

# CFD Modelling of VVER-440 Fuel Rod Bundle and Fuel Assembly Head for Thermal-Hydraulic Analysis

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**Abstract.** This paper presents a CFD analysis of coolant flow and heat transfer in a VVER-440 fuel assembly, including both the fuel rod bundle and the fuel assembly head. A detailed 3D computational model was developed and validated against experimental data from a full-scale VVER-440 facility at the Kurchatov Institute. Due to computational limitations, the fuel rod bundle was modeled using a 60° sector approach, and results were compared with subchannel calculations using the CALOPEA code, showing good qualitative agreement. CFD simulations provide a higher level of detail than subchannel methods, capturing local variations of temperature and velocity within subchannels. Sensitivity analyses of turbulence models showed only minor differences in global results, with the RNG  $k-\epsilon$  model giving slightly better agreement with experiments, while the Realizable  $k-\epsilon$  model exhibited more stable convergence. The flow in the fuel assembly head was identified as inherently unsteady, requiring iteration-averaged evaluation. Although the sector model limits lateral mixing, the main thermo-hydraulic phenomena, including the effects of spacer grids and bypass flows, were successfully reproduced. The validated CFD model provides reliable boundary conditions for further analyses and supports the development of improved fuel assembly designs.