PROTECTIVE COATINGS FOR ACCIDENT TOLERANT FUEL CLADDING: IMPACT OF INNER-SIDE CHROMIUM COATING ON REACTOR NEUTRONIC PERFORMANCE

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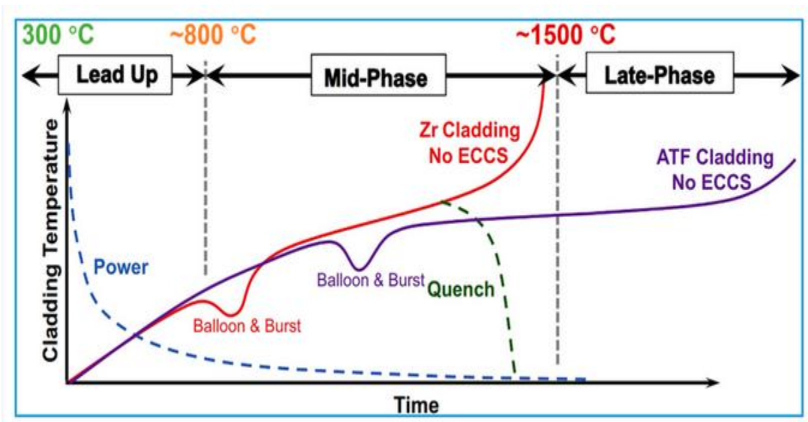
- Protective coatings on Zirconium based claddings are one of the proposed near-term concepts to enhance Accident tolerance (ATF) of LWRs fuel.
- Expected to improve corrosion resistance in severe accidents, and enhance cladding performance during normal operation, without introducing major design changes.
- Metallic showed promising performance as potential coating material.



Potential delaying effect of accident-tolerant fuel (ATF) cladding [1]

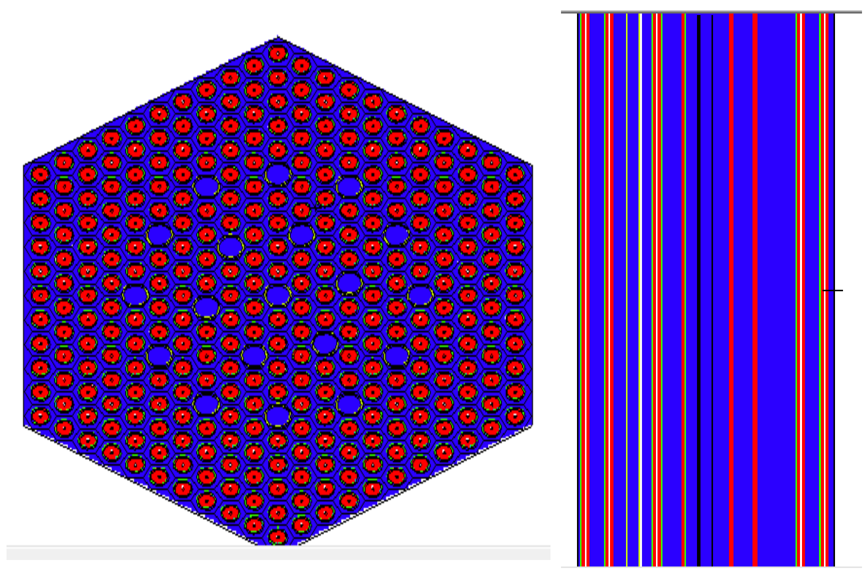
- Concerns that Inner uncoated side of fuel cladding may expose to the oxidizing environment under some circumstances (clad burst).
- Coatings are expected to work within the same designs of current LWRs.
- It's crucial to study the effects of their introduction into LWRs system.

Objective

- Assessment of Neutronic performance upon applying thin films of chromium on the inner side of nuclear fuel claddings.

Methodology

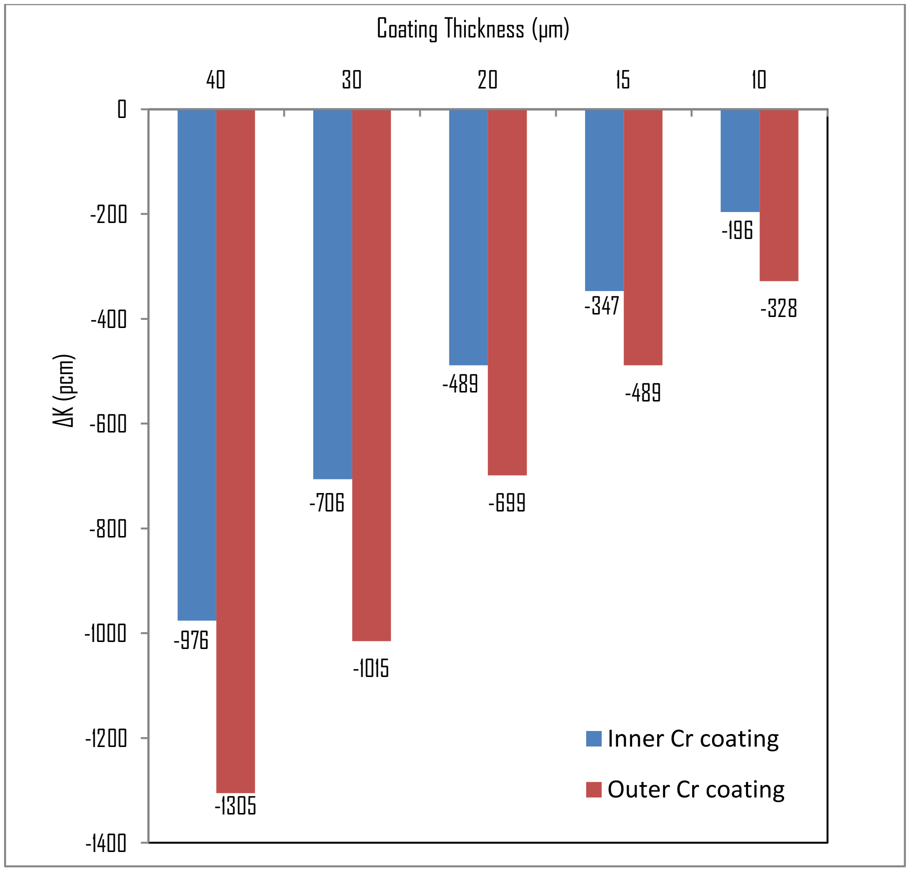
- Neutronic calculations performed using Monte Carlo probabilistic code MCNPX.
- The model used is based on VVER-1200 single fuel assembly
- Fuel assembly contains 312 fuel rods, 18 guide tubes and one central instrumentation channel
- Zirconium based Alloy E110 is used as cladding material
- Enrichment assumed 4.5%.
- An interior chromium coating applied with four different thicknesses 10, 15, 20, 30 and 40 μ,
- The deviation of the multiplication factor from reference case is calculated for each thickness
- Neutron flux behavior observed.
- Results also compared to outer side chromium coating.



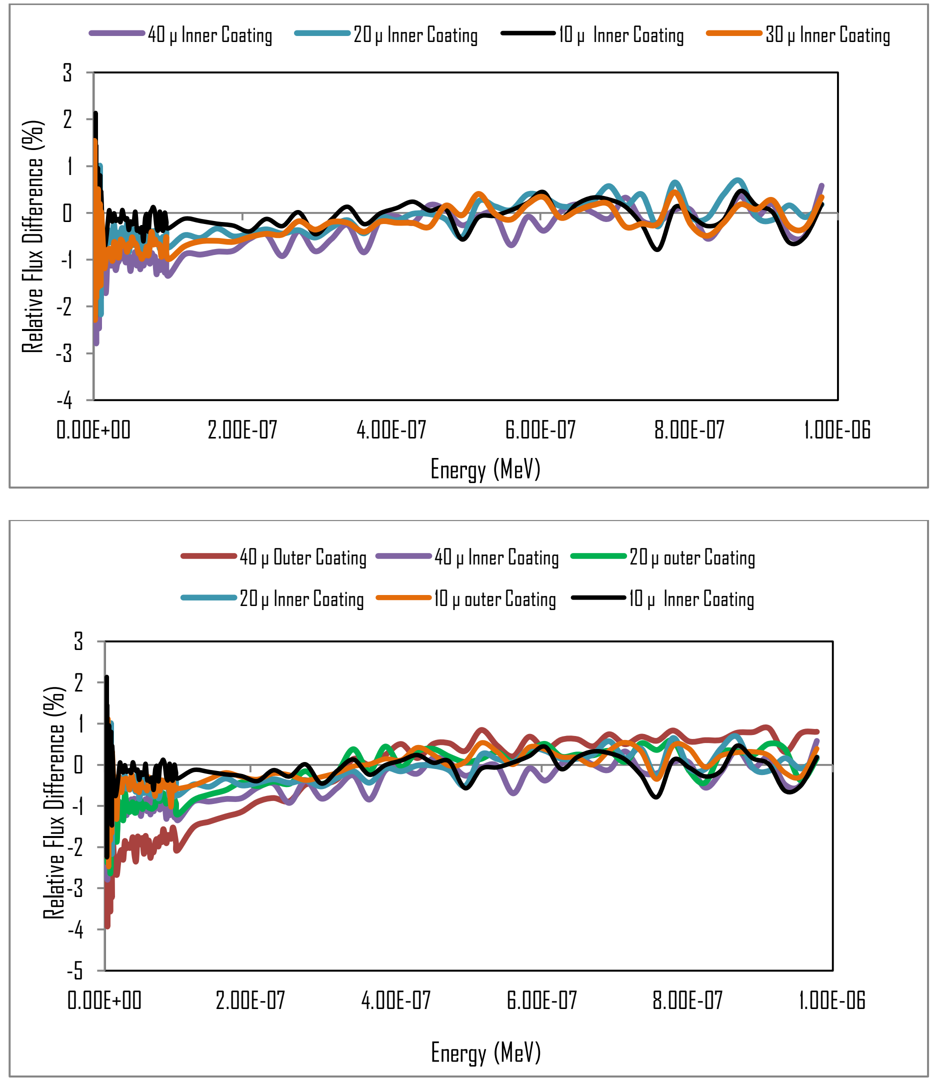
2D Reference VVER-1200 Fuel Assembly as generated by MCNPX

Results

- A small deviation in reactivity was observed.
- Increases with the coating thickness.
- Still remains smaller than the case of applying same thickness on the exterior side of claddings.
- Decreasing moderation due introduction of coatings on external surfaces leads to higher penalties.
- The presence of the inner chromium coating has small impact on the overall flux.
- Flux reduction on thermal region observed.



Reactivity penalties for inner coatings compared with external ones



Neutron Flux for inner-side coating and its comparison with external coatings flux changes

References

[1] Chen, Xiaoming Wang and Ruiqian Zhang, Application and Development Progress of Cr-Based Surface Coatings in Nuclear Fuel Element: I. Selection, Preparation, and Characteristics of Coating Materials, 2020, Coatings-MDPI.