

NUCLEAR HEATING IN CRITICAL COMPONENTS OF ALTERNATIVE ITER FIRST WALL ATTACHMENT MECHANISM

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New Concept to Attach ITER First Wall to Shield

- Solid hinge “knuckle” at base of shield block (A)
- Notched beam on back of first wall mounts on knuckle (B)
- Yoke & pin (C) provide fixed attachment to shield block

Concerns

- Conductive cooling may result in excessive heating/temperatures in
 - stainless steel (SS-316) hinge knuckle
 - stainless steel (SS-316) hinge notch
 - copper yoke
 - Inconel-718 yoke bolts

Neutronics Analysis

- DAG-MCNP5 & FENDL 2.1
- 1-D/3-D hybrid analysis [Ref. 1]
 - 1-D R-Z cylindrical system
 - 3-D detailed Module 4 model (FW @ 402.7 cm)
 - homogenized outboard first wall & shield (FW @ 842 cm)
 - Uniform source normalized to Module 4 NWL (0.567 MW/m²)
 - Localized to 519 cm < R < 719 cm
 - Depth of regions of interest insensitive to source model [Ref. 2]
- Combined neutron & photon heating in following regions
 - hinge knuckle head/base
 - hinge notch front/back
 - yoke & yoke pin
 - bolt & bolt head

Bolt Variations

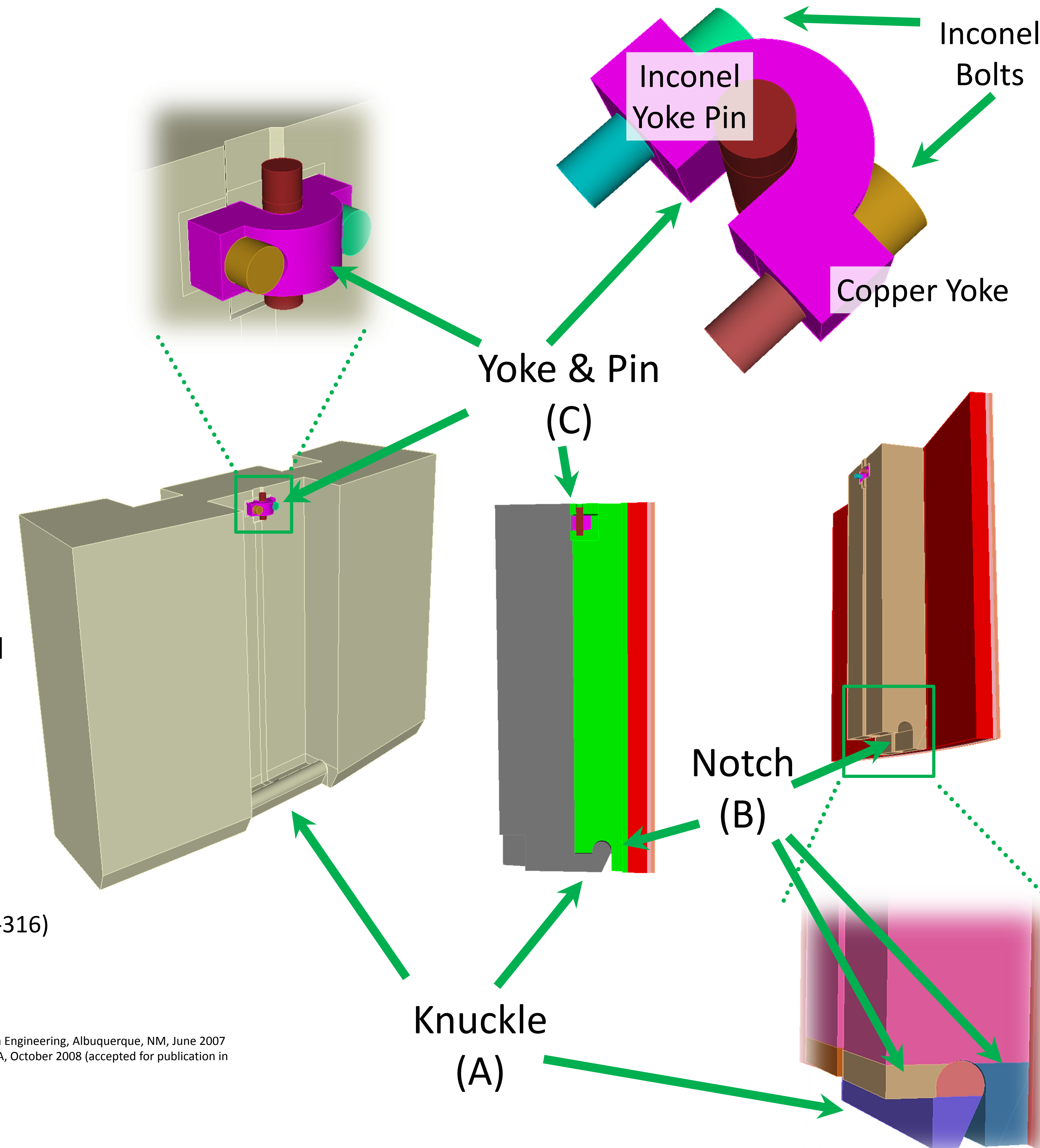
- Compare Inconel-718 bolts with molybdenum (Mo) bolts
- Bolt access holes through FW are radiation streaming path
 - Compare open holes with those plugged with 100% stainless steel (SS-316)

References

1. B. Smith, P.P.H. Wilson, M.E. Sawan, “Three Dimensional Neutronics Analysis of the ITER First Wall/Shield Module 13”, Proc. of 22nd Symposium on Fusion Engineering, Albuquerque, NM, June 2007
2. B. Smith, P. Wilson, M. Sawan, T. Bohm, “Source Profile Analysis for the ITER First Wall/Shield Module 13”, 18th Topical on Fusion Energy, San Francisco, CA, October 2008 (accepted for publication in Fusion Science and Technology)

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Total Nuclear Heating [W/cm³] (±relative statistical error)

Part	Total Nuclear Heating [W/cm ³]
Knuckle Head	2.83 (±0.45%)
Knuckle Base	3.22 (±0.40%)
Hinge Front	5.07 (±0.28%)
Hinge Back	1.87 (±0.54%)
Yoke	2.44 (±1.05%)
Yoke Pin	2.44 (±1.63%)

Bolt Material	Bolt Part	Open Holes	Plugged Holes
Inconel-718	Head	2.88 (±1.7%)	2.76 (±2.0%)
	Shaft	2.09 (±1.8%)	2.04 (±3.3%)
Mo	Head	3.45 (±1.6%)	3.35 (±2.2%)
	Shaft	2.48 (±1.6%)	2.46 (±2.3%)

Discussion

- Results consistent with previous 1-D analyses
- Plugging holes has little effect
 - majority of heating due to photons born in structure

Conclusions

- Heating in hinge knuckle/notch too high
- Mo bolts preferred
 - Slightly higher heating offset by higher melting temperature