CALCULATION OF TEMPERATURE FIELD IN HNS USING EXPERIMENTAL RESULTS OF GRAPHITE FELT CONDUCTIVITY AND POWER GENERATION

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Hot neutron spectrum produced by a hot neutron source (HNS) of the reactor PIK [1] considerably depends on the size and temperature of the graphite block which is the high-temperature scatterer of neutrons. When the capsule size is given increase or decrease of the graphite block size leads to decrease or increase of the thickness of the thermal insulation from the graphite felt and changes the power generation in HNS. Therefore temperature of the graphite block depends on its size. At present measurements of the power density in the HNS capsule elements are carried out on the physical mock-up of the reactor PIK [2] and the heat conductivity coefficients of the graphite felt "carbotextim-B" are measured in a wide temperature range (200–1500°C) in vacuum and in helium and nitrogen atmospheres [3]. These investigations give a possibility to calculate more exactly the dependence of the graphite block temperature on its size and kind of a filling gas. It is necessary for the physical optimization of the HNS.

The calculations of the temperature field in the HNS have been carried out according to a special program which provides the possibility to change sizes of a graphite block and a capsule shells as well as a number of graphite felt layers. The heat conductivity coefficient of the graphite felt was calculated by empirical formula [3]. The effective heat conductivity coefficient of a gas in a small gap between double shells of the capsule HNS was calculated taking into account thermic accomodation of the gas molecules on the walls.

The program of the HNS temperature field calculation was tested by numerical calculations carried out for one of the HNS construction variant.

Fig.1 presents the calculation temperature of the graphite block centre and the lateral surface as a function of the radius and a kind of a gas — helium and nitrogen. This calculation and its comparison with the physical calculations of the HNS relative gain show that the optimal radius of the graphite block have the range $0.09 \div 0.1$ m. It corresponds to the temperature 2000–2100°C in the centre of the graphite block when the HNS capsule is filled with helium. The temperature gradient in graphite block is no more than 50°C due to good conductivity of the graphite. Substitution of helium for nitrogen or the other gas having nearly the same heat conductivity coefficient considerably increases the graphite block temperature nearly by 500°C. This reserve can provide an effective work of HNS when the reactor power is less then nominal.

Fig.2 presents the temperature of the capsule inner and outer shells from the radius of the graphite block. The temperature gradient on the gas gap width 0.3 mm between inner and outer shells for optimal radius of the graphite block forms 100°C for helium and 450°C for nitrogen. In the last case the inner shell temperature exceeds the maximum permissible temperature for the loss of zirconium alloy strength due to the recrystallization. Therefore using the gas with a small thermal conduction in the HNS is acceptable only at a lesser reactor power.

The HNS power release and the heat flux density on the outer surface of the capsule are determined. For the optimal size of the graphite block the heat flux density is quite high so that the nucleate boiling on outer surface of the capsule is possible.

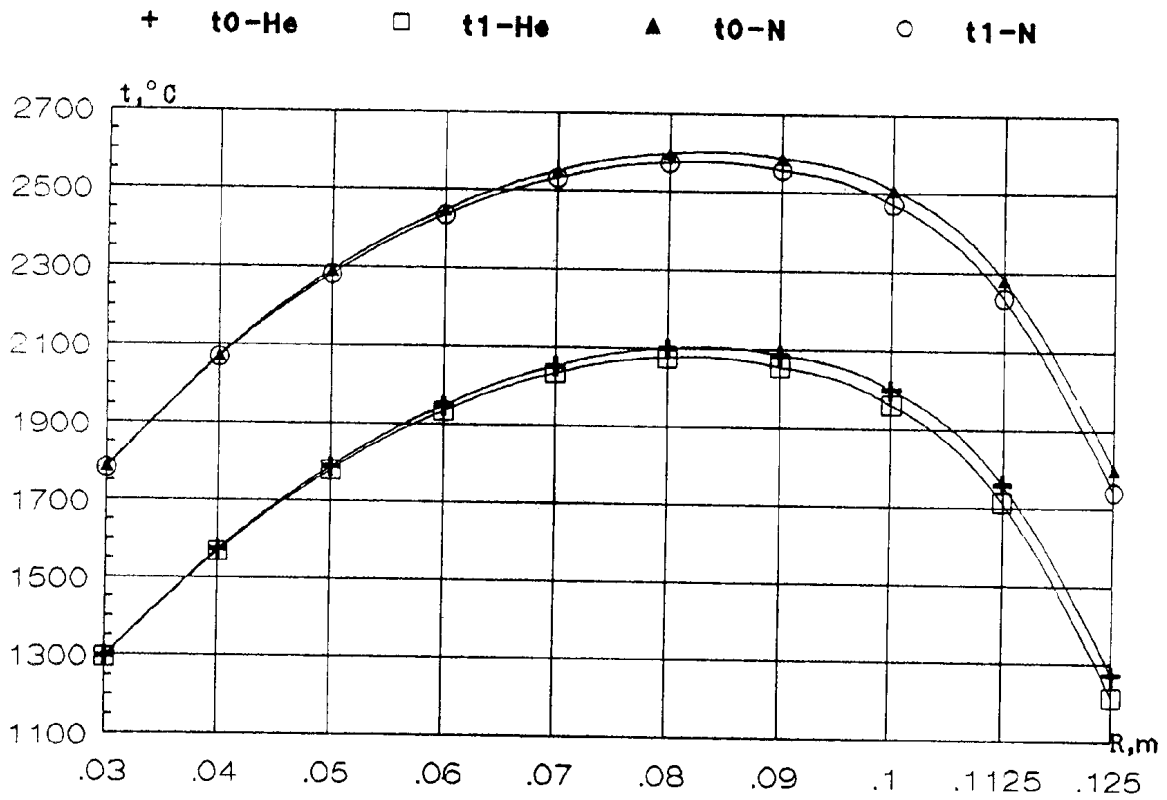

Fig.1. Dependence of temperature of graphite block centre ($t0$) and lateral surface ($t1$) as function of radius and kind of gas — helium (He) and nitrogen (N)

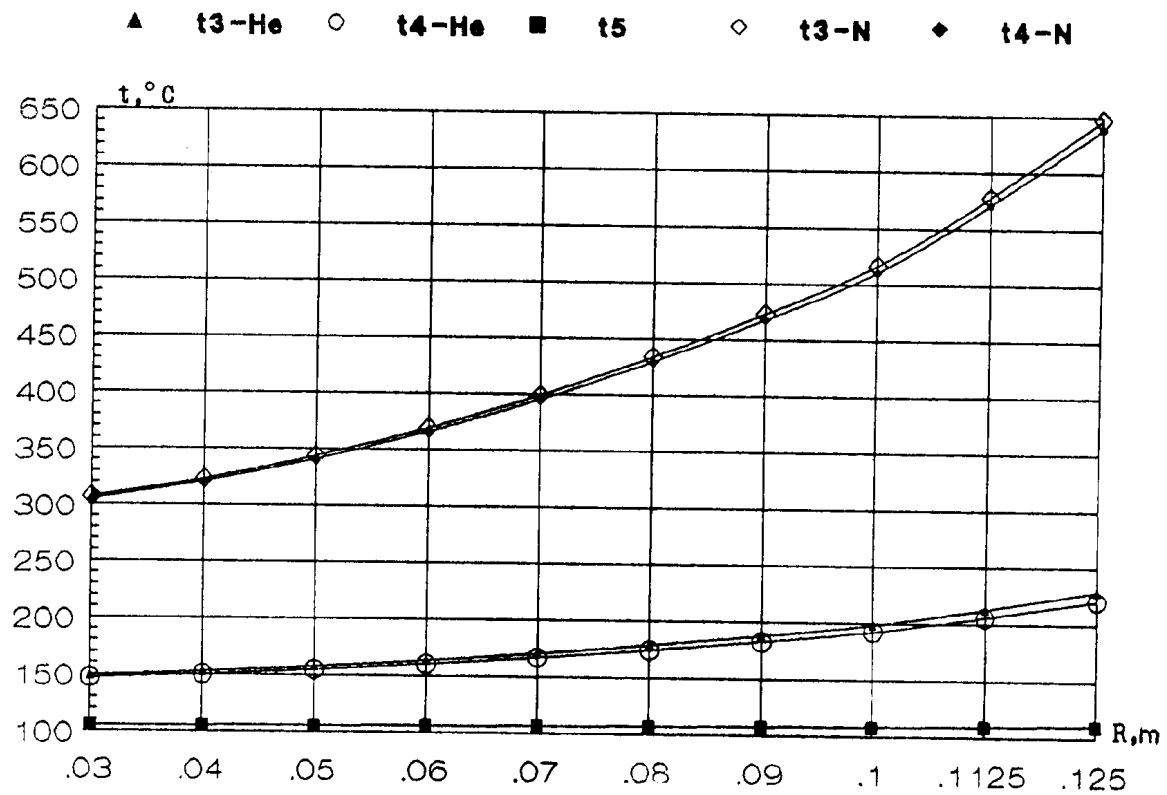

Fig.2. Dependence of temperature of capsule inner ($t3$) and outer ($t4$) shells on the radius and kind of gas — He and N

The results of these calculations [4] allowed to choose the optimal size of the HNS graphite block and to estimate the increase of the graphite temperature by substitution of a filling gas.

REFERENCES

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