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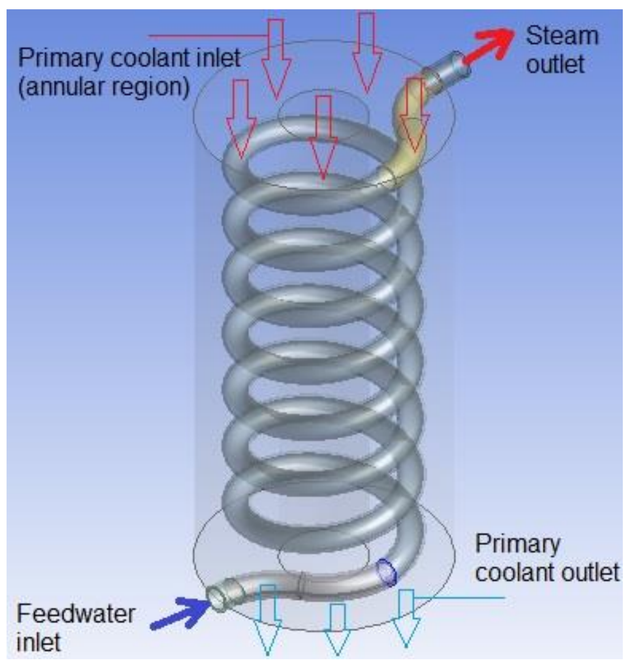
Computational Fluid Dynamics Approach for Optimizing Temperature and Flow Profile in a Natural Circulation Based Integrated SMR

A. SHAFIQUE
Pakistan Nuclear Regulatory Authority
Karachi, Pakistan
Email: ammar.shafiq@pnra.org

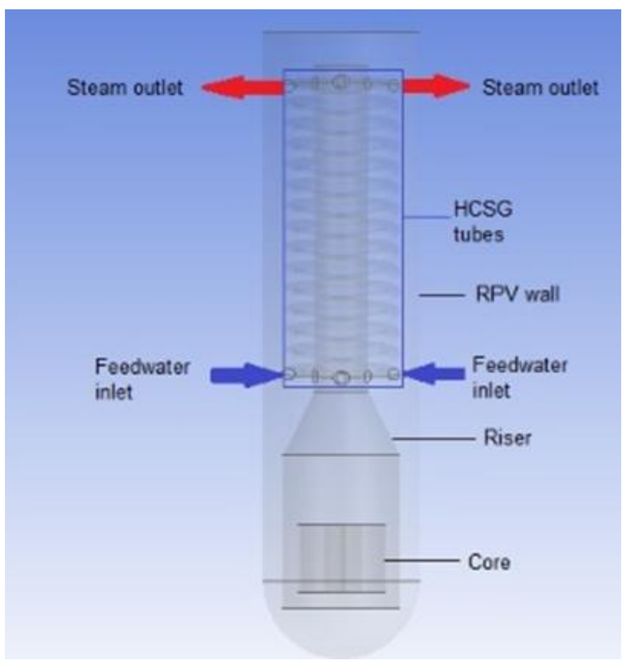
INTRODUCTION

- Flow assessment was performed for natural circulation based primary coolant system in an integrated SMR.
- Secondary side temperatures were computed for two inter-woven helical coil steam generators (HCSGs) by fluid-structure-interaction (FSI) analysis.
- CFD analysis was performed for the temperature and gravity driven naturally circulating primary coolant inside the reactor pressure vessel. Velocity vectors were obtained.

MODELING METHODOLOGY

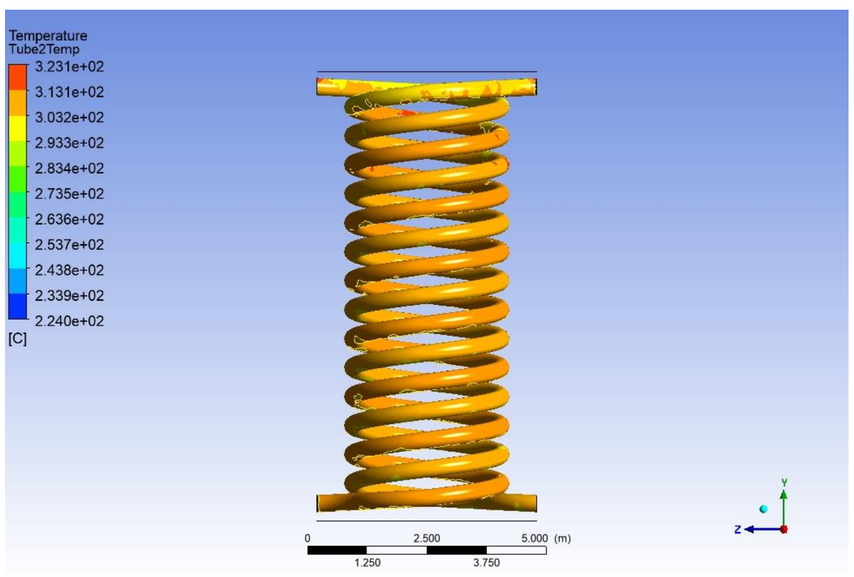


FSI modeling methodology for the secondary side with flow boundary conditions

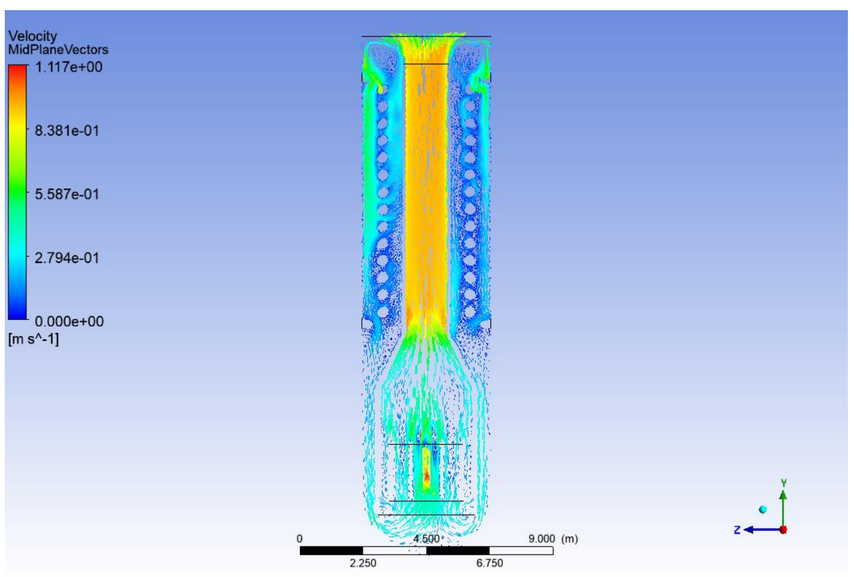


Primary system flow regime model – helical coils modeled as solid boundaries

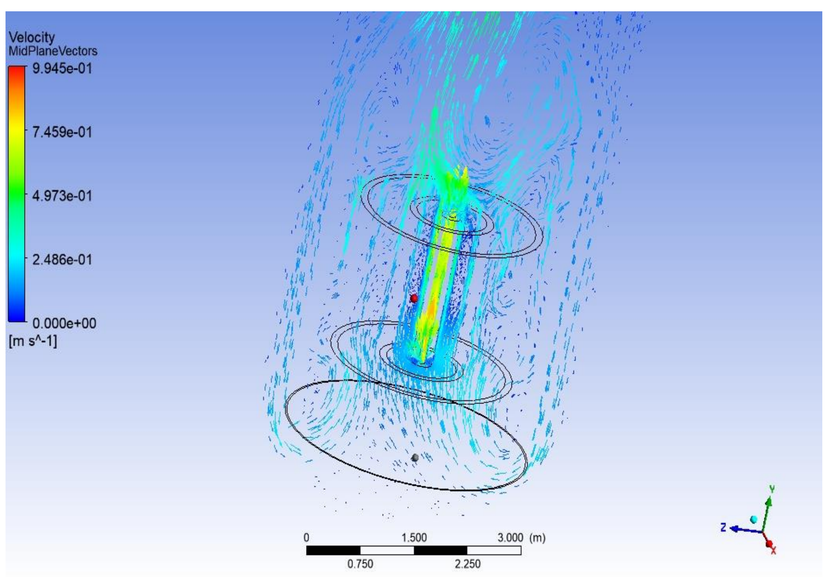
CFD RESULTS



Temperature (secondary side) boundary conditions computed



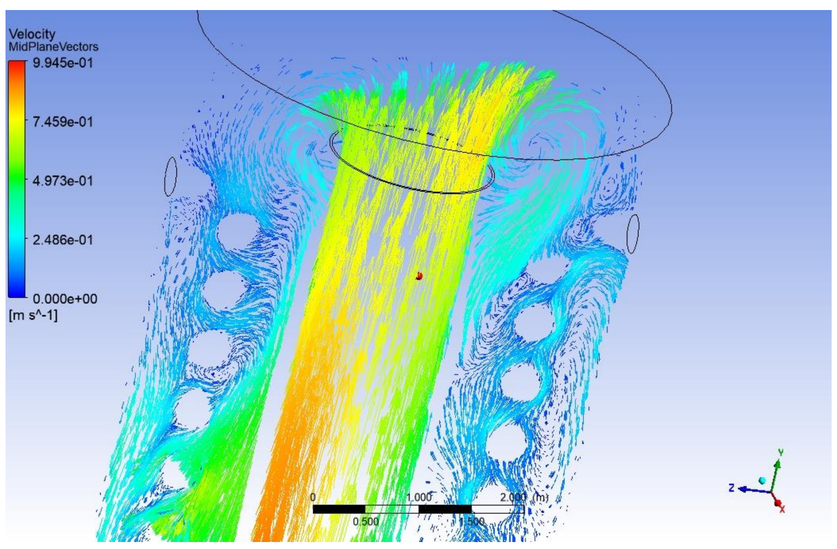
Velocity vectors showing naturally circulating flow between the core and HCSGs



Primary coolant travelling upwards (and accelerating) through the core

CONCLUSION

- The 2-tube HCSG configuration removes more heat than the 1-tube HCSG configuration – a difference of 25^{o}C.
- Increasing the number of HCSG tubes increases the primary coolant flow velocity (1.429 m/s for 1-tube and 2.07 m/s for 2-tubes HCSGs).
- Increasing elevation difference between the core and HCSGs (from 3.5 m to 4 m), for both HCSG configurations, increases the velocity by ~0.2 m/s
- No flow instabilities (flow reversals) were observed.



Primary coolant exiting the riser, then traveling down, exchanging heat with the HCSG tubes