not succeed as a creation of such facilities is a national priority and if such object is to be created every country prefer to create it in own country.

The main hopes in completing of the construction are an our government,support of interested scientists and our persistence.

CALCULATION OF PIK REACTOR PERMISSIBLE POWER BY A STATISTICAL TECHNIQUE

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Introduction

Probability technique of reactor limiting - permissible power calculation proposes determination of stationary power, at which the heat technology emergency probability is equal to prescribed value. Under heat engineering emergency is understood the event, concluded in excess by determining heat engineering parameter of limiting value established for it. If the value A is limiting value for determining heat engineering parameter a, then probability of event, at which the determining function $F = A - a$ will have negative value is heat engineering emergency probability [1,2]. In general case the determining function depends on reactor power and on many values, possessing statistical nature, and, if their statistical characteristics are known, basically, it is possible to determine probability distribution of determining function for given reactor power and to determine heat engineering emergency probability. At given emergency probability it is possible to select of power value, at which given condition is satisfied.

In given work the brief description of PIK reactor limiting - permissible power technique calculation by Monte-Carlo technique, developed by authors, is indicated, some questions of heat engineering emergency probability and determining factor choice are discussed and some results of calculations are presented.

Technique of Calculation

We shall propose, that the determining function, responsible for safety of reactor operation, is known function of reactor power and many statistically independent values x_i such as enters reactor regims parameters, geometrical characteristics of fuels and the core, as well as variate factors, connected with reactor features, accuracy of measurement and maintenance regims parameters and errors of the settlement formulas. We allow also, that for each value x_i normalized function of probability density, i.e. law it probability distribution is known. To set any value of reactor power, it is possible to make variate sample of parameters x_i by computer according to the laws of their probability distribution, and, using of value of these parameters, to calculate value of determining function. To make such calculation a plenty time, it can be considered quantity of negative values of determining function and to determine value of reactor heat engineering emergency probability for prescribed value of reactor power.

$$R = n/N \tag{1}$$

Where n-number of negative values of determining function from complete number of accounts N. By consecutive selection of values of reactor power it is possible to satisfy with a condition, that the probability of emergency did not exceed the given value μ ($R \leq \mu$). The value of reactor power at which $R = \mu$ represents limiting - permissible power value for given heat engineering emergency probability μ.

Choice of Heat Engineering Emergency Probability

Analysis of foreign work [3,4] shows, that as allowable probability of heat engineering emergency value of the order $1.3 \cdot 10^{-3} \div 10^{-4}$ is chosen. For a particular reactor type the value 10^{-4} means, that, on the average, at one such reactor from 10^4 same reactors casual deviations of parameters will develop unfavourably, and in one of its channels at a reactor exit on limiting - permissible power will be infringed normal heat exchange. Commission of USA Reactor Inspection for research reactors is established 5% heat engineering emergency probability at 95% of initial parameters confidential probability (so named criterion 95/95). Criterion of reliability 99.9/50, setting 0.1% probability of emergency is considered also at 50% value of initial values confidential probability. The restriction of initial parameters deviations at modeling their probability distribution by Gauss function, which gives infinite amplitude of initial parameters deviations from their rating values is justified the large deviations of regims parameters are prevented by a reactor design and technique of its management.

Choice of the Limiting Factor

Critical density of a thermal flow on a fuel surface as a limiting factor for PIK reactor is chosen. This parameter excess is integrated to real danger of transition the bubble boiling on a fuel surface to pellicle with sharp reduction of a heat exchange factor which conducts to fuel overheating. So, in experience on model of a single PIK reactor channel at power throw was determined, that at large unheating of a water up to temperature of saturation, it is possessing in PIK reactor, transition to film boiling results in reduction of a heat exchange factor whole in $1.5 \div 1.6$ of time, that causes a essential increase of fuel temperature, though it does not result to fuel melting . It should also note, that fuel quantity, the subjected danger overheating at this emergency makes a small share (less 1%) from complete fuels number in a active core. Thus the limiting factor is chosen reasonably conservatively, i.e. reactor remains within the framework of design emergency.

Results of Calculation

The calculation of PIK reactor maximally - permissible power was executed for various values of heat engineering emergency probability and various restrictions on amplitude of initial parameters deviations. Probability distribution of initial parameters approximated by Gauss function. Variance of values was calculated proceeding from a error of measurements or accounts of initial parameters. Possible deviations of technological reactor parameters within the limits of emergency setting up were taken into account also. The results of PIK reactor maximally - permissible power calculation at restriction by its critical thermal flow on a fuels surface are presented in table. In all cases design thermal PIK reactor power, equal $100MW$, is provided with a sufficient stock.

Table

Criterion of safety	99.87/99.9	99.87/95	99.9/50	95/95
Probability of emergency	$1.3 \cdot 10^{-3}$	$1.3 \cdot 10^{-3}$	$1 \cdot 10^{-3}$	$5 \cdot 10^{-2}$
Restriction on amplitude of a deviation of initial parameters from rating values, expressed in σ units	3σ	2σ	0.7σ	2σ
Maximally - permissible reactor power, MW	118.6	126.9	139.7	135.3

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THE USING OF LIQUID REGULATOR SYSTEM IN SUB-CRITICAL REGIMES OF PIK REACTOR

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Layout peculiarity of the PIK research reactor [1] and its control system is the system of two absorbing shutters arranged around the neutron trap. The 8 regulators in the heavy-water reflector are used only in the reactor start-up and as scram rods. Their effectiveness is $4.5\beta_{eff}$. One shutter effectiveness is about $4.5\beta_{eff}$, therefore the analysis of event: "one the most hard regulator failure" is the important part of the design safety validation. In the beginning of reactor lifetime this failure leads to the $1\beta_{eff}$ [2] reactor sub-criticality after the shut-down in the most unfavorable moment of the reactor lifetime. It's necessary that during the failure effect liquidation the sub-criticality after cock emergency protection corresponds to normative value 1%. For that the additional liquid regulator system (LR) is used. Absorber (gadolinium nitrates - $Gd(NO_3)_3$) is dissolved in the heavy water and introduced in the gap between two vessel barrels at the boundary between the core and the heavy water reflector. In ordinary situation this system isn't used. D_2O circulation circuit cools the reactor vessel, absorber is inserted during the time of mechanical regulator failure. The same system can be used for 1% reactivity worth before beginning of lifetime and for the "cold" reactor start-up realization from the sub-criticality. The inlet in the critical state and power raising carried out subsequently due to mechanical regulators.