating factors if the combined plant is presented in fig. 2, 3 and 4. Fig. 2 demonstrates the change of thermal capacity Q_c which flows from PHE condenser to the heating net, as well as coefficient of energy transformation (heating coefficient) φ, which characterizes the efficiency of HPE operation.

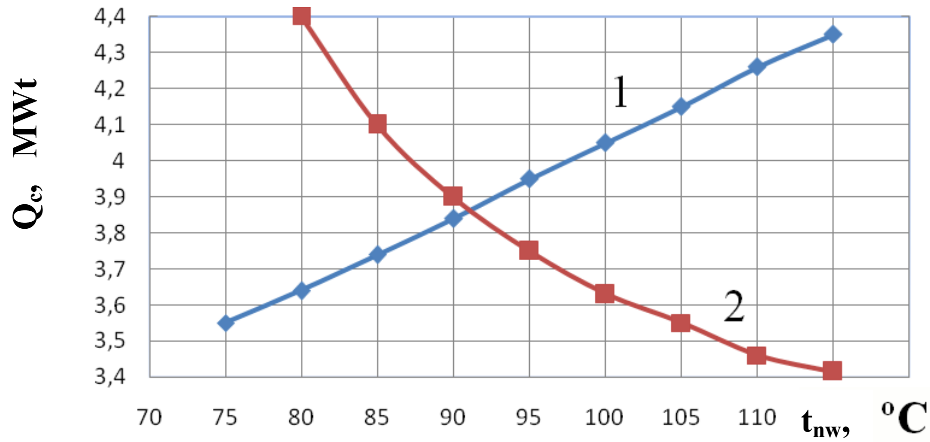

Fig. 2. Dependences: $Q_c = f(t_{nw})$ (line 1); $\varphi = f_1(t_{nw})$ (line 2).

Fig 2 shows that during temperature increase of net water, the capacity of the heat, flowing from PHE condenser increases linearly, but the PHE operating efficiency decreases, at the same time due to increase in capacity on compressor N_c (see fig. 3). It should also be noted that for t_{nw} = 110ºC the value φ makes up 3,3 and is commonly accept in operating practice of heat pump equipment.

Due to the utilization of discharge gas heat from the boiler and use of PHE, the required capacity of water boiler decreases by the value Q_c, which is supplied to the heating net from the PHE condenser. This conditions a certain economy of fuel ΔB, due to decreases of fuel consumption in the boiler. Values ΔB and PHE capacity of compressor N_c, depending on temperature of water in the net, is shown in fig. 3.

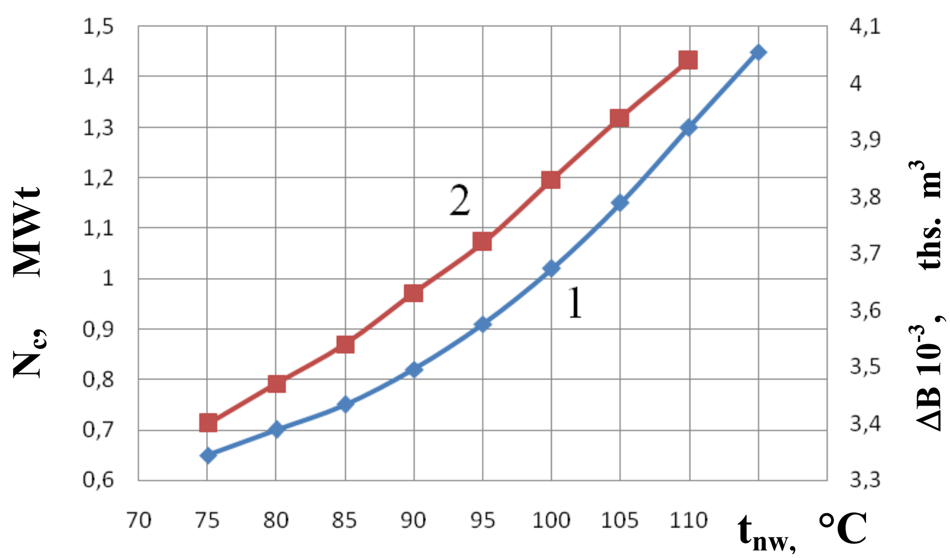

Fig. 3. Change character N_c (curve 1) and B (curve 2)

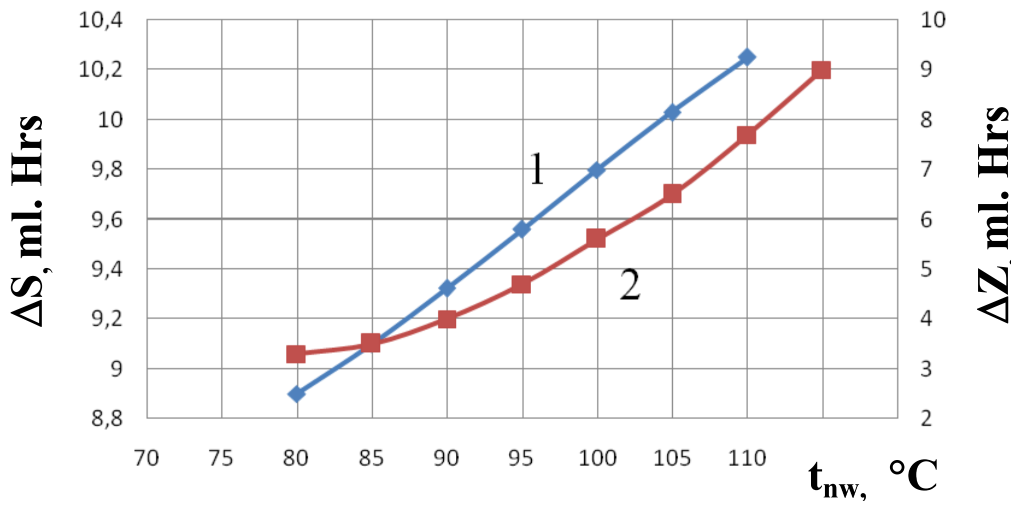

Fig. 4. Values of fuel cost economy (line 1) and cost overspending on electricity (curve 2).

It is obvious that due to fuel saving the cost of fuel S decreases .

It is clear that difference between them is the economy of financial resources for energy carriers fuel economizing reduces the annual spending on fuels ΔS. At the same time, the annual expenditures on electricity ΔZ increases due to the operation of circulating pump 6 and PHE compressor 8. Fig. 4 presents the current values of ΔS i ΔZ. Difference between them the costs saving on energy supply. The lower the value t_{nw} , the bigger the saving. In the considered range of change t_{nw} it decreases by 32 %. In the spring and autumn period the temperature of water in the net does not usually increase 75 75ºC. In this period costs savings for energy supply are the largest and make up 6,6 mln. Uhr. Calculations show that payments for consumed electricity at night hour at preferential rate which is double cheap as the day rate, allow to increase the cost saving by 10-12 %.

Saving the coal equivalent fuel causes the decrease in oxygen consumption as well as emissions into the atmosphere. Following the methodic of BAC 34.02.305-2002 "Emissions of contaminating substances into the atmosphere from the power-generating plants" there had been calculated the values of these quantities, the results of which had been tabulated.

Indexes	Temperature of water in the net, ºC			
	80	90	100	110
Annual saving of fuel, %	10,46	11	11,66	12,21
Annual decrease in oxygen consumption, tons	897,68	944,02	1001,62	1048,87
Annual decrease in emissions, tons: Carbon dioxide	0,482	0,508	0,541	0,563
Nitrogen oxides	843,55	888,57	941,42	983,96
	0,955	10,05	10,61	11,14

The obtained results show the expediency of using the plants of the suggested type and is the necessary precondition for the evaluation of the efficiency of such plants. With the availability of heating loads they may be used in industrial boiler rooms.

Conclusions

1. More deep utilization of boiler waste heat and its use in heat pump equipment may be realized without the complex reconstruction of thermal scheme of boiler room.

2. Use of contact economizers together with heat pump equipment allows to increase the heat capacity of the boiler by 10 – 20%, reducing by the same value the consumption of fuel and amount

of emissions into the atmosphere.

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