PROGRESS OF FULL MOX CORE DESIGN IN ABWR

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[Objectives] Full MOX core design in ABWR having favorable features for MOX utilization is developed comprehensively on the core performance and safety evaluation. The nuclear design method is validated with the criticality analyses of JAERI's TCA experiment by comparing the errors for full MOX cores with those for full UO₂ cores.

[Full MOX Core Scheme] Full MOX core design has been developed in ABWR with wider lattice pitch than conventional BWR (larger H/HM ratio) meaning the mitigation of void coefficient change effect with MOX loading. The main design concepts of full MOX core are as follows.

(1) MOX bundle configuration is selected to be the same design as STEP-2 UO₂ bundle (39.5GWd/t discharge exposure) having plenty of operational experience. This bundle has the large central water rod in the central region of 8x8 fuel rod configuration.

(2) MOX bundle exposures are selected to be the same exposures as STEP-1 UO₂ bundle (33GWd/t discharge exposure and 40GWd/t maximum bundle exposure), which are based conservatively on the MOX irradiation experience.

(3) The bundle average fissile material content is selected to be about 3wt% as Pu content and about 1wt% as U-235 enrichment in the design based on depleted uranium matrix and Gd containing rods with enriched uranium for the conditions of 13-month cycle length and standard Pu₃ fraction of 67wt%.

(4) Full MOX core is planned by EPDC to reach gradually from the initial core, loaded with MOX bundles up to about one third, where UO₂ bundle loaded together with MOX is 9x9 high burnup bundle (STEP-3: 45GWd/t discharge exposure).

[Core Performance and Safety Evaluation] Core performance on thermal margin and shutdown margin of full MOX core has similar characteristics to those of UO₂ core for the range from full UO₂ to full MOX, where MCPR is higher in the full MOX core owing to its lower radial power peaking, compensating for the ascending of MCPR operating limit (OLMCPR) due to void coefficient increase (Fig.1,Fig.2). Safety parameters, i.e. reactivity coefficient (void coefficient, Doppler coefficient) and dynamic parameters (delayed neutron fraction, prompt neutron lifetime) are affected continuously depending on the MOX loading fraction.

Based on the above safety parameter and MOX property, safety analyses have been performed on stability, abnormal transient during operation, transient and accident for control rod system, and accident, showing the conformity to the design criteria.

[Validation of Full MOX Nuclear Design] Besides ample operational experience where Pu builds up to about 60% fission fraction at the time of discharge, BWR nuclear design method has been verified for MOX configuration through MOX mock-up criticality experiment (partially loading of MOX bundles at VENUS facility) and lead-use basis utilization (irradiation of two MOX bundles at Tsuruga Unit-1). In order to confirm the applicability of the design method to full MOX cores, Tank-type
Critical Assembly (TCA) experiment data is employed and analyzed on criticality and power distribution measurements from the uniform MOX rod arrays (48 cases) and the uniform UO$_2$ rod arrays (40 cases), including different H/HM ratios. The evaluated result shows the equivalent accuracy between full MOX (Fig.3) and full UO$_2$ as follows.

(1) For criticality, full MOX analyses have the identical evaluation results as UO$_2$ analyses within the standard deviation (0.2%k) in both cases.

(2) For power distribution, full MOX analyses have the almost same deviation (1%2%: root mean square of the difference between calculation and measurement) as UO$_2$ analyses.

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**Fig.1** Cold shutdown margin of the equilibrium cycle core

**Fig.2** Minimum critical power ratio of the equilibrium cycle core

**Fig.3** Comparison of calculation and measurement of relative fuel rod power for TCA full MOX criticality experiment