Investigation on Nodalization Effect for a KNS-169 Experiment

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1. Introduction

Non uniform nodalization effect was studied using a KNS-169 49 % blockage experiment which had been run by KfK at Karlsruhe, Germany [1] as parts of experiments performed by Liquid Metal Boiling Working Group (LMBWG). The MATRA-LMR/FB calculation results have usually provided stable and reasonable results for the SFR application [2], regardless of a node size distribution. However, it was presumed that nodalization schemes might have an effect on the application to experiments. The present study demonstrates comparisons of the results obtained by applying the MATRA-LMR/FB to the experiment using three nodalization schemes. Those calculation results were also compared with other code predictions. A distinctive discrepancy was found between the results based on the nodalization schemes in the analysis.

2. Analysis

2.1 Simulation of the experiment

Figure 1 shows a schematic of the KNS test section for the 49 % blockage experiment. The heating section extends from from 275 mm to 565 mm above the inlet. A blockage is located at 312 mm with a thickness of 3 *mm*. There are 66 sub-channels which are partially blocked by the edge of the blockage plate. Therefore, reduction of those flow areas and gap distances due to the blockage plate was taken into account [3] for the analysis. There are totally 6 grid-spacers for the test section. Each grid-spacer was represented by reducing the flow areas properly and by adjusting the form loss coefficient. Three nodalization schemes were applied in the calculation, i.e. one uniform and two non-uniform nodalizations.

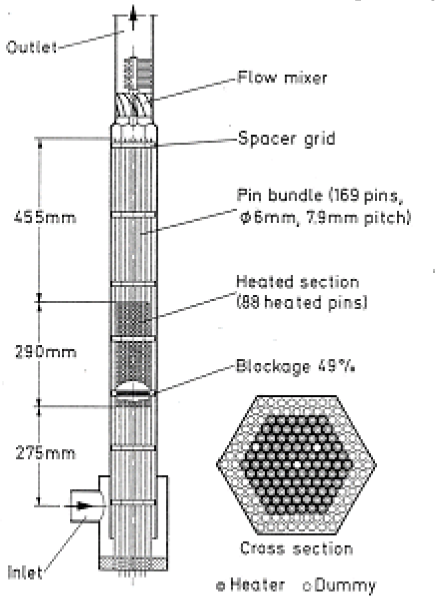
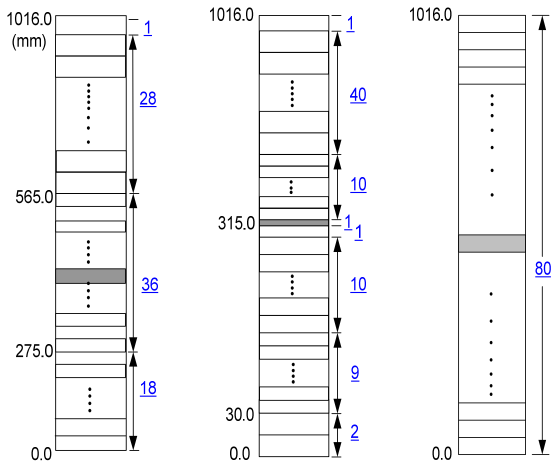


Fig. 1 Schematic of KfK KNS-169 test section



(a) 18-36-28-1 (b) 2-9-10-1-1-10-40-1 (c) Uniform (80)

Fig. 2 Nodalization schemes

Figure 2 depicts those three schemes applied to the test section modeling. In the uniform nodalization scheme, the total length (1016 *mm*) of sub-channels in the test section was equally divided with a uniform size of 1.27 *cm* as shown in Fig. 2(c). Two non-uniform nodalizations were made of (a) 4 zones; 18-36-28-1 (1.53, 081, 1.56, 1.50 *cm*, respectively), and (b) 8 zones; 2-9-10-1-1-10-40-1 (1.50, 1.40, 1.50, 0.89, 0.60, 0.75, 1.50, 2.0 *cm*, respectively). Total numbers of the nodes were 83 and 74, respectively. In the scheme (a), the whole heating zone (290 *mm*) was modeled with 36 single sized nodes, and the other nodes were sized close to the thickness of a grid-spacer. The node size of the heating zone was almost a half of those of the other zones. The blockage was one of the heating zone nodes. In the scheme (b), the test section was also segmented into sizes close to the size of a grid-spacer, but the heating zone was not distinguished in the nodalization. The blockage was represented with one node and its size was given 6 *mm*.

2.2 Analysis results

Figure 3 shows a result of transient temperature behaviors of a sub-channel based on the three different nodalizations. The temperature evolved smoothly with time without a fluctuation as it approached to the steady state for the case of the uniform nodalization. The cases of non-uniform nodalization with 4 and 8 zones, however, didn't exhibit a stable behavior as observed in the uniform nodalization. The 4-zone nodalization gave a smoother behavior than the 8-zone scheme. Thus, a larger error must be involved in the 8-zone scheme.

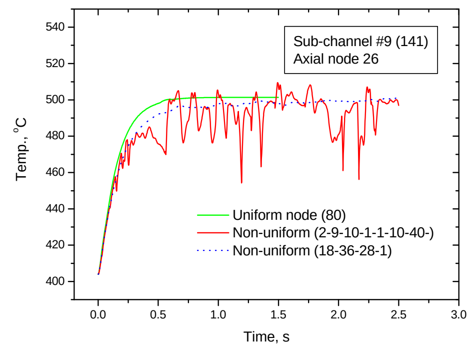


Fig. 3 Transient temperature evolution

The calculated velocities along the radial sub-channels were compared with both experimental data and other code predictions in Fig. 4. All trends followed those of other code predictions, and a point from the experiment was also consistent with the predictions.

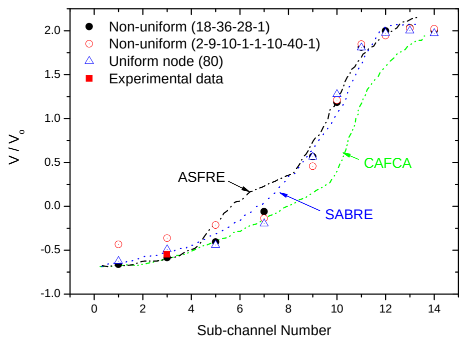


Fig. 4 Radial sub-channel velocity distributions

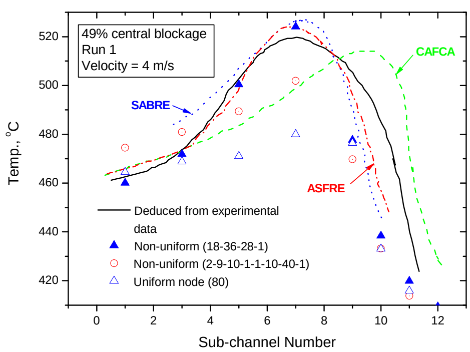


Fig. 5 Predictions for radial temperature distribution

The radial sub-channel temperatures obtained from the MATRA-LMR/FB calculation based on the three schemes, were displayed with both the experimental data and other code predictions in Fig. 5. A closer behavior to the experimental data was observed with the scheme (a) than the scheme (b), and the scheme (a) also followed the trends of other code predictions better. The uniform nodes followed neither the experimental data nor other code predictions in both trend and magnitude.

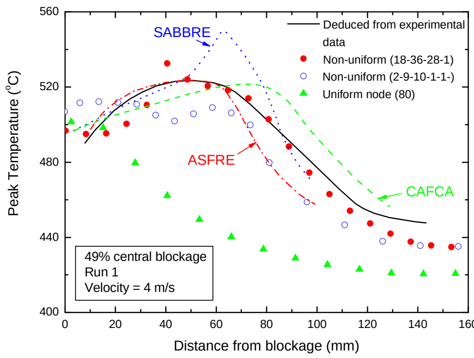


Fig. 6 Axial distributions of peak sub-channel temp.

The comparison of the axial temperatures was presented Fig. 5. Similar results were obtained with both non-uniform nodalizations, while it was clear that the uniform nodalization did not properly represent the experimental data.

3. Conclusion

The effect of the three nodalization schemes in the MATRA-LMR/FB was investigated by applying them to a KfK KNS-169 test. As a result, detailed nodalization did not always give a better result. It was clear that the experimental data was not well represented with a uniform nodalization in both trend and magnitude. Therefore, it is desirable for the MATRA-LMR/FB calculation that the nodalization of a system would be made depending on a thermal rapidness rather than a geometrical configuration for a better analysis. More tests should be simulated to ensure the MATRA-LMR/FB reliability throughout various sensitivity analyses.

REFERENCES

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