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BENCHMARK TESTS OF JENDL-3.2 FOR THERMAL AND FAST REACTORS

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ABSTRACT

Benchmark calculations for a variety of thermal and fast reactors have been performed by using the newly evaluated JENDL-3 Version-2 (JENDL-3.2) file. In the thermal reactor calculations for the uranium and plutonium fueled cores of TRX and TCA, the k_{eff} and lattice parameters were well predicted.The fast reactor calculations for ZPPR-9 and FCA assemblies showed that the k_{eff}, reactivity worths of Doppler, sodium void and control rod, and reaction rate distribution were in a very good agreement with the experiments.

I .INTRODUCTION

JENDL-3.1[1] was revised on the basis of much feedback information by various benchmark tests[2], and the revised version (JENDL-3.2) was released in March 1994[3]. In this paper, the benchmark tests of the newly evaluated JENDL-3.2 file will be described for the thermal and fast reactors.

In thermal critical experiments were selected the uranium fuel cores TRX and TCA-UO_2 with water moderated lattice of slightly enriched uranium metal and oxide rods, respectively, and as plutonium fueled cores TCA-MOX with 3.0 wt.% Pu rods. The benchmark calculations were performed with the continuous energy Monte Carlo code MVP and integral transport code SRAC. The results calculated will be described here.

Fast reactor benchmark cores consist of various critical assemblies such as MONJU plot type mock-up core (FCA-VI-2), the large LMFBR mock-up core (ZPPR-9), the FCA-IX cores with a wide variety neutron spectrum shapes, GODIVA, JEZEBEL and FLATTOP with hard neutron spectra. The benchmark calculations were performed by using the 70-group cross section library JFS-3-J32 based on JENDL-3.2. The basic integral data such as effective multiplication factor, central reaction rate ratios, sodium void reactivity, Doppler reactivity and control rod worth are compared between the calculations and experiments.

II. THERMAL REACTOR BENCHMARK

A. Uranium Cores

Figure 1 shows the k_{eff} and lattice parameters in TRX-2 core calculated with the continuous energy Monte Carlo code MVP. The k_{eff} value of JENDL-3.2 is increased by 0.5% as comparing that of JENDL-3.1, because the capture resonance integral of ^{235}U is decreased in JENDL-3.2. The lattice parameters of ρ-28, δ-25 and δ-28 are better predicted with JENDL-3.2. The k_{eff} values calculated for the TCA with UO_2 rods are slightly overestimated as shown in Fig. 2.

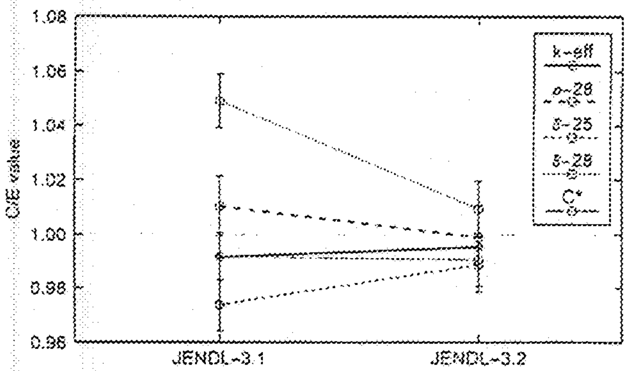

Fig.1 The C/E values of k_{eff} and lattice parameters

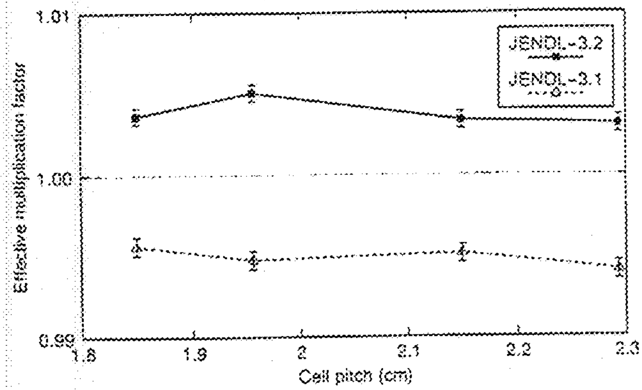

Fig.2 The k_{eff} values calculated for TCA-UO_2 cores

due to softer fission spectrum of JENDL-3.2 than Madland-Nix one of JENDL-3.1. The ratio of ^{238}U capture to ^{239}Pu fission rate is overestimated by 5 %.

Figure 6 shows the C/E values of the sodium void reactivities with the increase of void regions, and they are satisfactory both of JENDL-3.1 and 3.2.

The C/E values of control rod worths are well predicted with JENDL-3.2 as shown in Fig. 7.

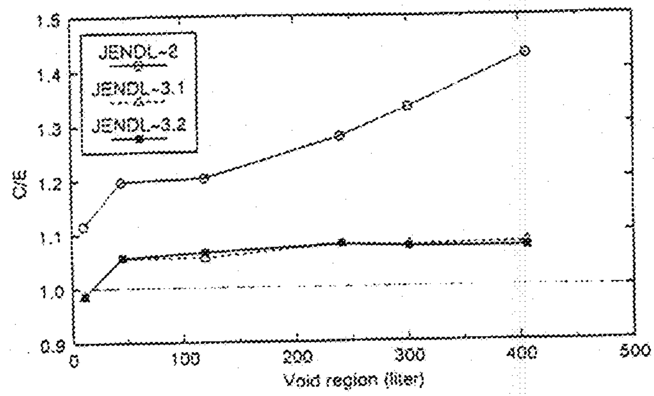

Fig.6 The C/E values of Na-void reactivity in ZPPR-9

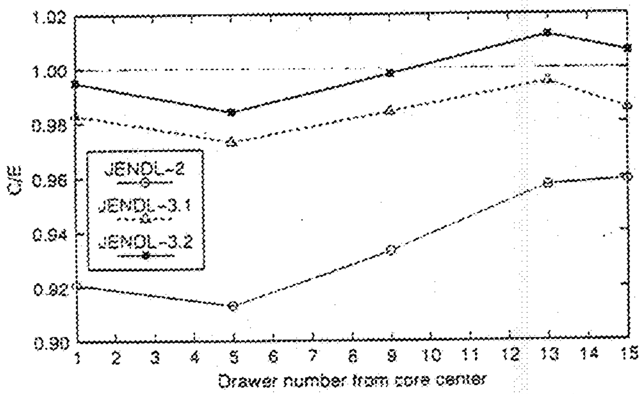

Fig.7 The control rod worth calculated for ZPPR-9

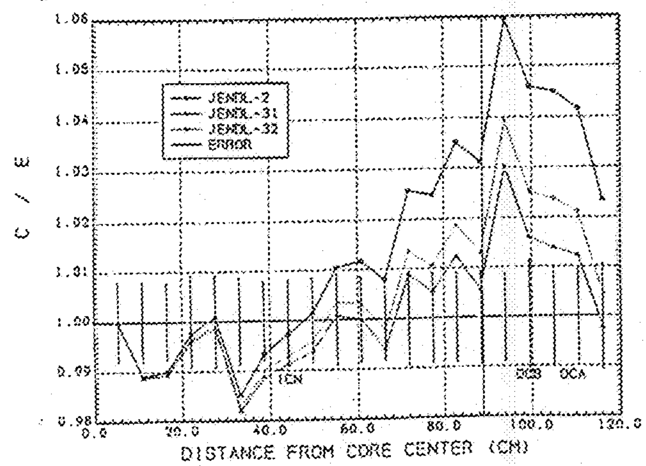

Fig.8 The ^{239}Pu fission rate distribution in ZPPR-9

Figure 8 shows the C/E values of ^{239}Pu fission rate radial distribution, and JENDL-3.2 overestimates slightly the experiments in the outer core region.

C. FCA-IX

The FCA-IX-1, 2 and 3 are uranium fueled cores with soft spectrum well moderated by graphite. As shown in Fig. 9, the k_{eff} values underestimated by JENDL-3.1 are well predicted with JENDL-3.2. This is due to decreasing the capture resonance integral of ^{235}U in JENDL-3.2 as described at the thermal reactor benchmark.

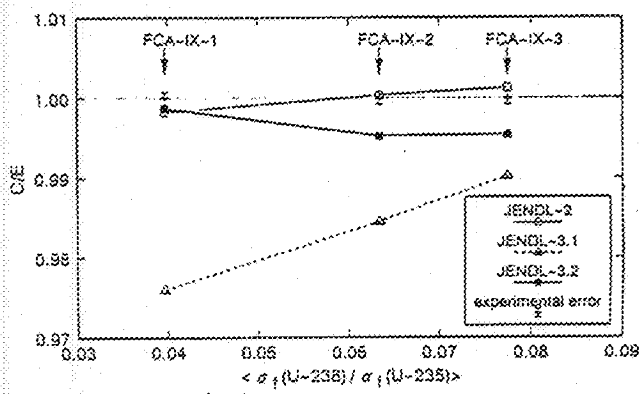

Fig.9 The C/E values of k_{eff} in FCA-IX-1,2 and 3

IV. CONCLUSION

The k_{eff} values of ^{235}U fueled thermal and fast reactor cores were well predicted with JENDL-3.2 as improving the underestimate by JENDL-3.1.

In Pu fueled cores, JENDL-3.2 was very satisfactory for the k_{eff} values in the thermal MOX lattice assembly. And in the fast reactor benchmark, the values calculated with JENDL-3.2 for k_{eff}, Doppler effect, sodium void reactivity, control rod worth and power distribution were in good agreement with the experimental results. But, the threshold fission rate ratio of ^{238}U to ^{235}U was underestimated by 6 % in ZPPR-9.

REFERENCES

1 K. Shibata et al.,"Japanese Evaluated Nuclear Data Library Version-3, JENDL-3," JAERI 1319 (1990).
2 H. Takano et al.,"Benchmark Tests of JENDL-3 for Thermal and Fast Reactors," Proc. Int. Conf. Physics of Reactors, Marseille, April, Vol. 3, PI-21(1990).
3 Y. Kikuchi,"JENDL-3 Revision-2 (JENDL-3.2)," to be presented at this conference, Gatlinburg, 1994.

B. Plutonium Cores

The k_{eff} values of the TCA cores with the MOX rods in the cell pitch from 1.8 to 2.5 cm are compared in Fig. 3. The calculations were conducted with the MVP code. The results of JENDL-3.2 predict very well the experiments.

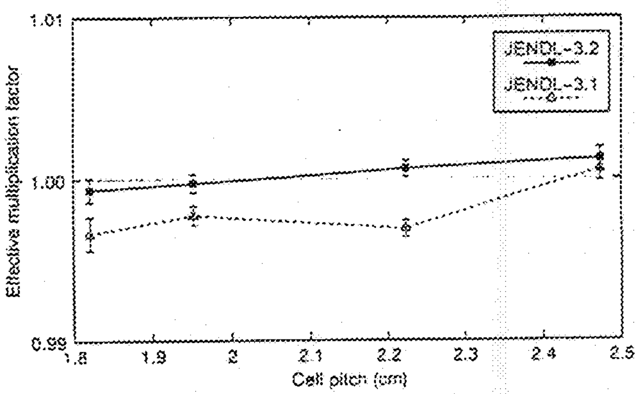

Fig.3 The k_{eff} values calculated for TCA-MOX cores

Ⅲ. FAST REACTOR BENCHMARK

A. GODIVA, JEZEBEL and FLATTOP

Very small cores with hard neutron spectrum were selected as plutonium fueled JEZEVEL,JEZEVEL-Pu,FLATTOP-Pu and THOR, enriched ^{235}U fueled GODIVA,FLATTOP-25 and BIGTEN, and enriched ^{233}U fueled JEZEVEL-23 and FLATTOP-23. These cores were analyzed by using the MVP code, and the results are shown in Fig. 4. The k_{eff} values for Pu cores are slightly underestimated excepting for that of THOR with thorium reflector. The results for ^{235}U cores are in good agreement with the experiments, and those of ^{233}U cores are improved but overestimated still.

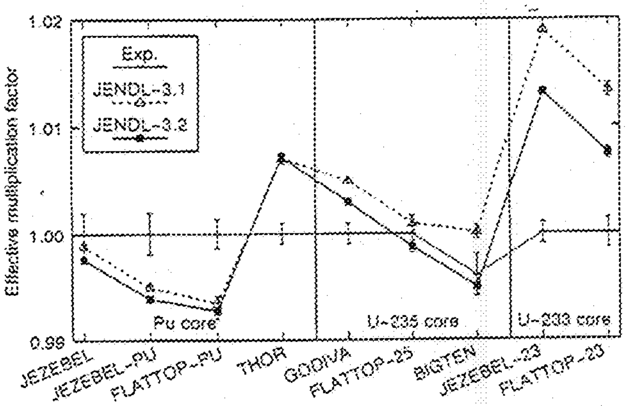

Fig.4 The k_{eff} values for hard neutron spectrum cores

B. ZPPR-9 and FCA-VI-2

The k_{eff} values are well predicted with JENDL-3.2 as shown in Table 1. In Table 2, the C/E values for Doppler reactivities of natural UO_2 sample are increased by JENDL-3.2 and become closer to the experimental values. Because the unresolved resonance region of ^{238}U is expanded up to 150 keV.

Table 1 The C/E values of k_{eff}

Core	JENDL-2	JENDL-3.1	JENDL-3.2
ZPPR-9	0.9991	1.0063	0.9967
FCA-VI-2	1.0066	1.0014	0.9992

Table 2 The C/E values of UO_2 Doppler reactivities

Core	Temp.(℃)	JENDL-2	JENDL-3.1	JENDL-3.2
ZPPR-9	300-487	0.91	0.94	0.96
	300-644	0.92	0.95	0.97
	300-794	0.89	0.92	0.94
	300-935	0.93	0.96	0.98
	300-1087	0.92	0.95	0.97
FCA-VI-2	300-823	0.93	0.91	0.95
	300-1073	0.93	0.91	0.95

The C/E values of central reaction rate ratios for ZPPR-9 are shown in Fig. 5. The fission rate ratios of ^{238}U to ^{235}U and ^{239}Pu are underestimated by about 6 %

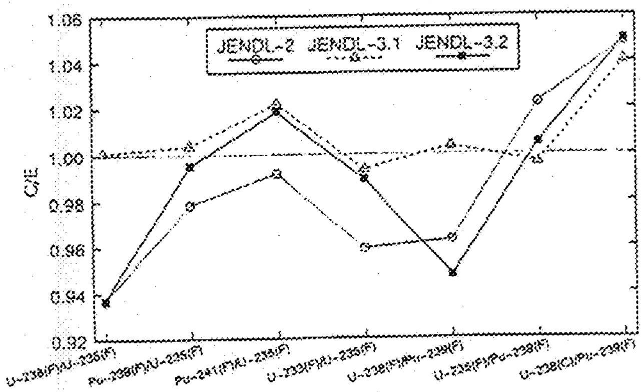

Fig.5 The central reaction rate ratios in ZPPR-9