DESIGN CHARACTERISTICS OF RESEARCH ZERO POWER FAST REACTOR LASTA

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ABSTRACT

LASTA is a flexible zero power reactor with uranium and plutonium fuel designed for research in the neutron physics and in the fast reactor physics. Safety considerations and experimental flexibility led to the choice of a fixed vertical assembly with two safety blocks as the main safety elements, so that safety devices would be operated by gravity. The neutron and reactor physics, the control and safety philosophy adopted in our design, are described in this paper. Developed computer programs are presented.

INTRODUCTION

The concept, purpose and design of the first Yugoslav fast research reactor LASTA are described in this paper. The methods of computing the reactor core parameters and reactor kinetics are presented together with basic calculated results and analysis for one of the LASTA configurations. The nominal parameters are calculated according to the chosen safety criteria. The most important aspects related to the overall reactor safety are examined in details[1].

The developed computer programs are presented[2,3].

REACTOR CONCEPT

To ensure maximum flexibility of the reactor LASTA, the fuel is chosen in the form of the square slabs of dimensions 40.8 x 40.8 x 5.7 mm. Stacking of the slabs (PuO_2, enriched and natural uranium) in the cassettes allows obtaining different fuel spatial distributions.

Dimensions of the system LASTA are 740 x 740 x 800 mm. The system is designed in the form of three vertical slices, Fig.1. The central slice is fixed whereas two side slices are vertically movable and are envisaged to perform the functions of safety blocks. The fuel and reflector elements are inserted into the system upwards automatically. This method of assembling rules out undesired introduction of high reactivities and the system is inherently safe from accidents such as the fuel element drop.

In the reactor design a special attention is paid to fast removal of reactivity. For both safety elements and safety blocks the force of gravity is aided by special safety devices.

All calculations presented have been performed assuming the configuration given in Fig.1.

BASIC DATA, METHODS AND PROGRAMS

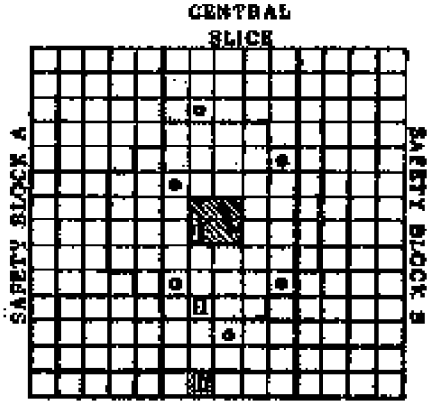
The LASTA system has no reference system and the calculations of the neutron characteristics (critical mass, reactivities of control and safety elements, etc.) and kinetics parameters are of the essential significance since they form the basis for defining the safety criteria and selecting the parameters of the core and the corresponding control and safety systems. The methods for these calculations have been selected and the original computer programs developed, VERA and MELT. The calculations include the effects of the resonant absorptions, heterogeneous resonant absorptions, elastic scattering anisotropy and the influence of the neutron energy distribution on elastic scattering slowing-down.

Program VERA calculates the spatial energy distributions of the neutron flux and the adjoint neutron flux, effective multiplication factor, prompt neutron decay constant, control rod reactivities, kinetics parameters, temperature coefficients of reactivity, etc.

Program MELT calculates the behavior of the system LASTA during accidents. The analysis of the designed basic accident is carried out.

NEUTRON CHARACTERISTICS

The neutron calculations, performed for the LASTA configuration presented in Fig. 1., gave $\Delta k_{eff} / H = 0.0116\ cm^{-1}$, i.e. 1% error of k_{eff} corresponds to 6 mm error of the system height. In Table I, the rate of change of k_{eff} versus positions of the blocks, safety and control elements is shown. The k_{eff} of the LASTA reactor in shutdown condition is 0.769. The reactor went in critical condition when both of safety blocks and all the safety rods are in upper position and the control rods are partially inserted.



I PuO_2

II U METAL (20% ^{235}U)

III NATURAL U METAL
SAFETY ELEMENT (U METAL, 20% ^{235}U)
CONTROL ELEMENT (NATURAL U METAL)

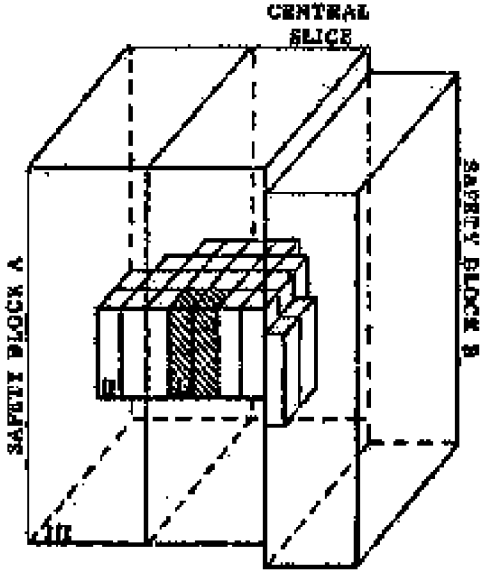
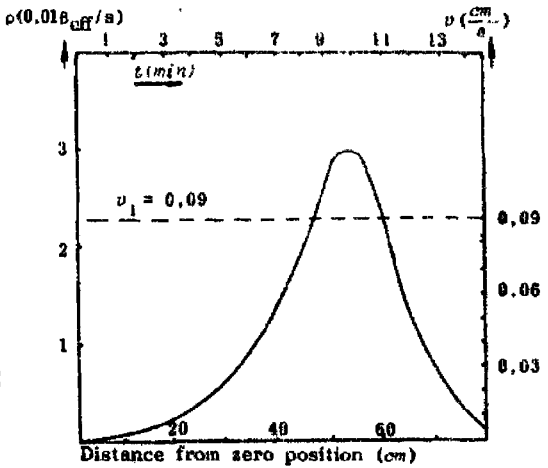
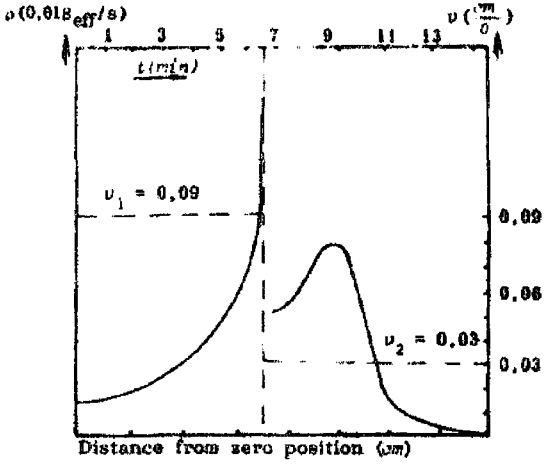


Fig. 1. Cross-sections of the KASTA reactor



RATE OF CHANGE OF REACTIVITY VS POSITION OF BLOCK A (SAFETY BLOCK B DOWN)



RATE OF CHANGE OF REACTIVITY VS POSITION OF BLOCK B (SAFETY BLOCK A UP)

Fig. 2. Ex[illegible]eactivity changes during safety blocks motion

TABLE I

Rate of Change of k_{eff} versus Positions of the Safety and Control Elements

	Positions	k_{eff}
I	Position I: All safety blocks, safety elements and control elements in down position	0.769
II	Position I + safety elements in up position	0.799
III	Position II + safety block A up	0.917
IV	Position III + safety block B up	0.993
V	Position IV + control elements partially in up position	1.000

REACTOR CONTROL AND SAFETY

In the process of conceptual design of the control system special precautions have been undertaken to exclude every possibility of introducing high reactivities or introducing reactivities at high speeds. The response of the system to different reactivity variations has been analyzed in order to formulate safety criteria for maximum speeds of introducing reactivities. Maximum permissible speeds of introducing reactivities must not cause the reactor period to drop below 20 s during first 20 s upon the start of the introduction. The following safety criteria have been established: (i) the speed of introducing reactivity must be less than $0.05\beta_{eff}$/s if the system is subcritical with $\rho > 3\beta_{eff}$; (ii) the speed of introducing reactivity must be less than $0.01\beta_{eff}$/s and the total excess of the reactivity must be less than β_{eff} if the system is close to delayed neutron criticality. Several examples of these calculations performed for different configurations of the system LASTA are presented in Fig. 2.

CONCLUSION

A preliminary design of the first research fast reactor LASTA according to fast reactor programme in Yugoslavia is shown. The reactor is based on uranium and/or plutonium fuel. The highest safety criteria are set and have been basis for the design. The fast reactor computing methods are introduced and new own computer codes are developed.

REFERENCES

The most references regarding work on the LASTA design are published in Serbocroatian as IBK Reports. We point out the three main papers:

1. M.Milosevic, D.Stefanovic, M.Pesic, D.Popovic, D.Nikolic, D.Antic, N.Zavaljevski, "Design Characteristics of Zero Power Reactor LASTA", Proc. of Yug. XXXI ETAN Conference, Bled (1987), Vol. IX, pp.3-11 (in Serbocroatian)

2. M.Milosevic, "VERA - a Computer Code for Fast Reactor Calculation", IBK NET Computer Code Library, Vinca 1984

3. M.Milosevic, "MELT - a Coupled Neutronics Kinetics and Hydrodynamics Computer Code for Fast Reactor Accidental Analysis", IBK - NET Computer Code Library, Vinca 1985