18. Tada, H. The Stress Analysis of Cracks Handbook [Text] / H. Tada, P. C. Paris, G. R. Irwin. – Del Research Corporation (Hellertown), 1973. – 677 p.
19. Bruchmechanische Bewertung von Fehlern in Schweißverbindungen. Merkblatt DVS 2401 [Text]. – Deutscher Verband für Schweißtechnik, 2004. – 271 p.
20. Newman, J. C. Stress Intensity Factor Equations for Cracks in Three-Dimensional Finite Bodies [Text] / J. C. Newman, I. S. Raju // Fracture Mechanics: Fourteenth Symposium – Volume I: Theory and Analysis. – 1983. – P. I-238–I-238-28. doi: 10.1520/stp37074s
21. Paris, P. Closure to «Discussions of 'A Critical Analysis of Crack Propagation Laws'» (1963, ASME J. Basic Eng., 85, pp. 533–534) // Journal of Basic Engineering. – 1963. – Vol. 85, Issue 4. – P. 534. doi: 10.1115/1.3656903
22. Panasyuk, V. V. A method for the Assessment of the Serviceability and Fracture Hazard for Structural Elements with Crack-like Defects [Text] / V. V. Panasyuk, I. M. Dmytrakh, L. Toth, O. L. Bilyi, A. M. Syrotyuk // Materials Science. – 2014. – Vol. 49, Issue 5. – P. 565–576. doi: 10.1007/s11003-014-9650-6

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THE USE OF CONTACT HEAT GENERATORS OF THE NEW GENERATION FOR HEAT PRODUCTION

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Обгрунтовано необхідність пошуку нових підходів для підвищення енергетичної ефективності та екологічної чистоти теплевиробництва в системах теплопостачання. Розглянуто переваги високоефективних компактних і недорогих контактних теплогенераторів різних типів для теплопостачання великих міст і промислових районів. Запропоновано використання теплогенератора контактного типу нового покоління, що дозволяє вирішити комплекс проблем щодо якісного спалювання палива і теплообміну

Ключові слова: контактний теплогенератор, теплова енергія, теплозабезпечення великих міст і промислових районів, теплевиробництво

Обоснована необходимость поиска новых подходов для повышения энергетической эффективности и экологической чистоты теплопроизводства в системах теплоснабжения. Рассмотрены преимущества высокоэффективных компактных и недорогих контактных теплогенераторов разных типов для теплоснабжения крупных городов и промышленных районов. Предложено использование теплогенератора контактного типа нового поколения, позволяющего решить комплекс проблем по качественному сжиганию топлива и теплообмену

Ключевые слова: контактный теплогенератор, тепловая энергия и теплообеспечение больших городов и промышленных районов, теплопроизводство

1. Introduction

The advantages of the centralized heat supply in large cities and large industrial centers by the indicators of energy effectiveness and the possibilities of attaining high level of ecological safety are well-known [1]. At the same time, the development of decentralized heat-power engineering has gained wide scope and scale over recent decades. And there are objective reasons to this: in the large cities and industrial regions the old centralized systems of heat supply are not only morally and physically obsolete and worn-out, but simultaneously, in this case, they gave rise to ecological problems of atmospheric pollution, they require serious capital expenditures for maintaining their operational mode. In addition, the density of buildings in the cities increases and this further complicates the process of quality heat supply. The process of designing new city blocks for new industrial, social and everyday-activity centers is also complicated.

These peculiarities require increase in energy generating capacities at the sources of heat supply, reliability of operation of heat mainlines and basic heat-power engineering equipment at the thermal power plants (TPP) and in the district boiler units. This entails the need for the search of essential capital expenditures for the large-scale reconstruction of those existing or construction of the new sources for heat supply. Present work proposes the solution for this problem through the use of highly efficient contact heat-generators. The relevance of study in this direction is predetermined by the need for the search for new approaches to increase the energy effectiveness and environmental cleanliness of heat supply for large cities and industrial regions.

In large cities essential difficulties are also connected with the provision of heat supply for the new residential areas under construction and their infrastructure (commercial-entertaining centers, sports facilities, polyclinics, schools supermarkets, etc.). In this case, the requirements for effectiveness and ecological safety of energy production significantly increase, and with a regard to the increase in cost of energy resources and adoption of stringent requirements for the cleanliness of the energy-converting processes, a task on the transition to new innovative technologies acquires essential importance and requires adopting serious effective solutions.

Using TPP and district heat plants with classic steam or hot-water boilers of the surface type for these purposes becomes problematic for different reasons, the main ones being:

– the absence of free areas in the cities for building new power facilities;

– existing objective limitations for increasing effectiveness (performance efficiency of boilers reaches limit of 91...95 %) and ecological safety of traditional steam and hot-water boilers do not make it possible to achieve and maintain under different operating modes the required indicators of operation;

– existing thermal utilities networks are not designed for significant overloads, they are physically obsolete, they are not capable of providing the necessary thermal regime for consumers in terms of temperature schedule and hydraulic loads;

– new contemporary plants and equipment from foreign firms and enterprises require essential capital expenditures both for the construction of new heat-generating units and thermal mains and for their maintenance.

In addition to the special features indicated, it is necessary to consider that in the systems of heat-supply to cities and large industrial regions, sufficiently acute problems of local nature have accumulated for many years, which render the real condition of the centralized heat supply in line with the provision of services on heating and hot water supply problematic. This is testified by both the numerous emergencies of thermal networks during the period of heating season and the cases when heating systems do not provide for the necessary temperature conditions of objects at all.

Reforms in the sphere of heat supply proclaimed by the government of the country imply the development and adoption of the laws, which stimulate highly effective heat supply for cities, as well as the implementation of programs of the modernization of systems of heat supply. But until today, new schemes and solutions for the questions of heat supply for a significant quantity of new city blocks in different cities have not been developed yet. Furthermore, it is necessary to consider that for many regions, such projects must be developed taking into account the interests of territorial development and general plans of development of the infrastructure of particular large and small cities. These programs must be realized within the shortest period taking into account of both the real condition of the sources of heat supply and thermal networks and the possibility of transition to the partial or complete decentralized heat supply with the use of contemporary highly efficient technologies of energy generation.

Thus, the society faces the task for the search and realization of fundamentally new approaches, using more effective physical, heat-mass-exchanging and aerodynamic processes, which will make it possible to increase energy efficiency and ecological cleanliness of heat generation in the systems of individual and decentralized heat supply.

2. Literature review and problem statement

The strategies of effective heat supply are examined only in general form without specified indicated actions to increase the energy effectiveness of equipment [2]. The survey of requirements for the systems of heat generation makes it possible to formulate the urgency of solving the problems in the energy sector only [3]. Describing optimum control of heat supply to the cities does not reveal the method for the solution to the problem, but rather describes the tasks, necessary for the generation of thermal energy [4]. The information we examined in papers [5, 6] only in theory, and incompletely, describe approaches for the selection of efficient heat supply. A survey of the sources given above attests to the fact that a question of increasing the energy effectiveness and ecological safety of heat generation for residential buildings and industrial zones has been investigated insufficiently and it requires further examination.

The use of contact heat-generators is one of the possible variants of successful solution for the given problem of heat supply to urban districts and industry [7]. The known designs of contact heat-generators make it possible to heat water for consumers up to 95 °C. They are already in use by some sectors of industry, including those for heating and hot water supply of residential and industrial facilities [8]. However, for the wide use of heat-generators of the contact type (HCT), it is necessary to improve them, to create conditions for the provision of their complete automation, to make them more compact and more reliable. Furthermore, it is necessary to provide the design of heat-generators with the possibility of using new types and mixtures of gaseous fuel, including based on hydrogen. This will make it possible to increase their competitiveness and attractiveness according to the effective and ecological indicators of operation.

3. The aim and tasks of the study

The aim of present work is the determination of optimum contact plants for heat supply of urban regions and industrial zones with further development of new approaches to their improvement and creation of new design solutions.

To achieve the set aim, the following tasks were formulated:

– a study of the existing designs of HCT, their thermal and aerodynamic peculiarities;

– to reveal structural nodes and operating conditions of heat-generators of the contact type, which are possible to improve;

– to develop design solutions, which make it possible to implement new, more efficient, processes of mixture formation, combustion, heat- and mass transfer into HCT of the new generation.

Solving the indicated problems must lead to the creation of new design of HCT with the energy and ecological indicators of performance that will exceed by 10–15 % those existing at present.

4. Materials and methods of research

In order to solve the set tasks, we examined critically analyzed the basic existing designs and operating conditions of HCT. In the studies, special attention was paid to critical analysis and the possibilities of special features which include the following.

1. High performance efficiency that reaches 104 % in the systems for hot water supply. This is explained by the fact that the main share of heat from the combustion products is transferred to water not through the metallic wall (as in boilers), but through direct contact between water and high-temperature gases.

In this case, the gases are cooled to temperature 30–35 °C, that is, below the dew point, and the heat, latent in them in the form of condensated water vapor, is used for heating the water. Heat losses with the exhaust gases under these conditions do not exceed 2 %.

2. Contact type heat-generators are simple by design are compact, they have the lowest specific metal consumption per unit of the generated heat (about 2 kg/kW) in comparison with the boilers [8].

The use of HCT is justified according to many characteristics and indicators. At present, this type of the heat-generating plants is developed in the following directions:

1) an increase in the single power, reduction in capital expenditures and decrease in specific fuel consumption;

2) specialization of HCT according to purpose: for technological purposes and the purposes of heat supply, which makes it possible to provide optimum technical and economic indicators of their performance under specific conditions;

3) the application of qualitatively new materials for the fabrication of surfaces of heat-mass exchange, improvement and modular unification of HCT elements and accessories, which increases reliability of their operation, decreases capital expenditures and makes it possible to reduce service periods between replacing the units and the repair work;

4) the application of rational designs of burner and combustion systems and the optimization of the processes of combusting fuel with the reduction in heat losses and expenditure of electric power for own needs;

5) the use of effective designs of contact gas-liquid systems and installations for decreasing harmful emissions into the atmosphere and losses with the exhaust gases;

6) an increase in thermal efficiency of HCT work under constant mode at the nominal thermal load;

7) wide application of computers, in particular automated control system of technological process (ACS TP) for the overall automation of HCT work, which increases their reliability and efficiency of their performance [9].

Thus, it is necessary to analyze the existing solutions of the provision of working process in HCT. The choice of the most effective and promising solutions will make it possible not only to solve the described tasks and problems, but also to create a base for the promising development of systems for heat supply with the different degree of complexity and reliability.

An insignificant number of enterprises and establishments deal with the problems of combustion of gaseous fuels in the installations of energy generation for the industrial and municipal heat-power engineering in Ukraine. For example, the scientific school of the carbon technologies for the combustion is noted for its achievements [10]. But the use of carbon energy technologies in the sources of heat supply inside or near the cities and the densely populated regions is impossible due to ecological restrictions.

In addition, other establishments are known, for example, the scientific school of ecologically clean technologies for the combustion of gaseous fuels in the power units [11, 12], which continues scientific studies and development of new innovative solutions.

The scientific school [11, 12] devised effective solutions for the processes of mixtures formation and created new innovative technologies for the combustion of gaseous fuels (natural gas, gas methane, associated petroleum gas, coke and blast-furnace gas, and hydrogen) in the power plants. Such power plants include gas turbine engines in the structure of gas-pumping plants of main gas pipes, steam and hot-water boilers, district and regional boiler plants.

The majority of these schools are also connected with the contact units, namely: the scientific school of the combustion of fuels in the apparatuses for immersion combustion and the scientific school of contact heat-mass exchange [13]. The list of considered scientific schools that address problems of combustion is not final and may be expanded, but they are unrelated to the problems examined in present article.

Two different types of HCT are known and developed: contact water-heating module (CWM) and contact modular heating unit (CMHU) [14].

A schematic of the contact water-heating module CWM is depicted in Fig. 1 [15].

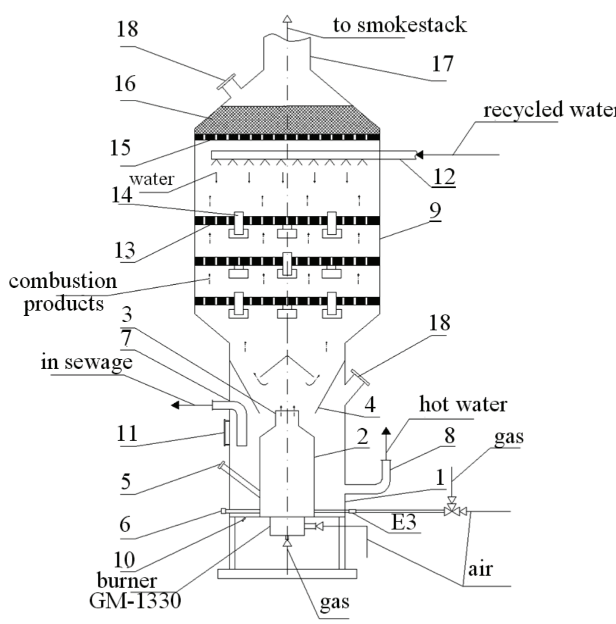

Fig. 1. Schematic of the module CWM: 1 — cylindrical housing; 2 — inner cylinder; 3 — branch pipe; 4 — cowling; 5 — eye; 6 — photo sensing device for the flame control; 7 — branch pipe of water lock; 8 — branch pipe of hot water outlet; 9 — adapter column; 10 — drainage branch pipe; 11 — water—level indicator; 12 — pipeline of recycled water; 13 — semi-through grid; 14 — overflow container; 15 — grid; 16 — a layer of steel chips; 17 — branch pipe of smokestack; 18 — break disk

The technical and economic indicators of the given contact module CWM characterize it as a sufficiently effective contact heat-generator, which was repeatedly tested in the running tests. At the same time, the peculiarities of operation of the given contact module CWM include difficulties, related to the provision of a stable operating mode under conditions of changing load. In addition, a layer of contact cap creates the non-uniform and uncontrollable distribution of gas flows over its section with the presence of non-uniform distribution of water by the volume of the cap, which negatively influences the apparatus efficiency. This requires additional efforts on adjustment and control of reliability of the operating regimes; it narrows operating ranges of effective loads and limits the power of apparatuses.

Contact water heater of the KVN type (Fig. 2) is also designed and installed at the industrial enterprises [16].

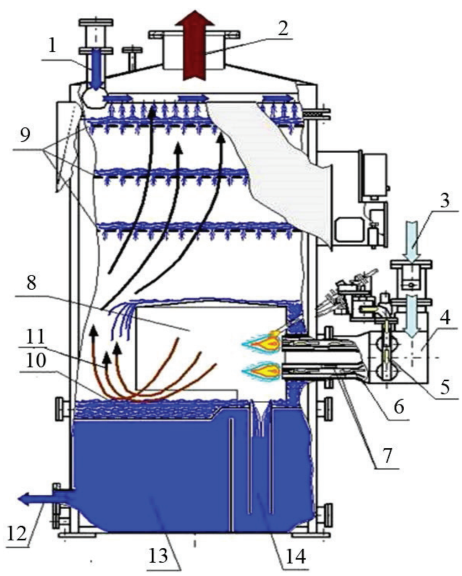

Fig. 2. Schematic design of contact water heater of the KVN type (Department of TPT): 1 – recycled network water; 2 – output of combustion products; 3 – air from the fan; 4 – burner; 5 – natural gas; 6 – gas–air mixture; 7 – secondary air; 8 – combustion chamber; 9 – block of grids; 10 – contact container; 11 – combustion products; 12 – heated network water; 13 – storage tank; 14 – water lock

A contact water heater of the KVN type is developed for the work in the autonomous thermal networks as a heat-generating device. However, plants of this type have limitations by the thermal power and can be used for low thermal loads. This is connected with the limitations by heat- and mass exchange in the zone of contact between gases and water and with the difficulties of providing uniform density and temperature of aerodynamic flows of the flue gases, which are released from the combustion chamber.

5. Results of studies of the existing HCT designs

An analysis of the existing HCT designs, which we conducted, demonstrated that the overall deficiencies were inherent in them. These shortcomings are connected to the impossibility of increasing specific thermal power, improving the level of automation and control and the absence of real possibilities for the transition to the more intensive thermal loads. The latter of the specified features excludes the possibility of using high-calorie gases, such as hydrogen, and it makes impossible for these design concepts of HCT to be used under thermally-intensive operating conditions.

The most promising for the solution of the set problems is the contact heat-generator of the CMHU type (Fig. 3) [17].

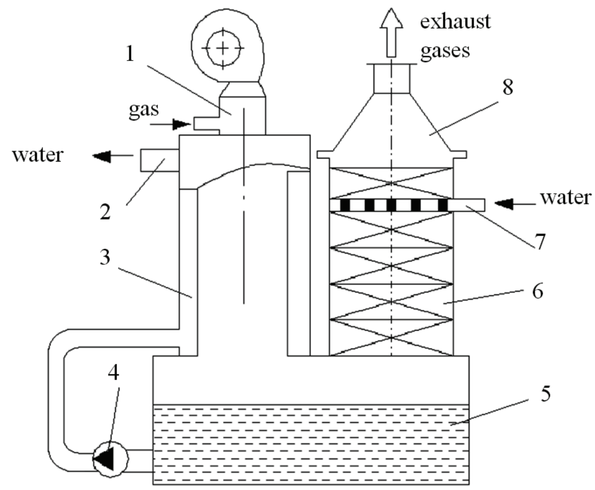

Fig. 3. Schematic of the first generation of heat-generator of the CMHU type: 1 – block gas burner of the micro-torch type GGMT-750 NTC «ECOTES»; 2 – branch pipe of the heated water; 3 – water-cooling furnace chamber; 4 – circulating pump; 5 – water tank; 6 – contact chamber; 7 – branch pipe of water supply to sprayer; 8 – exhaust duct

A characteristic feature of the given design is the new type of a burner system, previously described tubular technology of the combustion of gas [11, 12]. Based on this technology, it was possible to solve a set of problems on the qualitative combustion of fuel and efficient heat exchange between gases and the heated water. Subsequently, this technology gained new traction as the micro-torch technology of the combustion (MCT) of gaseous fuels and it was used for creating burner systems of the new generation of the GBMT type (gas burner of the micro-torch type) for the combustion chambers of GTU (gas turbine unit) and furnaces of energy boilers [18, 19].

For CMHU, there were developed three standard size types (Table 1) for different thermal power 0.5, 1.0 and 2.5 MW, which are intended for the systems of decentralized heating.

Table 1

Basic characteristics of heat generators, CMHU series

No.	Indicator name	CMHU-0.5	CMHU-1.0	CMHU-2.5
1	Thermal power, MW (Gcal/p.a.)	0.5 (0.43)	1.0 (0.86)	2.5 (2.15)
2	Performance efficiency, % (calculation by Q_{lw})	104 (at recycled water temperature 40 °C)		
3	Natural gas working pressure	Low (< 5kPa) or medium (10–30 kPa)		
4	Working temperature of water heating, °C	90		
5	Level of automation	Automatic starting and maintaining the assigned thermal mode at any temperatures of the environment		
6	Mass, kg	1600	2200	4000
7	Dimensions, (w*d*h)	1.6×0.9×2.0	2.0×1.0×2.0	3.0×1.6×2.5

As the traditional materials for the contact cap, the apparatuses of the first generation used different materials, such as ceramic balls, Raschig rings, metal chips, and grids. However, a regular cap, created with the perforated corrugated thin metallic sheets, is the most effective. That is why HCT of the CMHU type in the second generation (CMHU-II) (Fig. 4.) is principally different from the previously examined contact water heaters by the comprehensive method of heat transfer from hot gases to water. In these apparatuses, water heating takes place through direct complex contact of gases in the gas volume of the plant due to water spraying and contact of gases with the water film that flows down the perforated corrugated cap (nozzle of sulzer type).

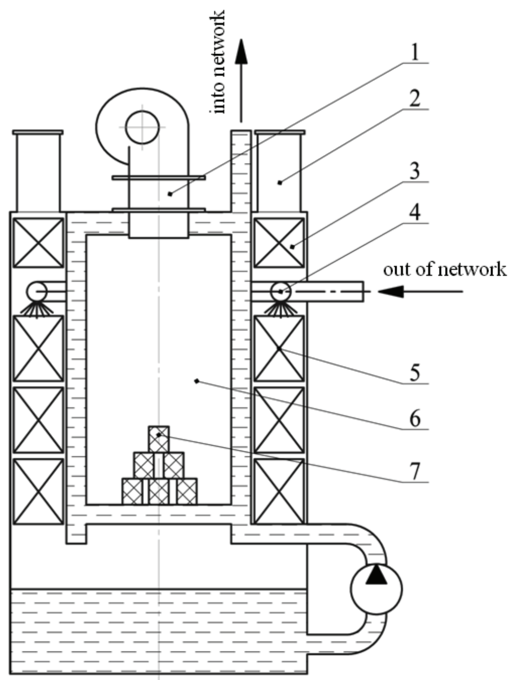

Fig. 4. Schematic of HCT of the CMHU -II type: 1— burner; 2 — smokestacks; 3 — drop catcher; 4 — water collector; 5 — contact cap; 6 — water—cooling furnace; 7 — secondary emitter

This method of heat mass exchange provides for high specific heat exchange characteristics in CMHU – 300 m^2 of heat exchange surface per 1 m^3 of the cap's volume, which makes it possible to cool flue gases to the temperatures considerably below «the dew point», to improve the process of condensation of water vapors from the combustion products at any thermal loads and to use this condensation heat of purposefully. In addition, the furnace chamber, surrounded by water «jacket» makes it possible to actively conduct additional heating of the water, supplied to consumer.

Thus, in CMHU-II, transfer of heat from torch and combustion products to water is achieved by the radiation method in the furnace chamber through the dividing wall of the water «jacket» (near 60 %) and due to the direct contact between recycled network water and hot combustion products (near 40 %).

An experience of operating CMHU at different objects (Table 1) demonstrated that the absence of heat exchange surfaces and their greasing makes it possible to completely abandon chemical water treatment, which considerably simplifies and reduces the cost of operation of the contact plants. Such a method for the organization of water-chemical regime implies the use of inhibitors.

A HCT design on the base of CMHU apparatuses is constantly improved with the use of new innovative solutions, directed toward the decrease of specific metal consumption, increase in specific calorific intensity of burning process for decreasing the overall sizes and weight of the plant with a simultaneous increase in the energy effectiveness and ecological cleanliness of heat generation. The latest innovations in the HCT design of the new generation CMHU-III are described and protected by new patent [20], Fig. 5.

Low concentration of harmful emissions in the combustion products and low specific fuel consumption by CMHU-III makes it possible to substantially improve ecological indicators in the work of the units of heat supply based on CMHU in comparison with boilers of traditional design.

CMHU-III is characterized by a broad range of the regulation of power without a decrease in efficiency; it makes it possible to automatically optimize the generated thermal power with the real indicators of heat consumption, which provides for the additional fuel savings.

One additional advantage of CMHU is the process of generation of additional water. Thus, during the combustion of 1 kg of natural gas, CMHU generated more than 2 kg of water through the oxidation of hydrogen with methane. The dew point for the products of combustion of natural gas at the excess air coefficient equal to 1,0 (stoichiometric combustion) composes 53 °C in the ratio. At the temperature of recycled network water below 50 °C, which enters the input of CMHU, effective condensation of water vapors from the combustion products occurs as well as the useful realization of gross heating value of fuel, which is transmitted to water in the plant. In this case, the difference between the lowest and gross combustion value reaches approximately 11 % and its beneficial use provides for the efficiency of this contact heat-generator of the HMCP type at the level of 104 %. Taking into account that hot-water boilers functioning in the structure of boiler units demonstrate efficiency in the best case at the level of 91–93 %, the essential positive difference is observable in a positive increase in the efficiency by 12–13 %, which is the main, but not the only one, advantage of CMHU over any boilers. Thus, for instance, Table 2 represents results of comparison of the fundamental characteristics of modern hot-water boiler of the VK-21 type and CMHU-1.0 of identical thermal power.

The posed problem of increasing the energy effectiveness and ecological cleanliness of heat generation with the aid of the contact heat-generators is solved due to the introduction of innovations in the design [20].

A change in the configuration of the heating surfaces of furnace chamber and contact cap of heat-generator makes it possible to substantially improve the required indicators on weight, overall dimensions and specific metal consumption of the plant (Fig. 5).

One additional advantage of this type of the contact heat-generator over other CTH is the fact that clean condensate of water vapors from the exhaust gases, when mixed up with the network water, regularly feeds the network water. Thus, the heat-generator CMHU-1,0 (capacity of 1 MW) that works in the heating system with the volume of 5 m^3 of water, is capable to add 5 t of condensate over three days (the calculation is conducted at the assumption that a half of water vapors from the products of combustion of natural gas is condensed). This situation makes it possible to come up with the encouraging prediction as for the quality of network water in connection with the contact with the fuel combustion products and potential possibility of formation of weak nitric acid.

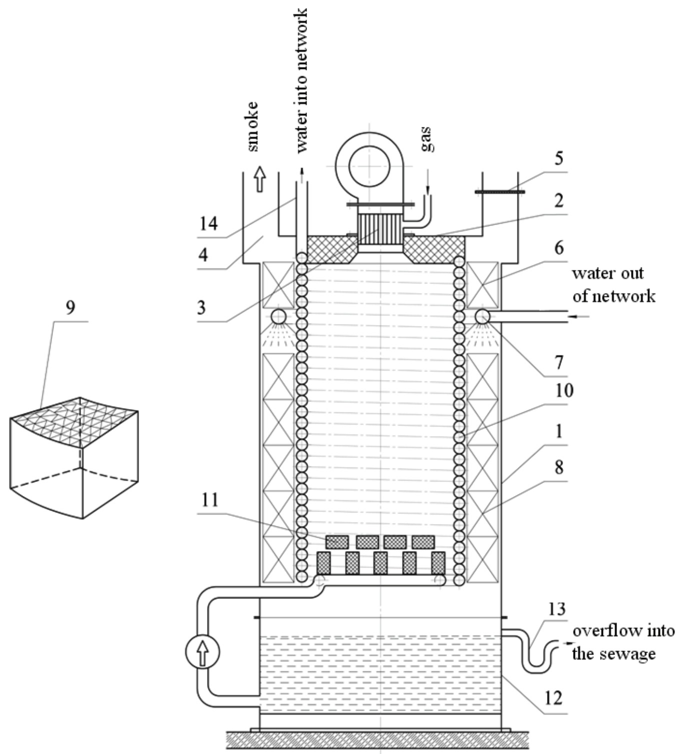

Fig. 5. General view of contact heat-generator of the second generation, realized on the base of CMHU: 1 — housing; 2 — cover; 3 — burner; 4 — smokestacks; 5 — break disk; 6 — drop catcher; 7 — water collector; 8 — contact cap; 9 — housing of contact cap; 10 — heating surfaces; 11 — secondary emitter; 12 — reservoir with the liquid; 13 — overflow pipe; 14 — discharge of network water

Table 2

Table of comparison with existing analogues

Indicators	Traditional water heating boiler VK-21	CMHU-1
Power	1 Gcal/h / 1.16 MW	1 Gcal/h/1.16 MW
Performance efficiency	92 %	104 %
Specific gas consumption	135.9	117.9
Resource of heating season	5000 hours	5000 hours
Payback period, years	the basic point of reference	1.25 or 15 months at the replacement of VK-21
Implementation: location, year, quantity	– Institute of Gas NANU, 2003, 1 pc. – Factory «Progress», Berdychev, Ukraine, 2004, 1pc. – OAO «Teplokommunenergo», Sumy, Ukraine, 2000, 3 pcs. – Gaspromupravlenye «Shebelinkagazdobycha», 2005, 5 pcs.	

The production of contact plants of this type (together with the receiver tank) will use on average 1.5 times less metal than in the production of boilers with the appropriate accessory equipment [19, 20]. And, accordingly, the total cost of building and equipping a boiler room with the contact water heaters is approximately 1,4 times less compared to the total cost of the boiler plant of the same capacity.

Basic technical features of the heat-generator CMHU:

– low metal consumption (less than 2 kg of weight per 1 kW of the heat produced);

– high efficiency (performance efficiency up to 104 % when calculated for the lowest combustion heat);

– simple design and operation;

– compactness, the ease of installation and maintenance;

– the total volume of automation.

6. Discussion of results of conducted studies

As a whole, the use of HCT for the purposes of heat supply in the district, industrial and individual heat supply is promising. This is related to the existence of a set of positive peculiarities and characteristics of the contact heat-generators, the main being the increase in efficiency by 10 % on the average and the decrease in gas consumption by minimum 13 %.

HCT have low thermal inertia, which characterizes them as apparatuses with the capacity of rapid start and rapid stop. Thus, for instance, CMHU, after starting, in 10–15 min after switching on the burners makes it possible to deliver to consumer water at temperature 95 °C, which is important in the regime of peak loads in the systems of hot water supply and heating of buildings or technological purposes. The water supply in HMCP after turning off the burners may be terminated in 12–15 min. This capability makes it possible to rapidly stop them at the sharp reduction in thermal load from consumer.

In addition, HCT do not require auxiliary thermal equipment, which is compulsory for boilers: feeding pumps, installations for chemical water treatment.

The use of the contact plants, which have low metal consumption (less than 2 kg of weight per 1 kW of the heat generated), will make it possible to decrease total expenditures for the construction of boiler rooms (together with the receiver tank) by 1.4 times on average in comparison to the total cost of a boiler facility of the same capacity.

The total cost of 1 Gcal of heat, obtained from the contact plants, with regard to operating costs and fuel consumption, electric power, staff, amortization and servicing of equipment is 4.3 times lower than for the variants of boiler facilities.

Thus, the conducted studies allowed us, based on the comprehensive analysis of the existing HCT designs, to reveal their constraints and deficiencies from the point of view of solving the problems that were set.

The uses of plants of the new generation of the hydrogen heat generator unit contact type (HHUC) will make it possible to switch over to the detailed study of the new energy paradigm (NEP) for heat supply to the local and district zones of the residential and industrial areas of cities. HHUC will allow using the possibilities of accumulating electrical energy by hydrogen generators in the periods of «drop» in electric consumption and of the accumulated hydrogen in the period of «peak» heat consumption. Realization of such NEP will allow the power units of atomic and thermal power stations to operate in a uniform schedule of energy production; it improves their reliability and effectiveness by 3...5 %, it creates conditions for the transition to the ecological indicators of energy generation.

7. Conclusions

1. We examined the possibility of effective use of HCT for solving the problem of improving effectiveness and reliability of heat supply under contemporary conditions of urbanization.

2. New promising constructive solutions for HCT are developed, which make it possible to attain the new level of heat generation. Their special features include compactness due to the lower metal consumption. Because of this design feature, the savings of means for the construction of boiler facility as a whole is ensured.

3. Conditions for further development of HCT and the creation of contact heat-generators of new generation are formed. They include the use of new types and mixtures of gaseous fuel in the contact heat-generator, including those based on hydrogen. This will make it possible to increase their competitiveness and attractiveness according to the ecological indicators of operation.

4. The outlined new designs with the use of HCT of the new generation and the use of hydrogen fuels must form the foundation for the new energy paradigm of heat supply and energy generation through the possibility of accumulating electrical energy by hydrogen generators in the periods of «drop» in electricity consumption and the accumulated hydrogen in the period of «peak» in heat consumption.

References

1. Sokolov, E. Teplofikaciya i teplovye seti [Text] / E. Sokolov. – Moscow: MEI, 2001. – 272 p.
2. Vakiloroaya, V. A review of different strategies for HVAC energy saving [Text] / V. Vakiloroaya, B. Somali, A. Fakhar, K. Pishghadam // Energy Conversion and Management. – 2014. – Vol. 77. – P. 738–754. doi: 10.1016/j.enconman.2013.10.023
3. Perez-Lombard, L. A review of HVAC systems requirements in building energy regulations [Text] / L. Perez-Lombard, J. Ortiz, J. F. Coronel, I. R. Maestre // Energy and Buildings. – 2011. – Vol. 43, Issue 2-3. – P. 255–268. doi: 10.1016/j.enbuild.2010.10.025
4. Haniff, M. F. Review of HVAC scheduling techniques for buildings towards energy-efficient and cost-effective operations [Text] / M. F. Haniff, H. Selamat, R. Yusof, S. Buyamin, F. S. Ismail // Renewable and Sustainable Energy Reviews. – 2013. – Vol. 27. – P. 94–103. doi: 10.1016/j.rser.2013.06.041
5. Kintner-Meyer, M. Optimal control of an HVAC systems using cold storage and building thermal capacitance [Text] / M. Kintner-Meyer, A. F. Emery // Energy and Buildings. – 1995. – Vol. 23, Issue 1. – P. 19–31. doi: 10.1016/0378-7788(95)00917-m
6. Ghahramani, A. A knowledge based approach for selecting energy-aware and comfort-driven HVAC temperature set points [Text] / A. Ghahramani, F. Jazizadeh, B. Becerik-Gerber // Energy and Buildings. – 2014. – Vol. 85. – P. 536–548. doi: 10.1016/j.enbuild.2014.09.055
7. Sosnin, Y. P. Vysokoeffektivnye gazovye kontaktnye vodonagrevateli [Text] / Y. P. Sosnin, E. N. Buharkin. – Moscow: Stroyizdat, 1988. – 376 p.
8. Gubarev, A. V. Povyshenie effektivnosti avtonomnyh sistem teplosnabzheniya pri ispolzovanii v nih teplogeneratorov kondensacionnogo tipa [Text] / A. V. Gubarev, M. I. Kuleshov, A. A. Pogonin // Vestnik NTU «KhPI»: energetichni ta teplotehnichni procesi j ustatkuvannya. – 2012. – Vol. 8. – P. 117–125.
9. Vakiloroaya, V. Energy-efficient HVAC systems: Simulation–empirical modeling and gradient optimization [Text] / V. Vakiloroaya, Q. P. Ha, B. Samali // Automation in Construction. – 2013. – Vol. 31. – P. 176–185. doi: 10.1016/j.autcon.2012.12.006
10. Kesova, L. A. V innovaciya v ugolnyh tehnologiyah dlya pylevidnogo szhiganiya na tes [Text] / L. A. Kesova, V. V. Litovkin // Energetika ta elektrifikaciya. – 2010. – Vol. 10. – P. 3–8.
11. Hristich, V. A. Gazoturbinnye ustanovki: istoriya i perspektivy [Text] / V. A. Hristich, G. B. Varlamov. – Kyiv: Politehnika, 2006. – 435 p.
12. Varlamov, G. B. Ispolzovanie metodov tehnologicheskogo predvideniya dlya analiza resursnyh i ekologicheskih problem energopotrebleniya [Text] / G. B. Varlamov, G. B. Lyubchik. – Innovacionnoe razvitie toplivno-energeticheskogo kompleksa: problemy i vozmozhnosti. Kyiv: Znaniya Ukrainy, 2004. – P. 55–63.
13. Dikij, M. Mathematical model of water droplets evaporation in air stream [Text] / M. Dikij, A. Solomaha, V. Petrenko // Eastern-European Journal of Enterprise Technologies. – 2013. – Vol. 3, Issue 10 (63). – P. 17–20. – Available at: http://journals.uran.ua/eejet/article/view/14856/12658
14. Pat. 46806 Ukrayina: MPK F 24 H 1/10. Kontaktnyy vodonahrival'nyy modul' [Text] / Sezonenko B. D., Karp I. M., Nikitin V. Yu., Soroka V. O., Komyak O. O., Skotnikova T. B., Sezonenko O. B., Aleksyeyenko V. V. – zayavnyk i vlasnyk patentu Instytut Hazu NANU. – 98063156; declareted: 17.06.98; published: 17.06.02, Bul. 6. – 4 p.
15. Pat. 46101, Ukrayina, MPK F 24 H 1/10. Kontaktno-poverkhnevyy vodonahrivach [Text] / Sezonenko B. D., Nikitin V. Yu., Soroka V. O., Komyak O. O., Skotnikova T. B., Sezonenko O. B., Aleksyeyenko V. V. – zayavnyk i vlasnyk patentu Instytut Hazu NANU. – 98105244; declareted: 05.10.98; published: 15.05.02, Byul. 5. – 3 p.
16. Pat. 59749 Ukrayina: MPK F24H 1/10. Kontaktnyy vodonahrivach [Text] / Salo V. P., Salo A. M., Salo A. V. – zayavnyk i vlasnyk Salo V. P., Salo A. M., Salo A. V. – 20021210047; declareted: 13.11.02; published: 15.09.03, Bul. 9. – 4 p.
17. Pat. 77099 Ukrayina: MPK F24H 1/10. Sposib kontaktnoho nahrivu vody [Text] / Marchenko S. H., P'yatnychko O. I., Makarenko V. O. – zayavnyk i vlasnyk patentu Instytut Hazu NANU. – 201209409; declareted: 02.08.12, published: 25.01.13, Bul. 2. – 4 p.
18. Pat. 019766 EAPO: MPK F23D 14/02. Nizkoehmissionnaya gazovaya gorelka trubchatogo tipa s napravlennym vozdushnym potokom [Text] / Varlamov G. B., Rodinkov S. F., Prijmak E. A., Olinevich N. V., Varlamov D .G. – zayavnik i vlasnik patentu Rodinkov S. F., Varlamov G. B. – 201101134; declareted: 29.08.11; published: 29.03.13, Bul. 6. – 10 p.
19. Varlamov, G. B. Aerodynamic and heat transfer characteristics of the combustion chambers of gtu with burner system of the tube type [Text] / G. B. Varlamov, A. A. Halatov // Eastern-European Journal of Enterprise Technologies. – 2013. – Vol. 3, Issue 12 (63). – P. 79–82. – Available at: http://journals.uran.ua/eejet/article/view/14888/12692
20. Pat. 7110596 Ukrayina: MPK F24H 1/10, F24H 8/00. Kontaktnyy vodonahrivach [Text] / Marchenko S. H., Varlamov H. B., Ocheretyanko M. D., Osipenko Ye. O., Makarenko V. O. – zayavnyk i vlasnyk patentu Instytut Hazu NANU. – 201605608; declareted: 24.05.16, published: 10.10.16, Bul. 19. – 4 p.