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REVIEW OF FAST REACTOR PHYSICS ACTIVITIES RELEVANT TO LMFBR PROGRAMME IN PNC JAPAN

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A brief review of the recent activities in fast reactor physics, together with the progress in the fast reactor development programme is presented in the following.

(1) JOYO Mark-I

Construction of the Experimental Fast Reactor, "JOYO" Mark-I, which is a 50 MWT loop type fast reactor using mixed oxides of plutonium and uranium (18% PuO_2 - 82% UO_2), has progressed and installation of all the components is expected to be completed by the end of June 1974. Preparation for the commissioning tests which will be started this summer is now under way.

"JOYO" is expected to reach criticality in the summer of 1975. Table 1 shows the time schedule of "JOYO" and "MONJU".

Regarding R & D activities in the field of reactor physics for "JOYO", a series of mock up experiments using FCA under a contract between PNC and JAERI, and their analyses was completed in March 1972.

Looking back on the past, FCA V-1 and V-2 assemblies were physics mock up cores of "JOYO", having simple cylindrical cores with uranium metal blankets of approximately 160 and 220 liters, respectively. In the V-3 assembly, a series of measurements on the mock up control rod worths, including detailed studied on the interference and heterogeneity effects was performed. The effects of radial oxide blanket on criticality, control rod worth and fission rates and gamma ray energy deposition distributions up to the in-vessel fuel storage rack were investigated on a V-3B

assembly. The C/E values of main measured parameters are summarized in Table 2.

The study of safety analysis relating to maximum reactor power at the second step of operation has been completed and the development of an operation monitoring code system using simple conventional design calculation methods are in the final stage.

On the other hand, preparations for measurements and analyses of the core performance at low power operation subsequent to reaching criticality are in progress. For the study on burn up physics, a measuring equipment using gamma ray spectroscopic methods, together with relevant data processing codes has been produced and three dimensional burn up calculation codes have also been developed. The validity of this system in burn up physics have not been confirmed sufficiently because of lack of experimental data on burn up. We are intently in search of burn up data and/or irradiated fuel samples.

(2) "JOYO" Mark-II

The design work on "JOYO" Mark-II core has progressed. The objective of the Mark-II core is to obtain a maximum neutron flux above 5×10^{15} n/cm^2-sec and as wide a irradiation zone as possible.

The designed core of Mark-II consists of two zones; core zone and reflector zone, in which fuel pellets of smaller diameters and of higher plutonium enrichment than those of Mark-I and steel as reflector material were considered from the standpoint of heat removal and neutron economy.

"JOYO" Mark-II core will be operated at 100 MW thermal. Application for the Safety Evaluation by JAEC is planning to be made forward the end of next year.

Reactor physics experiments and analyses on "JOYO" Mark-II core have already been performed in the FCA V-2R assembly, in which the effects of steel reflector, instead of blanket, on keff, fission rate distributions, etc. were studied.

Comprehensive analyses of experimental data from the mock up assemblies of Mark-I and Mark-II cores were completed and their results were effectively reflected in the design of Mark-II and Mark-I cores.

(3) "MONJU"

The third conceptual design of "MONJU", which is a 714 MWt, 300 MWe loop type fast breader reactor, was completed in last June, and refinement of the design is now under way by evaluating various advantages and disadvantages in different design concepts and by taking into account the results of various research and development activities.

Check and review on the final design will be conducted by JAEC this year, followed by Safety Evaluation. The construction of "MONJU" is expected to begin immediately after the Safety Evaluation, with a target for criticality set for 1980. The time schedules of the "MONJU" and the "JOYO" programmes are shown in Table 1.

The "MONJU" core consists of two regional core and depleted uranium blanket, and fuel is made up of plutonium and depleted mixed uranium oxides. The expected mean fuel burn up and breeding ratio are 80,000 MWD/T and 1.2, respectively.

For the reactor physics activities on the "MONJU" core, full scale mock up experiments, which was called the MOZART programme and carried out under collaboration with UKAEA was completed in early 1973. In this programme, a great deal of valuable information necessary for predicting physics parameters of the "MONJU" core were obtained.

On the other hand, a partial mock up experiment programme using FCA under a contract between PNC and JAERI was started in 1972 and is still in progress. FCA VI-1 and VI-2 assemblies are physics mock up cores which simulate the outer and inner regions of the "MONJU" core, respectively, and experiments on these assemblies have been completed. The VI-3 assembly is also a physics mock up core which is a combination of inner and outer cores of "MONJU", and experiments on this assembly will be continued until July 1974. The FCA VII assembly, which is a partial mock up core of a sectorial region of the "MONJU" core, is planned to be built, by the end of this fiscal year, after modification of the FCA. On this assembly, radial distributions, especially in boundary regions between cores and between core and blanket, of several physics parameters and the effects of mock up FP will be the central purpose of the study.

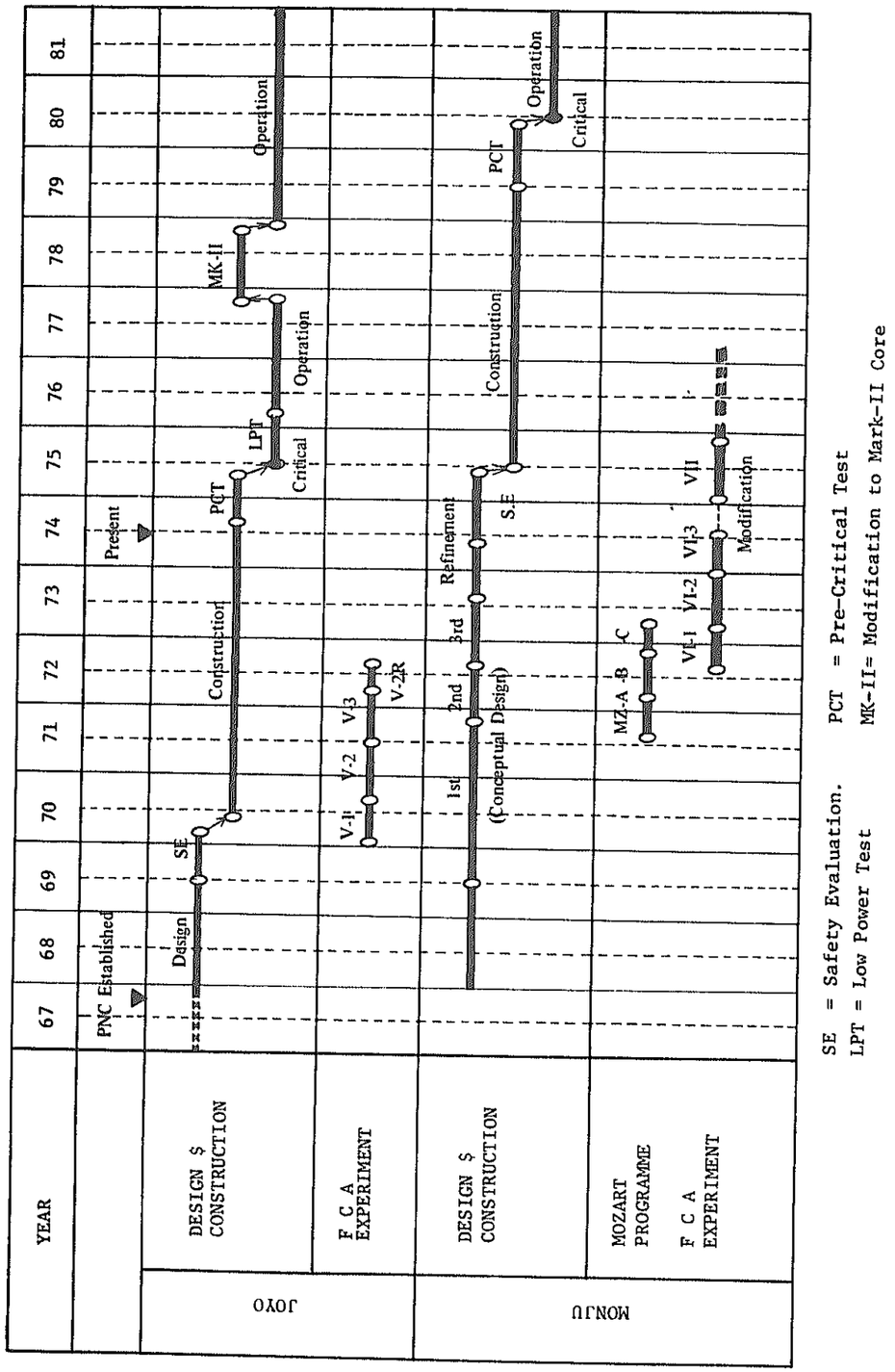
A great deal of experimental data obtained from the FCA and MOZART programmes have been analized by several major industrial groups and JAERI under the direction of

PNC, and their results have been reflected in good timing to the design of "MONJU" and with good effect, through the improvement of cross sections and calculation methods. Present work is, therefore, focused on the detailed analyses of important parameters for core design and safety analyses.

Furthermore, systematic analyses of the integral data gathered from FCA, MOZART, ZPPR and other assemblies are under way to make a comprehensive evaluation of the validity of Japanese design calculation methods.

On the other hand, assessment work of the accuracies in the prediction of physics parameters of the fast power reactor are in progress, in parallel with the study on how to extrapolate the results obtained from mock up assemblies to a fast power reactor. Preliminary results of this study are presented at this meeting.

Table 1. LMFBR development and reactor physics programmes



SE = Safety Evaluation. PCT = Pre-Critical Test
LPT = Low Power Test MK-II= Modification to Mark-II Core

Table 2. C/E Values from the mock-up experiment for "JOYO"

Quantity	C/E
(1) Keff (fresh core)	0.995 ± 0.005
(2) B_4C rod worth (90% B-10)	1.05 ± 0.07
(3) Fission rate distribution	
in core	1.00 ± 0.02
in blanket	0.9 ~ 0.8
(4) Doppler reactivity (Sample)	$1.1^{+0.2}_{-0.1}$
(5) Material Worths	
Fuel	$1.15^{+0.2}_{-0.05}$
SUS	0.80 ± 0.15
(6) Na-void reactivity	
core center	0.6 ± 0.2
large volume in core	0.75 ± 0.2

Table 3. C/E values from the mock-up experiment for "MONJU"

Quantity	C/E
(1) Keff (fresh core)	1.009 ± 0.3%
(2) B_4C rod worth (80% B-10)	1.061 ± 7.6%
(3) Fission rate distribution	
in core	1.00 ± 3%
in blanket	0.95 ~ 0.87
(4) Doppler reactivity	——
(5) Material Worth	
Fuel	1.15 ± 11%
SUS	0.91 ± 18%
(6) Na-void reactivity	
core center	1.01 ± 16%
off center	1.37 ± 20%