POWER UNIT WITH GT-MHR REACTOR PLANT FOR ELECTRICITY PRODUCTION AND DISTRICT HEATING

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ЭНЕРГОБЛОК С РЕАКТОРНОЙ УСТАНОВКОЙ ГТ-МГР ДЛЯ ПРОИЗВОДСТВА ЭЛЕКТРОЭНЕРГИИ И КОММУНАЛЬНОГО ТЕПЛОСНАБЖЕНИЯ

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Modular helium reactor with the gas turbine (GT-MHR) is a perspective power reactor plant for the next century. The project reactor is based on experience of operation more than 50 gas-cooled reactors on carbon dioxide and helium, and also on subsequent achievements in the field of realization direct gas turbine Brayton cycle. To the beginning of 90-th, achievements in technology of gas turbines, highly effective recuperators and magnetic bearings made it possible to start development of the reactor plant project combining a safe modular gas cooled reactor and a power conversion system, realizing the highly effective Brayton cycle. The conceptual project of the commercial GT-MHR reactor plant fulfilled in 1997 by joint efforts of international firms, combines a safe modular reactor with an annular active core of prismatic fuel blocks and a power conversion system with direct gas turbine cycle.

The reactor with the annular active core of fuel blocks allows to increase its power up to 550–600 MW providing increased level of safety for the account of inherent properties of self-protection and passive cooldown. Graphite as material of the active core and reflectors has sublimation temperature of more then 3000°C. It means that such the active core can't melt because there are no accidents with core temperature above 2000°C including ones with neglible probability of their realization. Fuel spherical particles in size of several hundred microns are covered by several layers of pirocarbon and a layer of silicon carbide. After that the particles are mixed up with a graphite matrix, and spherical or cylindrical compacts are formed. The type of an active core depends on use of this or that form of compacts: a pebble bed core or a core of hexagonal graphite blocks in which compacts are placed. Remarkable property of fuel particles is to retain reliably fission products up to 1600°C. Mass release of fission products through the coatings begins at temperatures above 2000°C. It enables to heat up the coolant in the active core up to 1000°C, that essentially expands possible field of application of nuclear power sources with HTGRs.

The property of HTGRs to allow high level of temperatures in the core without damage of fuel, was used to realize an idea to remove residual heat through the reactor vessel to a reactor cavity cooling system and further to the ultimate sink (atmosphere air, water pools) in the loss of coolant accidents without forced cooling of the core. In this case the residual heat is transferred only by natural mechanisms (convection, radiation, conductivity).

The efficiency of GT-MHR gas turbine cycle at level of about 48% makes it competitive in the electricity production market in comparison with any fossil or nuclear power stations. Application of the direct closed gas turbine cycle provides significant simplification and reduction of necessary equipment and systems as compared with other types of nuclear power plants with water-steam cycle. Turbine hall with steam generators, steam pipes, condensers, deaerators and so on, are completely excluded from the station structure. Such a simplification together with minimum of safety systems enables to decrease expenses for construction, operation and maintenance.

The GT-MHR reactor plant with gas turbine cycle, except for higher efficiency has thermodynamic and scheme potentiality to use waste heat. The low gas temperature in gas turbine cycle at optimal efficiency is higher (130°C) as compared with steam the condenser temperature (30–40°C) for water-steam cycle. Utilization of GT-MHR waste heat for district heating and other needs enables, together with electricity production to use almost all thermal power of the reactor.

In summary it is possible to note that the GT-MHR project is characterized by:

- increased safety in comparison with others reactor plants taking into account the ceramic core;
- high efficiency;
- competitiveness in electricity production market;
- possibility to utilize of waste heat for district heating;
- smaller impact on the environment in comparison with other nuclear power stations.

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