SIMMER-IV Simulation of a Single Control Rod Withdrawal Transient

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A single control rod (CR) withdrawal transient in a critical MYRRHA core is studied for the ANSELMUS EU-Project [1], where in particular spatial kinetics 3D effects are investigated. A new control rod withdrawal (CRWD) model for the SIMMER-IV code is developed so that the CR movement with a constant speed can be simulated. The spatial kinetics effect on the power shape is evaluated by comparing local relative power densities and the total one.

Keywords: SIMMER-IV, spatial kinetics, 3-D effect, single CR withdraw, MYRRHA reactor, ANSELMUS Project

Introduction

In the framework of the ANSELMUS EU-Project [1], a CR withdrawal (CRWD) transient is simulated with SIMMER-IV for a MYRRHA critical reactor model, where one of the six control rods is withdrawn at a certain speed. The purpose of this exercise is to investigate the 3-D spatial effects on power evolution during the transient and to use these 3-D results to examine the simple point-kinetics (PK) model.

The SIMMER code (SIMMER-III (2D) and SIMMER-IV (3D)) [2, 3] includes advanced fluid-dynamics/multiphase-flow and space-dependent kinetics neutronic transport models. In particular, SIMMER-IV is identified as the code that can perform the analysis for the project. At KIT, a MYRRHA sub-critical core, design version V1.4, was been investigated with SIMMER-IV in the past [4]. This serves as a good basis for this study and is adapted accordingly.

SIMMER-IV CRWD Model and Simulation

In the CRWD model, the control rod consists of absorber material, e.g. B_4C, and steel, which are movable in the particle form. The SIMMER code has been extended in order to control the movement of such a CR assembly. **Figure 1** shows the geometric set-up of the CRWD model.

Figure 2 shows the simulation core map, with the CR to be withdrawn, the neighboring FA near the CR and the peaking FA in the core center marked in yellow, blue and red. The core is loaded with MOX fuel with 33% Pu, so that the reactor is critical. β_{eff} is 343 pcm and the CR to be withdrawn, marker in yellow, has an integral,worth of about 0.85 $. The control rod is withdrawn downwards from a fully inserted position to a position outside the active

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core. **Figure 3** shows the CR withdrawed reactivity vs the axial position of the B_4C, i.e. the interface between pins and dash ram in **Figure 1**.

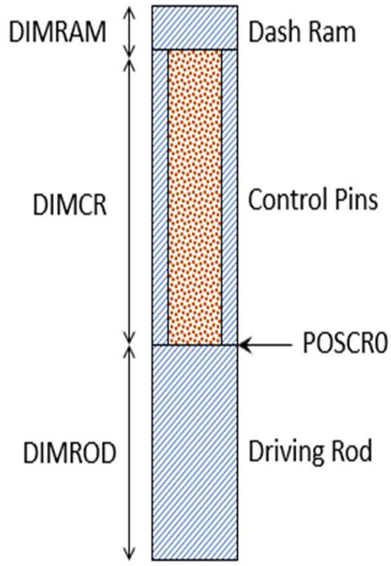

Figure 1. Geometric set-up of the CRWD model

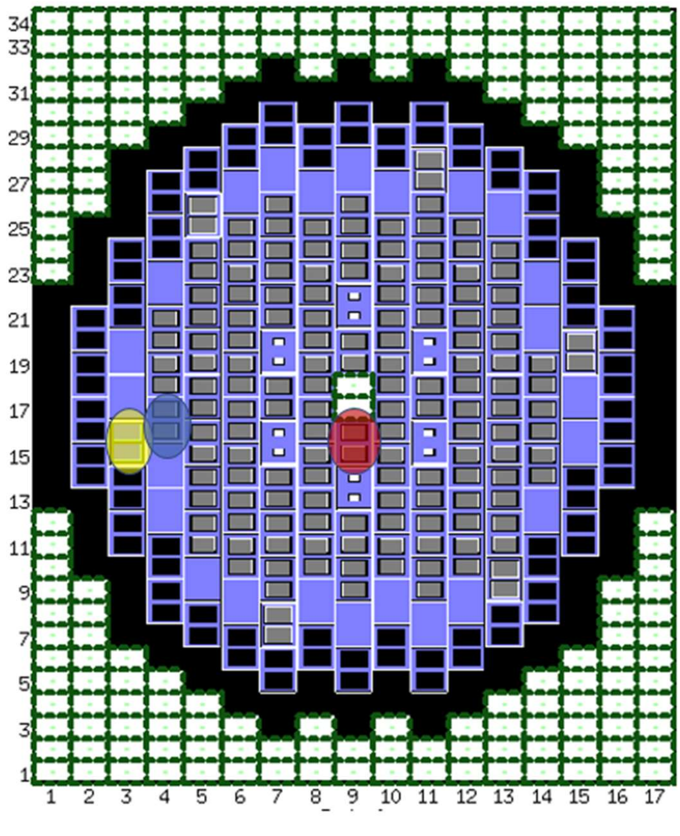

Figure 2. SIMMER-IV simulation model, with the CR to be withdrawn, the neighboring FA and the peaking FA in the core center marked in yellow, blue and red, respectively.

Results and Discussion

The results for a full control rod withdrawal in 3-seconds-corresponding to insertion of about 0.27 $/s are presented in **Figure 4.** It shows the power of the peaking FA, the neighboring FA and the average FA. Because of the positive reactivity insertion during the CR withdrawal, the FA power increases and then due to Doppler feedback stabilizes at a higher power level. The FA power is normalized by its initial value. The peaking FA clearly behaves almost same as the average one, while the neighboring FA increases 15% more than the average one. Of course, this is the local 3-D effect of the withdrawn CR.

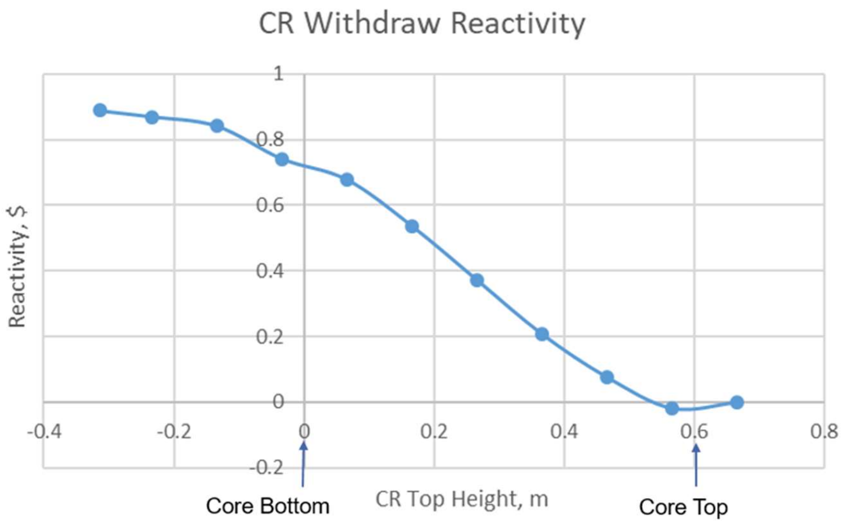

Figure 3. CR withdrawal reactivity as function of the axial position of B4C top margin.

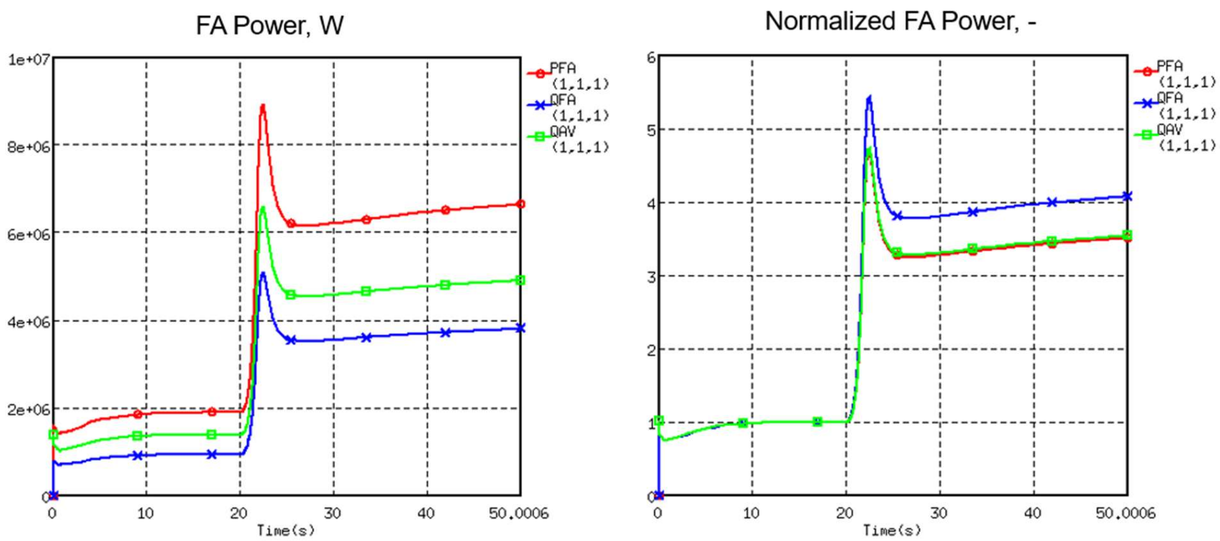

Figure 4. Transient results of FA power (left) and normalized FA power (right). The CR withdraw starts at 20 s and no scram is turned on. PFA (red), QFA (blue) and QAV (green) stand for the peaking FA, the neighboring FA and the average FA, respectively.

Conclusion

This study shows that the single CR withdraw can cause an average power increase by about 5 times and a local power overshooting at the neighboring FA by 15%, but there is almost no effect on the peaking factor of the hottest fuel assembly.

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