TRANSIENT STUDY OF TEHERAN RESEARCH REACTOR CORE IN FUEL CONVERSION

A.Pazirandeh ,A.Afshar Bakeshloo and G.Bartsch[1]
Physics Department, Teheran University,
P.O.Box 19395-1943, Teheran IRAN

1. INTRODUCTION

In fuel conversion of 5MW pool type Teheran Research Reactor (TRR) core from HEU to LEU fuel, safety aspects analysis of new core deemed necessary. The new MTR type fuel assembly is composed of 19 fuel plates with about 1450g 20 % enriched uranium oxide(U_3O_8) against HEU fuel assembly composed of 16 active plates and two dummy end plates in either sides of the assembly loaded with 207g 93% enriched uranium in form of U-Al alloy.

In this paper the outline of analysis of the HEU and LEU fueled core to the fast transients,as a result of reactivity insertion in step and ramp function, is discussed.

2. MATERIAL AND METHODS

To analyze the slow and fast transients of HEU and LEU fueled core, different reactivity insertion were considered and the trip point was set at 0.5s from the beginning of reactivity insertion. The reactivities were introduced in the core in form of step or ramp function. It should be pointed out that the power trip point at 6MW has been included in the code but in the figures 1 and 2 it is overrun.

The analysis was performed by applying two group point kinetic equations,with six group delayed neutrons,$\beta_{eff(HEU)}=0.0076$, and $\beta_{eff(LEU)}=0.00727$,implemented in the COSTANZA code[1]. The code was modified to take into account for the fuel and water temperature effect on core reactivity. The reactivity temperature coefficients, $\alpha_f(T)$, $\alpha_m(T)$, and $\alpha_v(T)$[2] which are temperature dependent were introduced in the code,see Table 1.The code requires two group nuclear constants. In order to investigate the effect of group constants on the core response to transients, three following sets of condensed two group constants are being envisaged to be used in the calculations (in the present results set 1 has been used):

(1) from the results of previous neutronic calculations for the HEU to LEU fuel conversion of TRR core using RSYST modular code system[3],
(2) an extracted data file, IRAN.LIB[4], from VITAMINE-4C, and
(3) the two group cross section output from TRR cell calculation using WIMS code[5].

For large reactivity insertion in step and ramp mode the following equations are being used[6],

Step Function:

$$P(t) = P_0\{\rho_0/(\rho_0-\beta)\exp[(\rho_0-\beta)t/\Lambda]-\beta/(\rho_0-\beta)\exp[-\lambda\rho_0 t/(\rho_0-\beta)]\}$$

$$C(t)=C_0\{[\Lambda\lambda\rho_0/(\rho_0-\beta)^2]\exp[(\rho_0-\beta)t/\Lambda]+\exp[-\lambda\rho_0 t/(\rho_0-\beta)]\}$$

Slow Ramp Function:

$$\rho(t) = mt$$

$$\Lambda . d^2P(t)/dt^2 + \{ \Lambda\lambda - [\rho(t) - \beta] \} dP/dt - [d\rho(t)/dt + \lambda\rho(t)].P = 0$$

$$P(t) = Go(2m/\Lambda)^{(\mu+1)/2} \exp[\lambda(\Lambda/2m)^{.5} y + \Lambda\lambda^2/(2m)] \int x^2 \exp(-x^2 - xy) dx$$

$$Go = \frac{Ao.\exp[-\lambda(\Lambda/2m)^2 yo - \Lambda\lambda^2/2m]}{(2m/\Lambda)^{(\mu+1)/2} \int x^{\mu}.\exp(-x^2 - xyo) dx}$$

$$x = (\Lambda/2m)^{.5}(s+\lambda)$$

$$y = (2m/\Lambda)^{.5}[(\beta - \Lambda\lambda)/m - t]$$

$$\mu = \lambda\beta/m$$

s = Laplace transform variable

Table 1 Slope of Reactivity Components of Different Contributors[2]

Effect pcm/oC	HEU					LEU				
	USA	FRG	JPN	SWZ	SPN	USA	FRG	JPN	SWZ	SPN
Wat.Tmp	11.88	10.70	11.00	11.60	8.14	8.07	7.75	8.73	8.2	6.27
Wat.Dens.	10.38	11.50	12.50	10.40	24.95	12.29	13.50	14.14	11.7	27.81
Fuel Tmp.	00.06	0.036	0.063	0.023	0.019	2.58	2.00	1.82	2.20	2.97

3. RESULTS AND CONCLUSIONS

The preliminary transient calculations showed that for the case of large reactivity insertion power rise and consequently the fuel temperature rise is very sensitive to small increase in reactivity insertion. However, in many cases, the rapid rise of power is abruptly stopped as a result of negative temperature coefficients of reactivity before the set point is reached and followed by power dropped by many orders of magnitude.

This preliminary calculations also indicated the effect of two group constant s on predicting the core response to the reactivity insertion. Figures 1 and 2 show the typical response of HEU and LEU core to the large reactivity insertion.

---

1. Institute for Energy Technology Technical University Berlin.

This project is supported by the Teheran University Research Council, (TURC) under contract No.515-1-267,1993.

REFERENCES

1. Forti G.,and Vincenti E.(1967) The codes COSTANZA for the dynamics of liquid-cooled nuclear reactors, EUR-3633e Joint Nuclear Research Centre, Ispra Establishment Italy.
5. Halsall M.(198) The use of WIMS-D/4 and LWRWIMS,READWT and FILSIX to

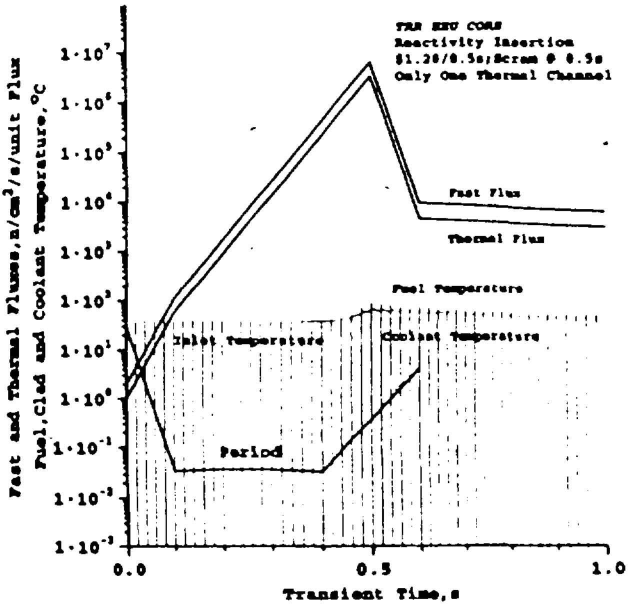
generate two group data for reactor calculations. AEEW-M 1785, Winfrith, UKAEA, Dorchester, Dorset, UK.

2\. IAEA-TECDOC-643(1992) Research Reactor Core Conversion Guidebook Vol.3 Analytical Verification(Appendices G and H)

6\. Garg Suresh, Ahmed Feroz and Kothari L.S(1986) Physics of Nuclear Reactors Tata McGraw-Hill Publishing Company Limited.

3\. Pazirandeh A.,Bartsch G., and Lutz D.(1987) Neutronic analysis of HEU to LEU fuel conversion calculation for the AEOI 5MW research reactor(TRR) Technical University Berli, TUBIK-62, July 1987

4\. Marashi M.K.,Maiorino J.R.,Mendonca A.G.,and Santos A.(1991) IRAN.LIB : A P3 coupled neutron-gamma cross section library in ISOTXS format to be used by ANISN/PC, Ann.Nucl.Energy Vol.18,No.10,pp597-602,1991.



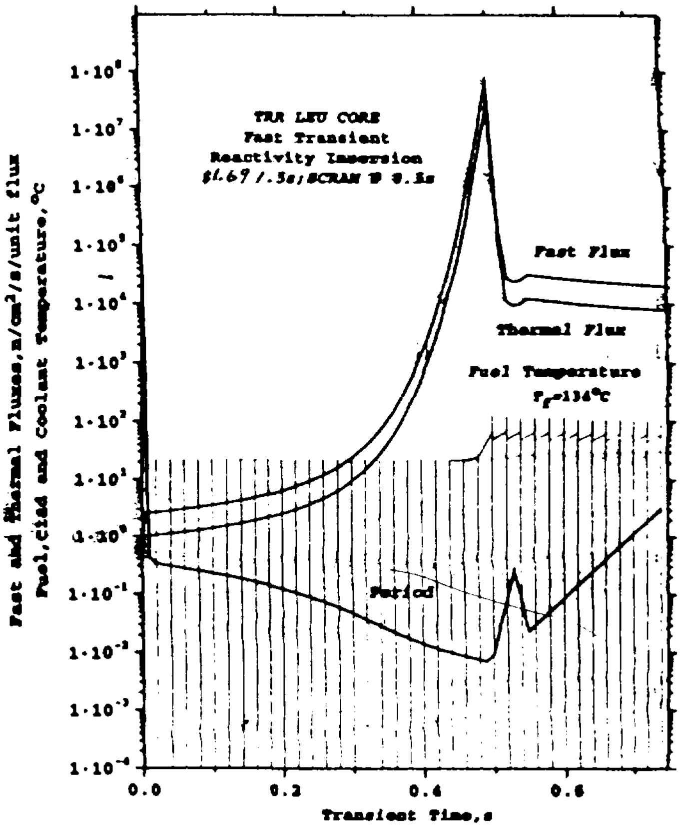


Fig.1 Two group flux, period and Fuel, Clad and Moderator Temperature in Transient of HEU Fueled Core in Step Reactivity Insertion.

Fig.2 Two group flux, period and Fuel, Clad and Moderator Temperature in Transient of LEU Fueled Core in Ramp Reactivity Insertion.