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NUCLEAR POWER PLANTS AND ITS FEATURES

Abstract: This article is devoted to explore the classification of nuclear power plants, basic operating principles, and design features are considered.

Key words: nuclear power plant, nuclear reactor, coolant.

Today, the economies of the world's countries are aimed at using energy sources with low cost and reduced emissions of harmful substances compared to traditional hydrocarbon energy production. This is due to the following aspects: a decrease in the share of the energy component in the cost of production, quotas and taxes on emissions of harmful substances, and the environmental situation in countries. The most relevant option for solving these problems is nuclear energy. Existing renewable non-traditional energy sources - solar and wind energy - are not capable of producing the same amount of energy per 1 m2 of occupied space as nuclear power plants, and are seasonal in nature. Therefore, even taking into account one of the most expensive components in the life cycle of a nuclear power plant - the disposal (burial) of spent nuclear fuel, the cost of which is up to 30% of the cost of building a plant, this type of energy production is the most economical. The average payback period of a modern nuclear power plant when operating at a nominal load is up to 5 years, while the standard service life is 20 years.

The operation of nuclear power plants (NPP) in normal mode is distinguished by its environmental friendliness. The counterbalance to the use of "peaceful atom" today is the impact of accidents on the environment.

Nuclear power plants are classified according to the reactors installed on them. According to the type of energy supplied, they are:

- Nuclear power plants designed to generate only electric energy. At the same time, many nuclear power plants have heating units designed to heat network water;
- Nuclear combined heat and power plants (CHPPs) that generate both electricity and thermal energy.

The operating principle of the nuclear power plant is considered on the basis of a nuclear power plant with a double-circuit water-moderated power reactor [1]. The energy released in the reactor core is transferred to the coolant of the first circuit. Then the coolant (in this type of reactor, water) enters the heat exchanger (steam generator), where it heats the water of the second circuit to boiling. The steam obtained in this way enters the turbines that rotate the electric generators. At the exit of the turbines, the steam enters the condenser, where it is cooled by a large amount of water coming from the reservoir.

Classification of nuclear reactors

a. a thermal neutron reactor (a "thermal reactor" is a nuclear reactor that uses neutrons from the thermal part of the energy spectrum, the "thermal spectrum", to maintain a nuclear chain reaction. The use of thermal spectrum neutrons is advantageous because the cross-section of the interaction of uranium-235 nuclei with neutrons participating in the chain reaction increases as the neutron energy decreases, while that of uranium-238 nuclei remains constant at low energies. As a result, a self-sustaining reaction using natural uranium, in which the fissile isotope 235i is only 0.7%, is impossible with fast neutrons and possible with slow (thermal) neutrons;

b. a fast neutron reactor (a “fast reactor” is a nuclear reactor that uses neutrons with an energy of more than 105 eV to maintain a nuclear chain reaction).

The active zone and reflector of a fast neutron reactor mainly contain heavy materials. The moderator is introduced into the active zone as part of the nuclear fuel (uranium carbide IS, plutonium dioxide PuO2) and coolant. The concentration of the moderator in the active zone is intended to be reduced to a minimum, since light nuclei soften the energy spectrum of neutrons. Before being absorbed, fission neutrons have time to slow down as a result of inelastic collisions with heavy nuclei only to 0.1...0.4 MeV.

To carry out a fast neutron chain reaction, a high concentration of fissile material in the active zone is required, which is tens of times greater than the concentration of fissile material in the active zone of a thermal neutron reactor. Despite this, the design and construction of expensive fast neutron reactors is justified, since for each neutron captured in the active zone of such a reactor, 1.5 times more fission neutrons are emitted than in the active zone of a thermal neutron reactor. Consequently, a significantly larger proportion of neutrons can be used to process nuclear raw materials in a fast neutron reactor.

Advantages of a reactor with an organic coolant:

- low pressure in the primary circuit significantly simplifies the reactor design;
- chemical inertness of organic liquids to metals. The problem of selecting coatings for fuel elements is simplified. In a reactor with an organic coolant, fuel elements have aluminum coatings with a maximum permissible temperature of 400 °C their surfaces. At the same temperature and water environment, the heat-generating elements must be coated with zirconium, since aluminum coatings, when cooled with water, can be used with a surface temperature of elements up to 300 °C.

Disadvantages of a reactor with organic coolant:

- the melting point of currently recommended organic heat carriers is higher than the ambient temperature. This forces provide communication lines and equipment with special heating devices;
- thermal and radiation instability. At high temperatures and under the influence of radiation, organic liquids disintegrate or form more complex viscous organic compounds. To clean the organic liquid from impurities, the first circuit must include cleaning devices, which complicates the power plant;
- liquid metals have low vapor pressure. The pressure in the system is determined only by the loss of pressure in the circuit (the pressure is usually less than 7 atm.). Low pressure significantly simplifies the design and operation of both the reactor and the auxiliary equipment of the station;
- the high boiling point of liquid metals provides greater flexibility in operation. For example, if the coolant temperature at the reactor outlet increases significantly, the melting of the fuel element caused by the formation of a steam film, as occurs with water cooling, will not occur. The permissible heat flows are almost limited by critical thermal loads;
- the high electrical conductivity of liquid alkali metals allows for the full use of sealed electric pumps (direct and alternating current). In terms of energy consumption for pumping, liquid metals are only slightly inferior to water. Of the liquid metals, alkali metals have the best characteristics in terms of energy consumption for pumping;

The WWER-1200 power reactor is designed to generate thermal energy through a chain reaction of fission of atomic nuclei. The reactor is a water-water, heterogeneous, vessel-type reactor operating on thermal neutrons with a water-water coolant-moderator (pressurized water). The reactor is a vertical cylindrical vessel with an elliptical bottom, inside which the active zone and in-vessel devices are located.

The reactor is hermetically sealed from above by a lid with drives for the mechanisms and control and protection devices of the reactor installed on it, and branch pipes for the output of cables of the in-reactor control sensors. The lid is fastened to the body with studs. In the upper part. The housing has pipes for supplying and discharging the coolant (two pipes per loop), located in two rows, as well as pipes for emergency supply of coolant in case of depressurization of the first circuit.

As a result of planned work, the equipment resource and the service life of the stations have been increased to 60 years. Due to the peculiarities of the physical properties of water in a subcritical state (weak dependence of the saturation temperature on the pressure in the range above 12 MPa), changes in the coolant temperature at the outlet of the WWER reactors are not so significant and amount to 325 °C.

Forced circulation of the coolant is carried out through four closed loops of the primary circuit due to the operation of the main circulation pumps (MCP). The water of the primary circuit, cooled in the steam generators, enters the reactor through the lower row of pressure pipes, passes down through the annular gap between the vessel and the internal shaft, then through the perforated elliptical bottom and the support pipes of the shaft enters the fuel assemblies (FA). From the FA through the perforated lower plate of the BZT the coolant exits into the intertube space, and then through annular gap between the shaft and the body and through the four upper outlet pipes of the body exits the reactor.

One of the engineering ideas expressed in the design of the WWER-1200 reactor is that the unit will be equipped with a passive heat removal system. With the help of such a system, it is possible to remove heat, devoid of any presence of carbon dioxide, into the air space, which is an almost infinite heat absorber, completely safely for the population and personnel.

The original "novelty" of the nulear unit is also that all the equipment and radioactive substances will be concentrated under a double reinforced concrete shell, absolutely hermetic. In case of an emergency, this will keep all the "radioactive dirt" inside, in complete isolation from the outside world. The double shell is also an anti-terrorist measure, it is designed to withstand an airplane crash. In case of an emergency, the design also provides for melt fuel trap.

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