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AN ANTHOLOGY OF THE DISTINGUISHED ACHIEVEMENTS IN SCIENCE AND TECHNIQUE. PART 43: TRADITIONAL POWER ENGINEERING. THERMAL POWER PLANTS: STATE AND PROSPECTS OF THEIR DEVELOPMENT

***Purpose.** Preparation of brief scientific and technical review with an analytical analysis about the state, achievements, problems and prospects of development of world thermal power engineering. **Methodology.** Known scientific methods of collection, analysis and analytical treatment of the opened scientific and technical information, present in scientific monographs, journals and internet reports, world level in area of thermal power engineering. **Results.** A brief analytical scientific and technical review is resulted about the present state, achievements, problem tasks and prospects of development of thermal power engineering in the industrially developed countries of the world. Considerable progress is marked in development and creation of technical base of modern thermal power engineering including such thermal power devices (TPD) as steam generators, steam turbines and turbogenerators. Basic TPDs are described, charts of design and types of the modern thermal power plants (TPP), producing in the world about 70 % annual production electric power are presented. From positions of approach of the systems advantages and lacks of TPPs are described before other types of electric stations, generating heat and electric energy in industrial scales. Basic technical descriptions of largest TPPs of Ukraine are resulted, TPDs of powerful power units of which behave to the morally out-of-date past generation and characterized a large physical wear. Some topical problem tasks and possible ways of their decision are indicated in area of thermal power engineering of Ukraine. In a review an accent is done on the necessity of development and acceptance of strategic plan of development of thermal power engineering of Ukraine on the nearest 10 years. A regard is paid to power engineering experts acceleration of rates of introduction in domestic practice of achievements alternative and ecologically clean power engineering specialists − especially wind energy and sun energy. **Originality.** Systematization of the scientific and technical materials touching functioning of such important sector of world economy as thermal power engineering known from the sources opened in outer informative space is executed. It is shown that for normal development and determination of the nearest prospects for domestic thermal energy the native revision of power politics of Ukraine is needed. **Practical value.** Popularization and deepening for students, engineers and technical specialists and research workers of front-rank scientific and technical knowledge in area of modern thermal energy, extending their scientific range of interests and further development of scientific and technical progress in society.* References 21, tables 2, figures 7.

Key words: **thermal power engineering, thermal power plants, steam generators, turbogenerators, characteristics of thermal power plants, problems and prospects of development of thermal power engineering.**

Приведен краткий научно-аналитический обзор о современном техническом состоянии и ближайших перспективах развития мировой теплоэнергетики. Рассмотрены основные теплоэнергоустройства, схемы построения и виды тепловых электрических станций (ТЭС). Указаны преимущества и недостатки ТЭС перед другими видами электрических станций, генерирующих тепло и электричество. Приведены основные технические характеристики крупнейших ТЭС Украины. Обозначены существующие проблемные задачи и возможные пути их решения в области теплоэнергетики Украины. Библ. 21, табл. 2, рис. 7.

Ключевые слова: **теплоэнергетика, тепловые электрические станции, парогенераторы, турбогенераторы, характеристики тепловых электростанций, проблемы и перспективы развития теплоэнергетики.**

Introduction. The development of human civilization on planet Earth was impossible without the use of energy by people. Scientists who studied different types of energy (mechanical, thermal, chemical, electrical energy, etc.), in the 18^{th} century, discovered one of the fundamental laws of nature - the law of conservation and transformation of power engineering [1]. In the society, that branch of the national economy, which covers energy resources, production, transformation, transmission, distribution and consumption of various forms of energy, has received the name of energy [2]. In power engineering, five main types of power plants are used: generating, converting, accumulating, transporting and consuming energy. With a fairly large variety in the nature of primary energy resources, at present the main forms of energy used in modern society are *heat* and *electricity*. As is known, these two types of energy, in turn, are used by people also in various forms [2, 3]: thermal energy in the form of water vapor, heated gases, heated water and other liquid heat carriers heated to different temperature levels, and electric energy in the form of alternating, direct and pulsed currents in wires, cables and other conducting structures at different values of electric voltage. The primary sources of thermal energy for earthlings have been and still remain minerals in the form of organic (coal, natural gas, oil, oil shale, etc.) and nuclear (uranium) fuel. The analysis of the interrelationships between energy sources, thermal energy and electricity belongs to the sphere of interests of heat power engineering [2, 3]. Therefore, it can be said that heat power engineering is a branch of the energy industry that is engaged in converting heat into such types of energy as mechanical and electrical. The subject of studying thermal power engineering are thermodynamic cycles, schemes for constructing power plants and their improvement, problems of fuel combustion and heat transfer, thermal properties of working bodies and coolants [2, 3]. The technical basis for modern heat power engineering is thermal power devices (TPDs), used primarily at thermal power plants (TPPs) [4]. The TPDs include boilers and steam turbines that are paired with turbogenerators. Generation of electricity at TPPs is carried out in synchronous turbogenerators. Since TPPs are one of the main types of power plants in the world, which generate at least half of the total energy consumed by mankind, an analysis of the current state and prospects for the development of TPPs in the developed countries of the world is an urgent task.

The goal of the paper is the preparation of a brief scientific and technical review of the extensive material available in information sources for the state and prospects of development in the world of thermal power plants.

1. General information about thermal power plants, their composition and construction schemes. TPP is the power plant that generates electricity by converting the chemical energy of the organic fuel first into the thermal energy of water vapor (gas) and then into the mechanical energy of the rotation of the shaft of the steam (gas) turbine and rotor of the turbogenerator, and then converting the latter this mechanical energy into electric energy of its stator [4]. Fig. 1 is a schematic diagram of the construction of a TPP containing such basic devices as [4] boiler-steam generator, steam turbine, synchronous generator, waste steam condenser and circulating pump that provides the closed-loop supply of condensed steam of cooled water back to the boiler-steam generator. The synchronous generator according to Fig. 1 operates only in conjunction with a steam turbine. TPP uses the chemical energy released by burning fuel in the boiler (coal, natural gas, fuel oil, etc.), to convert water into superheated steam (with a temperature of about 540 °C) of high pressure (about 240 atm) [4]. This steam rotates the steam turbine blades and simultaneously the magnetic system located on the rotor shaft of the synchronous generator. The rotating magnetic field of the rotor of this generator due to the phenomenon of electromagnetic induction causes the appearance of electromotive force in the windings of its stator [4, 5].

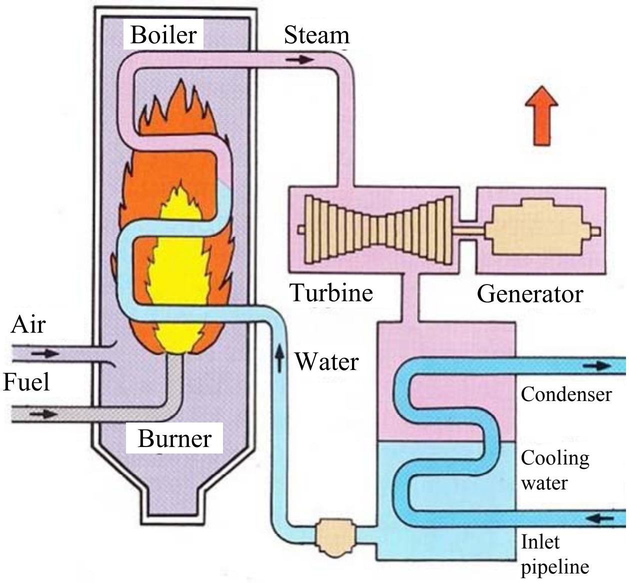

Fig. 1. Schematic diagram of the construction of TPP [4]

Modern TPPs with electrical power of up to several thousand Megawatts convert to electricity up to 50 % of the heat released during the combustion of fuel in their boilers-steam generators [4]. It can be seen that at TPP about 50 % of the generated heat energy is discharged through the boiler and condenser (cooling tower) into the environment. When using waste heat of TPPs for heating residential houses and industrial premises, the energy efficiency can be brought to 80 % [4, 5].

TPPs are subdivided into condensing power plants (CPPs) and heating electric centrals (HECs). CPP produces only electricity [5], and HEC - only heat for heating houses and buildings of enterprises [4]. Earlier in the domestic terminology, CPP was traditionally called as state district power plants (SDPP). Depending on the duration of the TPP operation during the year to cover the graphs of power loads, characterized by the number of hours of use of the installed power T, the power stations are classified into basic (T>6000 h/year), semi-peak (T≈3500 h/year) and peak (T<2000 h/year) [4]. The base stations are those that carry the maximum possible constant load during most of the year. In the world power industry, nuclear power plants (NPPs) and CPPs are used as the basic ones. At the same time, peak loads are covered by hydroelectric power plants (HPP), pumped storage plants (PSP) and gas turbine units with high maneuverability and mobility. Peak power plants are switched on at that time of the day when it is required to cover the peak (increased) part of the daily electric load schedule. At present, a gas turbine scheme has become widespread in a number of TPPs, in which the compression mixture of hot gases obtained by burning a gaseous or liquid fuel rotates the impeller of a turbine of a gas turbine plant whose steel axis is connected to the rotor shaft of the generator [4-6]. Such TPPs are called gas turbine power plants (GTPPs) [6]. At the GTPP, after the gas turbine, the exhaust gases remain sufficiently hot. For the useful use of the thermal energy of these gases, they are directed to the recovery boiler (Fig. 2) with further use in combined-cycle plants (engines) and heat supply schemes [7]. The electric power of the GTPP can be from tens of Kilowatts to hundreds of Megawatts [6]. A significant contribution to the creation and practical use of domestic gas turbines was made by the first Head of Department of Turbine Construction of the Kharkiv Polytechnic Institute (KhPI) Professor V.M. Makovsky (1870-1941).

Fig. 2. General view of heat recovery boiler of the GTPP [7]

1.1. Water tube boilers-steam generators. In the water-tube boiler of TPP, heat exchange of hot products of fuel burnt in its furnace with boiling steel pipes filled with water takes place [7]. There are direct-flow and drum-type water tube boilers. Fig. 3 shows the construction of a straight-flow water tube boiler, which is the main component of any steam generator [8]. A straight-flow water tube boiler is, as a rule, a pipe coil with water, placed in a furnace where the fuel burns. Heated water, passing through the evaporative tubes of this coil, gradually turns into steam. After the evaporative tubes, the steam-water mixture enters the boiler superheater. Further, the superheated steam along the steam line is directed to the impellers of the steam turbine.

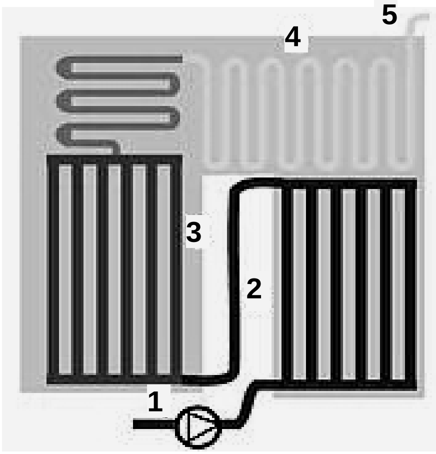

Fig. 3. The scheme of constructing a straight-flow water tube boiler used in the steam generator of TPP
(1 - a feed water pump, 2 - an economizer, 3 - evaporation tubes, 4 - a superheater, 5 - a turbine steam line) [8]

1.2. Steam turbines. At TPPs, a steam turbine, in fact, is the thermal engine in which the energy of superheated steam is transformed into mechanical (kinetic) energy of the circular rotation of its impellers with blades and, accordingly, of the axial steel shaft (Fig. 4). For better energy efficiency, this water vapor at the TPP should be dry and not contain microdroplets of water. Curvilinear high-strength turbine blades fixed around the circumference of its rotor are involved in a circular rotation at speed of about 3000 rpm (for bipolar generators) or 1500 rpm (for four-pole generators) by directing nozzles on them with steam from the steam generator [9].

Steam turbines, depending on the direction in which they drive a powerful vapor stream, are distinguished by axial flow (the steam flow in them moves along the longitudinal axis of the turbine, and its working blades are perpendicular to the latter one) and radial (the direction of steam flow in them is perpendicular to the longitudinal axis of the turbine, and its working blades are parallel to the latter one) [10]. Powerful steam turbines can contain high, medium and low pressure steam stages. In this case, the turbine is called a multi-body. This type of steam turbine is mainly used in powerful steam turbine installations. Depending on the purpose, steam turbines, similar to the above classification of TPPs, are divided into basic ones (carry a constant main electric load of consumption), peak (operate during short time to cover the peaks of the electric load of consumption) and auxiliary ones (provide the internal demand of TPPs for electricity).

Fig. 4. General view of the rotor and casing of a modern powerful steam turbine manufactured by Siemens (Germany) in the process of its installation on the TPP site [9]

Depending on the nature of the ongoing thermal process, steam turbines can be divided into three large groups [9]: condensing (without controlled steam extraction with the maximum conversion of its heat into mechanical work and the further release (exhaust) of the exhaust steam into the condenser as shown in Fig. 1); heating (with adjustable steam extraction); special purpose (operating on the waste heat of metallurgical and chemical enterprises). Steam turbines for TPPs have a park life estimated at about 270,000 hours with an overhaul period of 4-5 years [9, 10]. Steam turbines and generators are matched on a power scale. Each steam turbine corresponds to a certain type of electric generator. For block thermal condensation power plants, the turbine power corresponds to the power of the units, and the number of units is determined by the specified power of the TPP. On modern TPP units, ПТ type condensing turbines of power of 160, 200, 220, 300, 500, 800, 1000 and 1200 MW with intermediate steam superheating are used. An important contribution to the development, creation and enhancement of energy efficiency of domestic high-power steam turbines for TPPs and nuclear power plants produced by the Kharkiv-based enterprise Turboatom during the industrial boom of the country was made by the Head of Department of Turbine Construction of the KhPI (1941-1976) Professor Ya.I. Schnee (1902-1977).

1.3. Turbogenerators. These power units for TPPs are synchronous generators, working in conjunction with steam (gas) turbines. The main function of the turbogenerator (Fig. 5) is to convert the mechanical energy of rotation of the steam (gas) turbine into electrical energy. For this purpose, the rotor shaft of synchronous generator in the working zone must create a rotating magnetic field in the air gap between the rotor and the stator of the electric generator. The initial magnetic field of the stationary rotor of the generator is either due to permanent magnets mounted on it (the rotor) or due to the flow of direct current in the copper turns of the excitation winding of the said rotor [11]. The electric potential arising in the three-phase windings of the stator of the generator under consideration and the voltage induced in them will be the greater, the stronger the magnetic field of its rotor, determined by the DC current flowing in its windings. Note that in synchronous turbogenerators with external excitation, the voltage and current in the rotor windings are usually created by a self-excitation thyristor system or a special excitatory generator placed on the shaft of a turbogenerator [10, 11]. The massive steel rotor of the turbogenerator is mounted on two sliding bearings.

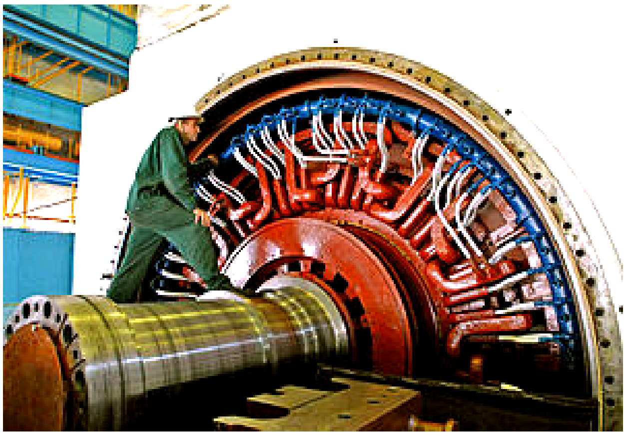
Fig. 5. General view of the fragment of a powerful synchronous turbogenerator of the Balakovo nuclear power plant (RF) after it has been stopped in the course of routine maintenance and repair (in the foreground the steel rotor shaft is seen, and in the background - the elements of its stator) [11]

For the needs of TPPs, the domestic industry produces 2-pole (with speed of rotation v_{p2} 3000 rpm) and 4-pole (with speed of rotation v_{p4} 1500 rpm) synchronous electric generators. Multi-pole turbogenerators can also be manufactured depending on the conditions of their operation. Depending on the cooling methods, the windings of the turbogenerator are distinguished [10]: generators with liquid cooling through the «jacket» of the stator of the turbogenerator; generators with direct liquid cooling of their windings; generators with air cooling of their windings; generators with hydrogen cooling of windings, often used at nuclear power plants. In the course of many years of operation of the TPP it was found that the more power of the turbogenerator, the more economical it is [9, 10]. This leads to a reduction in the cost of 1 kW of installed capacity of TPP. In this connection, turbine generators of high power are installed at the CPP. The rotor speed of the turbogenerator is proportional to the frequency of the current generated by it ($v_{p2} \approx 50$ rpm $\times$ 60 s $\approx$ 3000 rpm), numerically equal to (50±0.1) Hz in accordance with GOST 13109-97. A sharp drop in the electric frequency of the voltage (current) produced by the turbogenerator leads to an emergency stop of the power unit of the TPP and its shutdown from the industrial network [11].

We point out that currently about 86 % of the world's electricity production is produced by turbogenerators driven by steam turbines [10, 11]. These data testify to the important role of the heat and electric power equipment in question when generating electricity in various countries on an industrial scale. Electric power generators of various power at modern TPPs are used [4, 11]: turbogenerators of T series (air-cooled) with power of 2.5, 4, 6, 12 and 20 MW; turbogenerators of ТВФ series (with hydrogen cooling) with power of 63, 110 and 120 MW; turbogenerators of ТВВ series (with hydrogen-water cooling) with power of 160, 200, 220, 300, 500, 800, 1000 and 1200 MW. We point out that in a ТВВ series of turbogenerators with efficiency of up to 98.8 %, the stator voltage is up to 24 kV, the stator current is up to 27 kA, and the excitation current is up to 7 kA [11].

1.4. Advantages and disadvantages of TPPs. The main advantages of TPP in comparison with other types of power plants are the following [12]:

- organic fuel used at TPP is a relatively cheap raw material;
- for their creation and commissioning TPPs require less capital investment in comparison with such types of power plants as NPPs and HPPs;
- TPPs can be built much faster than NPPs and HPPs and virtually anywhere in the country, regardless of where the fuel source is located;
- for the construction and operation of TPP, the areas of alienation and their withdrawal from the economic turnover of the earth are much less than necessary for nuclear power plants and hydroelectric power plants (in this connection, TPPs occupy less production space and territory than NPPs and HPPs);
- the ability of TPPs to generate electricity without significant seasonal power fluctuations;
- unit cost per unit of installed capacity of TPPs is lower compared to nuclear power plants, and the cost of generating electricity is less than that of such power plants as diesel power plants.

The disadvantages of TPPs in comparison with other types of power plants include the following [12]:

- TPPs are not environmentally friendly sources of electricity and are characterized by high pollution of the environment due to smoke emissions (smoke) and the appearance of ash during their operation;
- higher operating costs compared to similar costs for nuclear power plants and hydroelectric power plants;
- characterized by relatively low efficiency (not more than 40-50 %) of the majority of existing TPPs;
- variability of TPP operation modes reduces their energy efficiency, increases fuel consumption and leads to increased wear of their power units.

1.5. Ecological aspects of TPPs. Expert assessments point to the fact that TPPs of the whole world are thrown into the earth's atmosphere every year [13]: about 250 million tons of ash, more than 60 million tons of sulfur dioxide, a large number of nitrogen oxides and carbon dioxide. These emissions lead to a greenhouse effect that causes global and long-term climate change on our planet. It is established that the excess radiation background around TPPs operating on coal is on average 100 times higher in the world than near nuclear power plants of the same power [13]. This is due to the fact that coal as a trace element always contains uranium, thorium and a radioactive isotope of carbon. Despite these negative features, well-developed technologies of construction, equipment and operation of TPPs, as well as a lower cost of their construction, lead to the fact that the TPPs currently account for the bulk of the world's electricity production.

1.6. The largest thermal power plants in Ukraine. According to the State Enterprise «National Energy Company «Ukrenergo», as of January 1, 2016, the total installed power of Ukraine's power plants was 54 826.1 MW, of which 34 266 MW (or 62.5 %) accounted for thermal power plants [14]. Electrothermal generation of Ukraine is now provided to six main companies. Five of them are private: DTEK Vostokenergo Ltd, PJSC DTEK Dneproenergo, PJSC DTEK Zapadenergo, PJSC Kyivenergo and Donbassenergo. Privatization of Centrenergo was postponed indefinitely due to a fire at the largest thermal power plant in Ukraine – Uglegorskaya TPP (Fig. 6) in March 2013. We point out that DTEK Vostokenergo Ltd, PJSC DTEK Dneproenergo, PJSC Kyivenergo and DTEK Zapadenergo are part of DTEK, which is the largest energy company of Ukraine, which is part of the financial and industrial group System Capital Management (SCM) [14]. Table 1 on the basis of [14] provides basic information about the largest TPPs in Ukraine.

Fig. 6. General view of the Uglegorskaya TPP with installed power of 3,600 MW with a nearby lake-cooler [4]

At present, the most widespread in the world are thermal power plants of the block type of building their power units. At the same time, each block of such a TPP in one operating mode specified by the operational personnel operates independently of other power plant units. Fig. 7 shows the general view of the control panel of the modern TPP, which serves a 300 MW unit [4, 15].

Table 1

Data on the largest TPPs in Ukraine [14]

No.	TPP name	Power, MW	Fuel grade	Region
1	Uglegorskaya (before the fire)	3600	Coal ГСШ	Donetsk region
2	Zaporozhskaya	2825	Coal ГСШ	Zaporozh. region
3	Burshtynskaya	2334	Coal Г	I.-Frank. region
4	Krivorozhskaya	2328	Coal Т	Dnipro region
5	Zmievskaya	2200	Coal АШ, Т	Kharkiv region
6	Starobeshevskaya	2010	Coal АШ, Т	Donetsk region
7	Trypilskaya	1800	Coal АШ	Kiev region
8	Ladyzhynskaya	1800	Coal ГСШ	Vinnitsa region
9	Kurakhovskaya	1527	Coal Г	Donetsk region
10	Zuevskaya	1270	Coal Г	Donetsk region
11	Pridneprovskaya	1195	Coal АШ	Dnipro region
12	Slavianskaya	800	Coal АШ, Т	Donetsk region
13	Dobrotvorskaya	510	Coal Г	Lviv region
14	Myronovskaya	275	Coal Г	Donetsk. region

Fig. 7. General view of the control panel of a modern high-power TPP [15]

1.7. TPPs generation in the industrialized countries of the world. A huge amount of electricity is produced and consumed all over the world. So, in 1990 its annual volume was about 11900 billion kWh, and in 2000 - 15100 billion kWh [13]. This electricity has been generated and generated by three traditional types of power plants [13]: TPP, NPP and HPP. It should be noted that in modern conditions the annual volume of electricity generation by non-traditional energy (for example, wind, hydrogen, geothermal and solar power plants) does not exceed 10 % in the world annual electricity production balance [16]. At the same time, in some countries (for example, Denmark) as of 2014, only such a type of alternative energy as wind energy provided electricity generation up to 40 % in their total annual electricity production balance [16]. As of 2010, about 70 % of the world's annual electricity production was generated by TPPs [13]. For example, in the Russian Federation (RF) about 67 % of electricity is generated at TPPs located in places of organic fuel production (in the central and eastern regions of the country) [13]. In the western and southern regions of the RF, nuclear power plants operating on thermal neutrons are given advantages in the production of electricity. In Table 2, based on the data from [13], the main comparative quantitative indicators of electricity production in the world for 1990 and 2000 are given.

Table 2

The main indicators of electricity generation in the world of thermal power plants, nuclear power plants and hydroelectric power plants [13]

Indicator	Year	
	1990	2000
1. Share of total electricity production by types of power plants in the world, %		
- NPP	17	16
- Natural gas TPP	14	19
- Black oil TPP	12	10
- Coal TPP	38	37
HPP and power plants on renewable energy sources	19	18
2. Installed power of power plants in the world, GW	2830	3580
- NPP	340	394
- Natural gas TPP	481	716
- Black oil TPP	424	501
- Coal TPP	934	1146
HPP and power plants on renewable energy sources	651	823
3. Electricity generation by regions of the world, %		
- Western Europe	20	19
- Eastern Europe	18	13
- Americas	36	34
- Asia and Australia	21	28
- Middle East and Africa	5	6

2. Problems of thermal power engineering and prospects of development of thermal power plants in Ukraine. The basis of modern TPPs and nuclear power plants, as well as HECs is a TPD. In this regard, the technical level of the development of the TPD determines the level of development of technological progress in a particular country in the world as a whole. By the mid-1960s, TPPs using coal in the furnaces of steam generators in a pulverized state had almost reached the limit of perfection in the technology of flare (coal-dust) burning of coal. This made it possible to achieve at these TPPs the conversion factor for the thermal energy of the fuel and steam into electricity at the output of their turbogenerators (efficiency factor) to 40 %. The general crisis in a number of countries (including Ukraine) has led to the fact that they have to spend more money on generating 1 kWh of electricity than in the advanced countries of the world. Thus, in the RF these indicators have increased to 1.5 times [17]. In this regard, in the RF specific consumption of conventional fuel for the generation of 1 kWh of electricity at TPPs is now required to be reduced from 360 to 280 grams [18]. In addition, the greater part of the existing TPDs at TPPs both in the Russian Federation and in Ukraine, built by the end of the 1970s, is worn out and needs to be reconstructed and replaced. Boiler units, steam turbines and turbogenerators of TPPs in Ukraine, which have a design life of 100 thousand hours of operation, have practically exhausted these indicators of their resource [19]. We should be depressed additionally by the fact that the current situation with high depreciation of productive assets concerns all other branches of our economy. For comparison, we note that in the RF approximately 90 % of all operating steam turbines at TPPs have an «age» of at least 20 years [18]. Therefore, one of the most difficult problems (*task No. 1*) for domestic heat power engineering is the decommissioning of the old power equipment from TPPs and replacing it with new and more highly efficient one. Current decisions related to the motivated reasons for the extension of the operational life of the existing TPDs at TPPs (these tasks concern the nuclear power plants, too) do not solve the problem of physical and moral deterioration of the TPD, but only postpone its decision for a certain later time. For this, it is obviously necessary to have a strategic plan for the development of Ukraine's heat and power industry for the next 10 years at least. To my great regret, for the time being, there is no such plan in the energy sector of Ukraine under consideration, in my opinion. Therefore, we are lagging behind the development of new highly efficient TPDs for TPPs. One of the examples of such TPDs is steam and gas installations of power units of TPPs and HECs with efficiency of up to 50 %, actively used in the world practice [19, 20]. Another topical problem (*task No. 2*) in our power engineering is the replacement at the TPPs of the old technology of burning fine-grained coal with a more advanced technology for burning solid fuel in circulating fluidized layer (CFL) at atmospheric pressure [19]. In Western Europe, such advanced technology at TPPs has already been successfully applied in the last 15 years. The use of this technology makes it possible to increase the economy and ecological purity of modern high-power TPPs. In the opinion of authoritative heat-and-power engineers, it is the technology based on the CFL that is the most promising in the reconstruction and construction of new power units of TPPs in Ukraine [19]. By the way, it should be noted that in Ukraine for the past 40 years, due to lack of private investment and due government funding for TPPs, no new power units have been commissioned. During the years of Ukraine's independence, only one new boiler was built with CFL at the Starobeshevskaya TPP, and only one pulverized coal boiler was reconstructed at Zmievskaya TPP (SDPP) using modern high-efficiency technology [19]. So, one can justifiably say now that even the nearest prospects for the development of TPPs in Ukraine are tightened with «fog» of uncertainty and are covered by a «mountain» of internal problems.

The next problematic task (*task No. 3*) in the heat and power industry of Ukraine is related to the effective solution of the actual environmental aspects arising during the operation of the TPP. Modern power industry including heat and power engineering is causing tangible damage to the environment worsening the living conditions of people on our planet. All technologies for generating electricity at TPPs are associated with a large number of industrial wastes emitted into their environment. Today, the problem of the impact of power industry and especially heat and power engineering on nature becomes particularly acute, as the pollution of the environment (land, air atmosphere and hydrosphere) is increasing every year [21]. Combustion products of organic fuel, getting into the atmosphere, cause the precipitation of acid rains and intensify the greenhouse effect, which has an extremely unfavorable effect on the overall ecological situation. An urgent task for coal-fired TPPs is ash dumps requiring large areas. In addition, they are the centers of accumulation of heavy metals harmful to humans and have increased radioactivity [21]. In this connection, the issues of improving heat and power technologies at TPPs and reducing their negative impact on the environment around the world have been and should continue to be given great attention.

Conclusions.

1. The brief scientific and technical review of the development of the global thermal power industry shows that TPPs in the industrialized countries of the world continue to maintain their high positions in industrial power generation. Despite the fact that since the mid-1970s, in the former USSR and in several other countries of the world, the priority in the development of power engineering has been given to the construction of the nuclear power plants with its subsequent rapid «freezing» and, despite the termination since this period of time, real investments in their heat and power engineering and power machinery, TPDs developed and created in those years, having chosen their calculated resource, continue to successfully «work» (for example, in the RF and Ukraine) on many dozens of powerful units of TPPs of the old generation. The countries of Western Europe, in contrast to the above-mentioned countries of Eastern Europe, significantly more successfully modernize their TPDs, increase their energy efficiency and the generation of electricity at the powerful power units of the TPPs of new generation.

2. The normal development of domestic power engineering requires a radical revision of the country's energy policy aimed at ensuring energy saving in all sectors of the economy, training highly qualified electric power professions, supporting relevant research institutes and design bureaus, and developing and creating new heat-resistant materials and technologies for manufacturing and introduction of high-efficiency TPDs on powerful units of the TPPs of new generation TPP. With this new approach, the Ukrainian thermal power industry has a real prospect for its further progress and active participation in the country's energy market.

3. Unconventional (alternative) energy with inexhaustible and renewable energy sources, especially wind power and solar energy, in the coming decade should make up the traditional energy of Ukraine with its powerful TPPs, HECs, NPPs and HPPs, if not a worthy intra-industry competition, then at least a worthy energy supplement in the annual balance of industrial output in Ukraine of heat and electricity.

4. The problem of environmental safety of powerful TPPs in operation in Ukraine for its successful solution requires a new approach and large investments from both private capital and the country's budget. Avoiding its solution only exacerbates the situation of domestic power engineering.

REFERENCES

1. Khramov Yu.A. *Istoriia fiziki* [History of Physics]. Kiev, Feniks Publ., 2006. 1176 p. (Rus).

2. Available at: http://energetika.in.ua/ru/books/book-3/part-1/section-1/1-1 (accessed 22 January 2016). (Rus).

3. Available at: http://elemo.ru/article/teplovye_jelektrostancii.html (accessed 20 May 2015). (Rus).

4. Available at: https://en.wikipedia.org/wiki/Thermal_power_station (accessed 08 August 2016).

5. Available at: https://en.wikipedia.org/wiki/Thermal_power_stations_in_Russia_and_Soviet_Union (accessed 12 June 2016).

6. Available at: https://de.wikipedia.org/wiki/Gasturbinenkraftwerk (accessed 08 April 2015). (Ger).

7. Available at: https://ru.wikipedia.org/wiki/Котёл-утилизатор (accessed 18 September 2013). (Rus).

8. Available at: https://en.wikipedia.org/wiki/Water-tube_boiler (accessed 25 August 2015).

9. Available at: https://en.wikipedia.org/wiki/Steam_turbine (accessed 02 May 2014).

10. Burov V.D., Dorokhov E.V., Elizarov D.P., Lavygin V.M., Sedov V.M., Tsanev S.V. *Teplovye elektricheskie stancii. Uchebnik dlja vuzov* [Thermal electric stations. Textbook for high schools]. Moscow, MEI Publ. House, 2007. 466 p. (Rus).

11. Available at: https://en.wikipedia.org/wiki/Turbo_generator (accessed 12 February 2015).

12. Available at: http://elstan.ru/articles/teplovye-elektrostantsii/10045/ (accessed 28 September 2016). (Rus).

13. Available at: http://www.gigavat.com/tipi_elektrostancij.php (accessed 11 October 2015). (Rus).

14. Available at: https://ru.wikipedia.org/wiki/Список_тепловых_электростанций_Украины (accessed 28 May 2016). (Rus).

15. Available at: http://forca.ru/knigi/arhivy/ustroystvo-i-obsluzhivanie-vtorichnyh-cepey-22.html (accessed 15 March 2016). (Rus).
16. Baranov M.I. An anthology of the distinguished achievements in science and technique. Part 32: Alternative energy: state and prospects of development. *Electrical engineering & electromechanics*, 2016, no.3, pp. 3-16. (Rus). **doi: 10.20998/2074-272X.2016.3.01**.
17. Andryushchenko A.I. Modern problems of thermal energy and the most important ways of their solution. *Vestnik of Saratov State Technical UIniversity*, 2003, no.1, pp. 140-143. (Rus).
18. Available at: http://paes250.ru/ru/pts-problem/index.html (accessed 12 May 2017). (Rus).
19. Kravchenko A.N. Global problems of Ukrainian thermal energy. *Electrician*, 2013, no.9, pp. 38-41. (Rus).
20. Available at: https://en.wikipedia.org/wiki/Combined_cycle (accessed 22 September 2016).
21. Available at: http://www.saveplanet.su/articles_114.html (accessed 15 March 2016). (Rus).

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