# Evaluation of C35MN clad as Accident Tolerant Fuel for Small Modular Reactors

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**Abstract:** This presentation analyses the viability of C35MN, a FeCrAl alloy developed at Oak Ridge National Laboratory as a contender for ATF in PWR-SMRs. This paper is a summary of the research done by the authors to study the neutronics aspect of ATF and compare the changes it brings along with the pre-existing standards (PWR) and future research plans.

**Keywords:** ATF, SMR, neutronics, CBC, FeCrAl alloys.

**1. Introduction:** In the wake of the Fukushima Unit 1 accident, research into alternative materials for use as cladding in Pressurised Water Reactors to prevent severe accidents. C35MN alloy was considered in this research due to its slow rate of oxide formation during operating and accident scenarios, low propensity for propagation of irradiation induced defects and its mechanical properties [1][2]. This research utilises the Montreal Version5[3] code developed at Polytechnique Montréal to gauge the differences in reactor operation when C35MN clad is used.

**2. Method:** A two-step, 26 energy group was done on a core with 37 traditional 17 x17 fuel assemblies along with axial and radial reflectors. The 2D DRAGON [3] calculation was done using transport theory over a 1400-day period to simulate a 4-batch fuel cycle, then a full core 3D DONJON [3] diffusion theory calculation for a 400-day operating cycle was conducted using the COMPO files extracted from DRAGON. A comparison was conducted to study the changes in the various reaction rates, flux spectra, fission product generation and Critical Boron Concentration (see fig.1). The 200MWth SMR design uses three fuel assemblies with enrichments 3.2%, 3.8% and 4.2% for Zircaloy4 and 4.2%, 4.4% and 4.6% for the C35MN cladding with an EOC burnup target of 52GWD/thm. The Zirclaoy4 clad has the standard thickness of 0.05715cm and the C35MN clad has thickness 0.045cm [4].

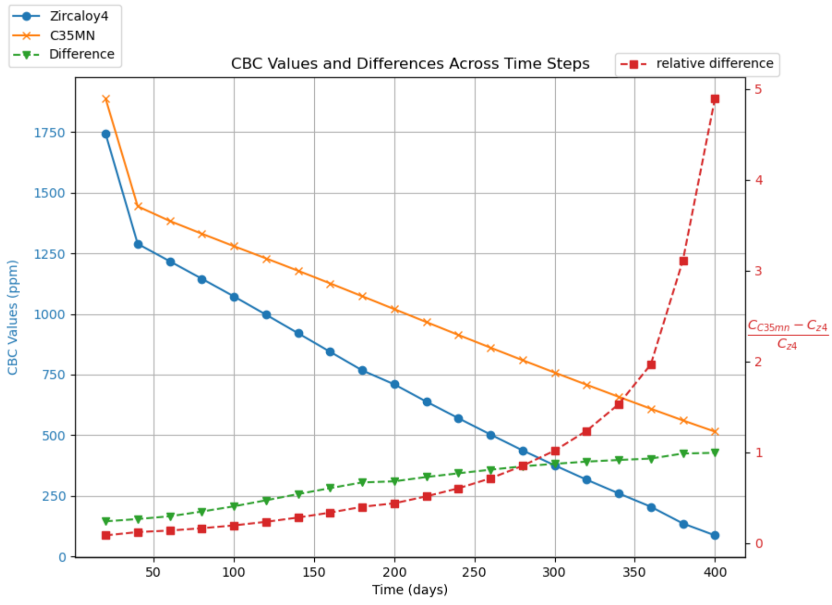


*Fig.1 Comparison of the CBC for the two clad cases*

**3. Result:** There is minimal change in the flux spectra and reaction rates in the hard end of the spectra but substantial change in the soft end and due to this change in the reactor characteristics, a variation in the amount of fission products generated is seen. To maintain criticality for the same cycle length and batches, an increase in enrichment from the initial loading of 3.2% for Zircaloy4 to 4.8% for C35MN is needed along with an increase in the amount of soluble Boron.

**4. Conclusion:** The results show that for the above considerations, the operation of a reactor with C35MN clad, in terms of cycle length, enrichment and soluble boron amount, is possible from a neutronics point of view. Further research will be conducted to calculate a suitable clad thickness to strike a balance between the increment of enrichment and reduction of clad thickness from the Zircaloy4 standard. There is a strong possibility, limited to neutronics, to include MOX assemblies to study the effect on the reactor's operation and to aim for higher EOC burnup.

**References**
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