https://doi.org/10.1080/00295450.2020.1725382

KRUSTY Fuel Core

- Highly Enriched Uranium (HEU)
- Center hole (two modes of operation)
  - Nuclear testing - B4C control rod
  - Non-nuclear testing - 10 kW electric heater
- Side holes x8 for heating pipes (sodium)

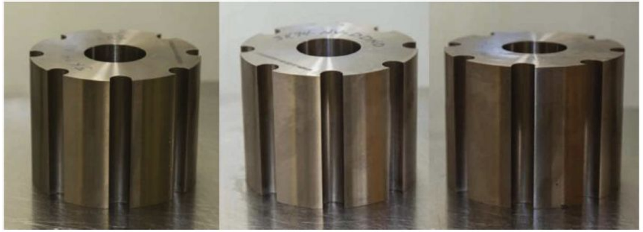
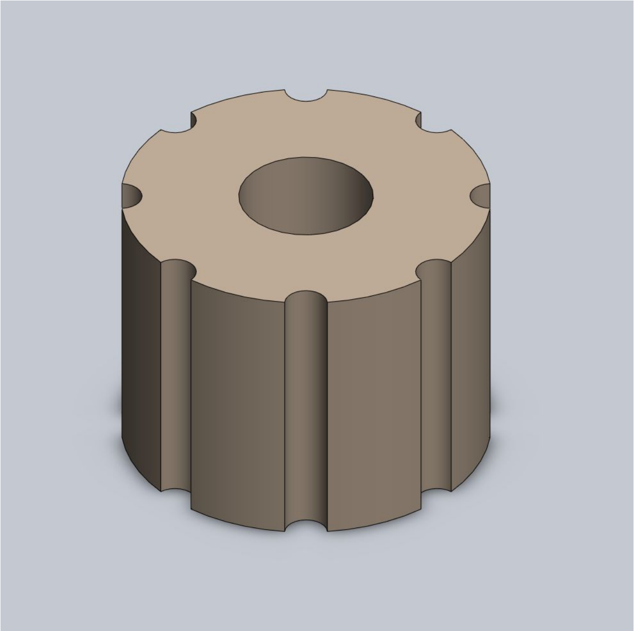
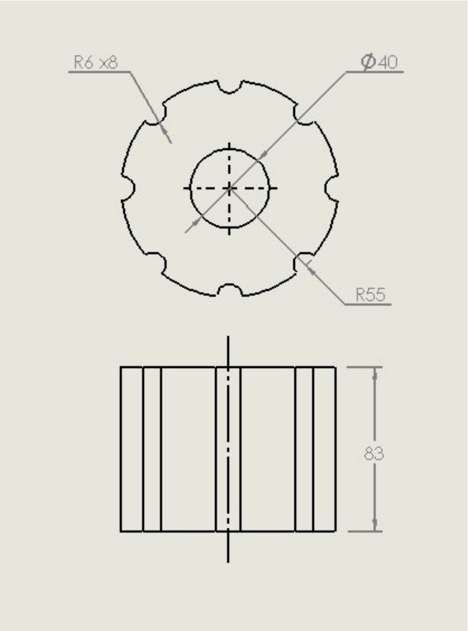


Fig. 5. KRUSTY HEU core sections.

Material Properties

- Uranium Molybdenum Alloy
- U-8Mo
  - **84.4% U-235**
  - 8.00% U-238
  - 7.65% Molybdenum
- Mass density 17.3 g/cm^3
- Melting point 1135ºC
- Specific heat 0.155 J/gK
- Thermal expansion coefficient 5x10^5 K^{-1}
- **Heat power 5 kW (thermal)**





Solidworks Custom Material

Physical properties of monolithic U8 wt.%–Mo

https://doi.org/10.1016/j.jnucmat.2010.04.024

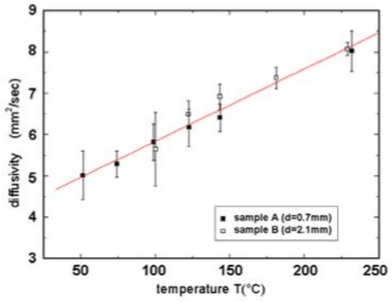


Fig. 6. Thermal diffusivity of unirradiated U8Mo.

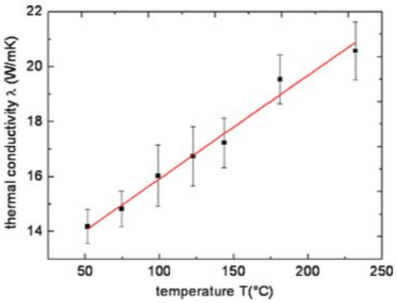


Fig. 8. Thermal conductivity of unirradiated U8Mo.

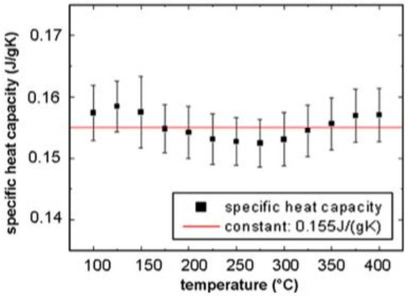


Fig. 7. Specific heat capacity of non-irradiated U8Mo.

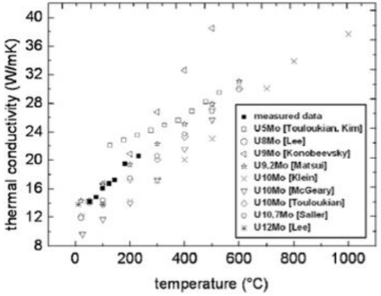
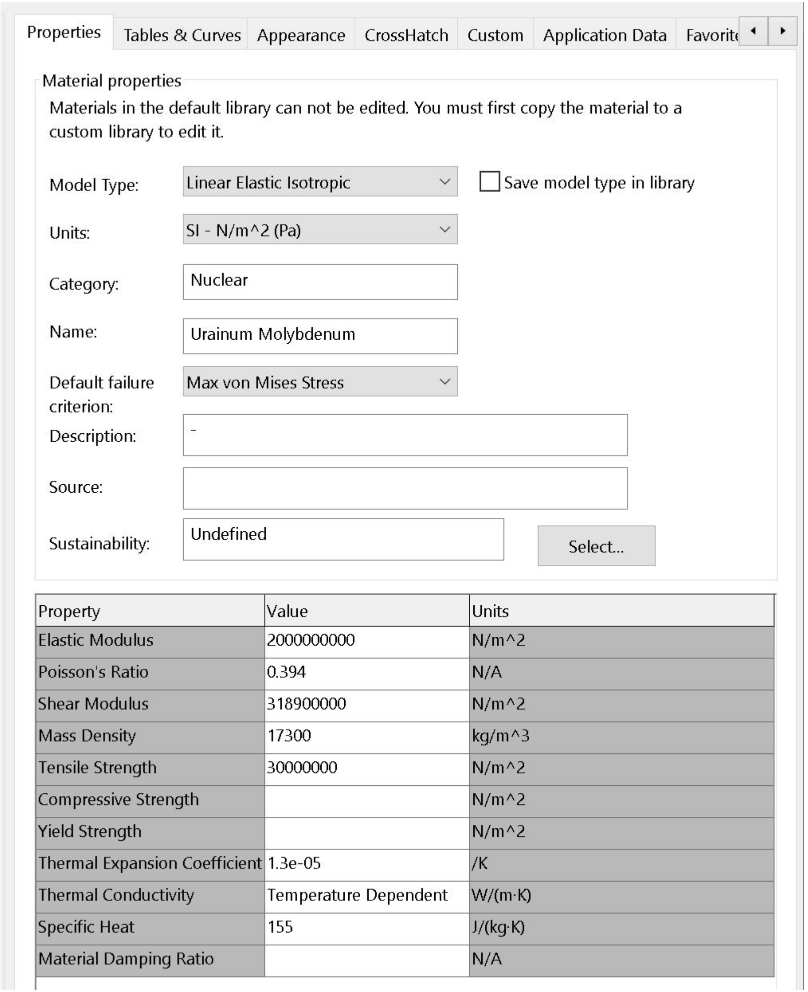


Fig. 9. Thermal conductivity of unirradiated U8Mo: comparison with literature data; measurement errors are given in Fig. 8.



Property	Value	Units
Elastic Modulus	2000000000	N/m^2
Poisson's Ratio	0.394	N/A
Shear Modulus	318900000	N/m^2
Mass Density	17300	kg/m^3
Tensile Strength	30000000	N/m^2
Compressive Strength		N/m^2
Yield Strength		N/m^2
Thermal Expansion Coefficient	1.3e-05	/K
Thermal Conductivity	Temperature Dependent	W/(m·K)
Specific Heat	155	J/(kg·K)
Material Damping Ratio		N/A

Steady State Thermal Analysis

Thermal Loads

- Heat power 5 kW
- Convection coefficient 550 W/m^2K
- Ambient temperature 300 K

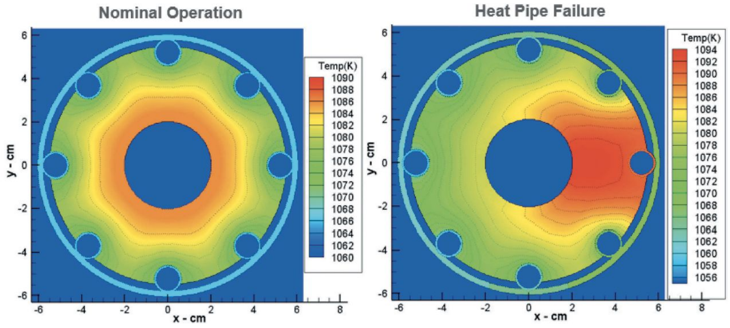
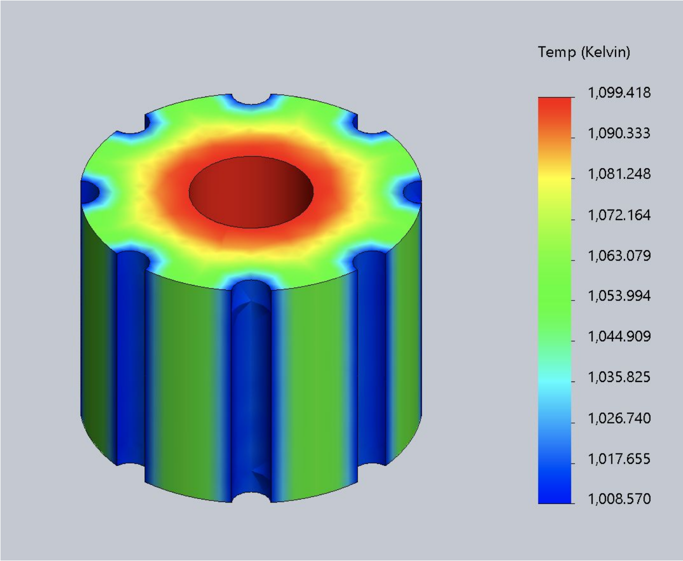
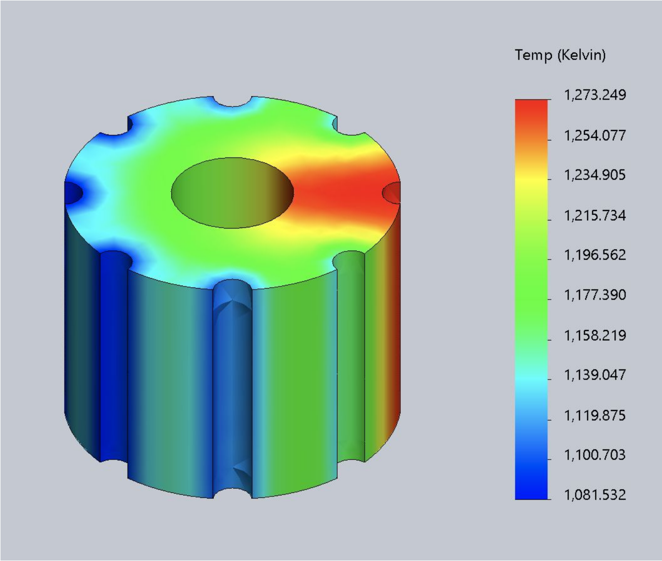


Fig. 13. KRUSTY core temperature calculations at axial center.

Note: Convection coefficient for heating pipes was estimated by trial and error. Pipes are made of Haynes-230 Alloy with Nickel wick and filled with sodium.





KRUSTY Fuel Assembly

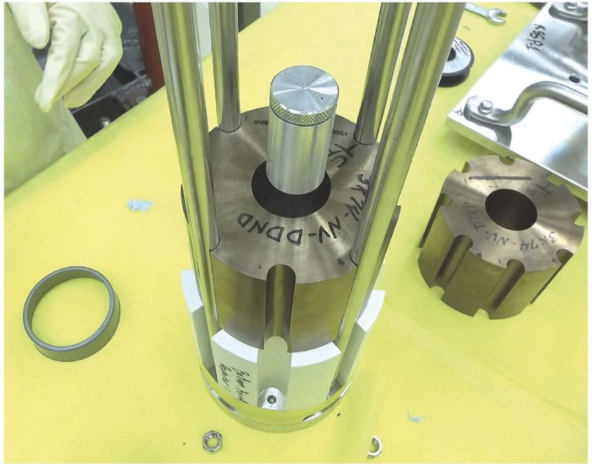


Fig. 1. Partially assembled configuration for the component criticals. The first (of three) HEU UMo core segments rests on top of the lower BeO axial reflector. The central cylinder aids assembly and alignment and is later removed.

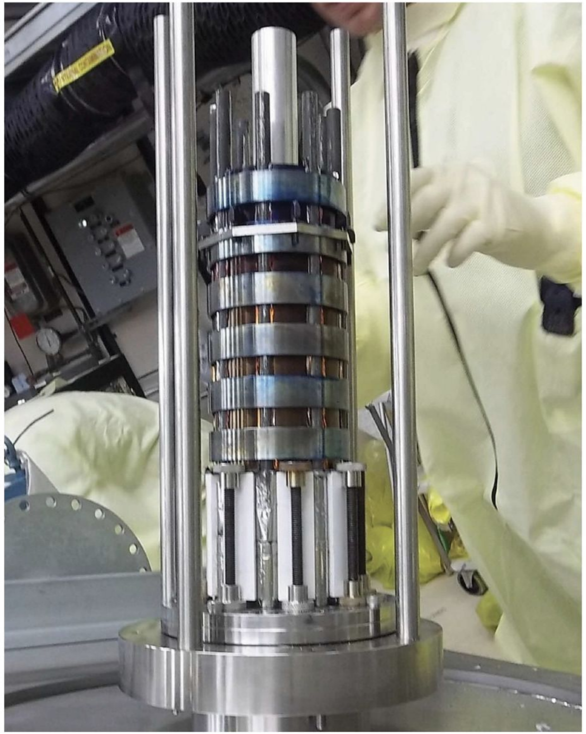


Fig. 8. Assembled KRUSTY core (upside down) showing attached heat pipes using ring clamps.

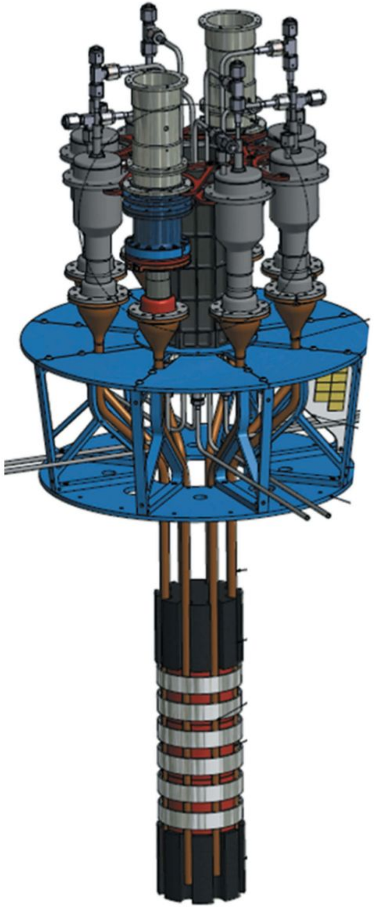


Fig. 5. KRUSTY in-vacuum components.

Monte Carlo Neutronics Simulations

- Heat power for KRUSTY was given
- For designing own fuel core it must be computed
- Monte Carlo methods considered gold-standard (fewest assumptions)
    - Simulate neutrons through defined model
    - Compute how often and where fission occurs
    - Heat power given by [rate of fission]
- How simulation softwares work
    - Describe geometry
    - Describe nuclide/densities for each material
    - Set number of neutrons to simulate (small error with enough particles confirmed by central limit theorem)
    - List of physical quantities to return

OpenMC: A state-of-the-art Monte Carlo code for research and development
https://doi.org/10.1016/j.anucene.2014.07.048