Part 6

ADVANCED TECHNOLOGIES AND POWER INSTALLATIONS FOR THERMAL AND ELECTRIC ENERGY GENERATION

6.4. Application of air condensers in power industry

*Introduction**

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Ecological safety of electrical energy generation largely depends on operating conditions of the low-potential part of TPP, possibility of forming a deep vacuum in the condenser, possibility of reliable and environmentally safe operation of the condensing installation.

During the period of water resource scarcity, marked even for Russia, innovative solutions for power engineering in the field of steam condensation process arrangement and usage of cooling circulating water, which losses reach of 3,5 ... 4% at application of open cooling systems, are required.

Due to tightening of requirements relating to environmental protection and rational use of water resources, the further application of traditional cooling systems of exhaust steam in the turbine is problematic. In contrast, use of air cooling systems can significantly reduce the level of environmental stress, almost completely eliminate the consumptive water use, eliminate the formation of deposits in the form of scum and bioformations in the heat exchange equipment and improve its reliability.

Applying air condenser (ACs), there's no necessity in construction and operation of water intake and treatment plants, construction of water cooling towers and other water supply systems. From the ecological issue, ACs allow to avoid saturation of atmospheric air with water vapor, and also significantly reduce withdrawal of water resources from the natural environment.

At AC application TPP position does not depend on water supply source, which is a significant positive factor, especially for the city conditions at construction of plants of decentralized combined heat and electrical energy generation, and also for isolated power plants, using thermal energy of waste incineration plants, diesel and combined cycle plants.

Unfortunately, in the Russian power engineering ACs are not used at all, while in Germany, USA, France, Holland, South Africa and other countries every year they find more and more wide appliance. Our research and design institutes, even in the long term do not consider a possibility of AC appliance in domestic power engineering.

A problem of application of air-condensing installations at TPPs is set in connection with the increasing lack of water and land resources, environmental requirements, domestic and foreign market demands. For shallow and anhydrous areas there is the only possibility – application of dry cooling systems: direct with ACs and indirect with the radiator water cooling tower. Dry systems have incontestable advantages compared to evaporative ones as from the environmental point of view, and considering the air availability as the cooling medium.

In case of direct system, steam dumps the heat in the surface condenser directly to the air, in case of indirect system, in the surface or mixing condenser steam dumps the heat to the intermediate heat medium - water, which is then cooled by air in the surface heat exchanger of the radiator tower.

The direct system is easier than the indirect, and AC requires less surface of finned tubes than heat exchangers of radiator tower at the same parameters of steam and air. For ACs relationship of thermal, hydrodynamic and climatic conditions is specific.

Currently applied surface condensers, cooled by atmospheric air, usually have finned external surface of tubes, inside which steam is condensing.

In recent years, research efforts have been directed to improve AC construction. A complete series of condensers with different profile of fins and tubes was designed.

It should be noted that the run-around system with dry cooling tower due to a presence of additional heat exchanger (contact condenser) in it, is more complex and requires at the same estimated temperatures of exhaust steam and outside air by 25...30% more heat exchange surface of radiator elements of the tower than the AC surface or more high cooling air flow rate.

All stated above increased AC competitive advantage compared to the circulating water supply systems with dry (radiator) cooling towers, designated for TPPs in shallow areas, used instead of water cooling towers (wet) with evaporative cooling of circulating water.

AC operational experience at power plants in the U.S., France, Holland, South Africa and Germany showed an inexpedient application of contact condensers in circulating water supply system, leading to connection of contours of feed and cooling water with each other and causing together with operational difficulties additional costs, associated with installation of circulating pumps under the contact condensers, taking a mixture of cooling water with formed condensate from the vacuum. Appliance in tower cooling cells of aluminum tubes of small diameter (14...15 mm) and small wall thickness (0,5...0,75 mm) also did not justify itself. They were damageable under the impact of sufficiently sharp variable temperature regimes. At the same time, appliance of all-welded AC construction when at their production the modern welding engineering and modern methods of welding quality control are used, that can ensure sufficiently high density of vacuum systems. In addition, it is necessary to note the following indisputable AC advantages

- independence of plant-siting from the source of water supply;
- low capital investments;
- ecologically clean cooling process.

All listed above leads to a conclusion about the preference of AC appliance, therefore, development and research on aspects of AC application at TPPs for improving environmental conditions at the plant location area is a very important task.

AC competitors can be direct-flow systems of water supply or the reverse ones. Direct-flow system assumes availability of natural water bodies with plenty of water. Such a system is cheaper, because it does not require construction of expensive facilities such as water cooling towers or water-cooling ponds. Direct-flow system also provides lower temperature of cooling water. Therefore, in cases where the plant site plan and environmental conditions permit, preference shall be given to the direct-flow system of water supply. However, actual combination of favorable geographical and ecological factors is becoming rarer, and with tightening of environmental regulations its very likely

to be an exclusion even for condensing power plants.

As for combined heat power plants, then due to specifics of the generated energy, they should be built close to heat consumers. Therefore, a real AC competitor is the reverse system of water supply with water cooling towers or spray-type pools. Due to a lack of domestic experience of production, installation and operation of ACs, estimations of effectiveness, reliability and environmental safety we conducted by us according to the foreign data.

According to expert estimations of the company GEA (Germany), AC cost make about 80...100% of the cost of circulating water supply system with surface condensers; power consumptions for fan and circulating pump drives are approximately equal.

Modern power plant engineering solves problems on intensification of heat and mass exchange by conventional methods, for which hydrodynamic resistance at heat medium flow is proportional to the square of its velocity. At this, heat transfer increase remains short of resistance growth. This does not provide a further improve of power industry efficiency. Therefore, an important role in the further progress in energy exchange and energy-conversion efficiency should play new technical solutions on arrangement of the condensation process as well as heat exchange from the side of cooling air. To solve this problem, it is necessary to use essentially new forms of heat transfer surface arrangement from the side of cooling air and new ways of arranging the processes of heat and mass exchange from the side of condensing steam.

Attempts of widespread AC introduction led to creation of various designs of condensers. In this connection it is necessary to carry out an analysis of existing AC designs and compare their heat and aerodynamic characteristics in order to identify ways of creation of more advanced devices, considering an efficiency of heat and mass exchange process behavior during condensation, as well as other technical, economic and ecological indicators.

-* In process of preparation of § 6.4, data for study under RFBR grants # 06-08-01537-a and # 05-08-50028-a have been used.