Fuel Rod Temperatures: Centreline, Gap, Clad and Film

Temperatures through a fuel rod from coolant to pellet centreline at a given linear heat rate: film, cladding, gap and pellet conduction drops.

Method: Radial conduction in a fuel rod with uniform heat generation

Input parameters

Unit system: SI

Parameter	Value	Unit
Linear heat rate	18.000	kW/m
Pellet radius	4.1000	mm
Radial gap width	0.080000	mm
Cladding thickness	0.57000	mm
Fuel thermal conductivity (UO_2 about 2.5–4)	3.0000	W/(m·K)
Gap conductance	6,000.0	W/(m²·K)
Cladding thermal conductivity (Zircaloy about 17)	17.000	W/(m·K)
Bulk coolant temperature	310.00	°C
Coolant heat transfer coefficient	34,000	W/(m²·K)

Calculated results

Parameter	Value	Unit
Volumetric heat generation in the pellet	340.84	MW/m³
Heat flux at the clad outer surface	603.11	kW/m²
Clad outer surface temperature	327.74	°C
Clad inner surface temperature	349.28	°C
Pellet surface temperature	465.74	°C
Pellet centreline temperature	943.20	°C
Temperature drop across the pellet	477.46	K

Notes for this case

- Steady radial conduction with uniform heat generation in the pellet and constant conductivities; gap conductance referred to the pellet surface. UO_2 conductivity falls with temperature, so a constant value underestimates the centreline temperature at high power; use the conductivity integral for design.

Formula and method

$$T_{max} - T_b = q' \left[\frac{1}{4\pi k_f} + \frac{1}{2\pi r_f h_g} + \frac{\ln(r_{co}/r_{ci})}{2\pi k_c} + \frac{1}{2\pi r_{co} h} \right]$$

Variables

q'	Linear heat rate	W/m
r_f	Pellet radius	m
δ_g	Radial gap width	m
t_c	Cladding thickness	m
k_f	Fuel thermal conductivity (UO_2 about 2.5–4)	W/(m·K)
h_g	Gap conductance	W/(m²·K)

k_c	Cladding thermal conductivity (Zircaloy about 17)	W/(m·K)
T_b	Bulk coolant temperature	K
h	Coolant heat transfer coefficient	W/(m²·K)
q'''	Volumetric heat generation in the pellet	W/m³
q''	Heat flux at the clad outer surface	W/m²
T_{co}	Clad outer surface temperature	K
T_{ci}	Clad inner surface temperature	K
T_{fs}	Pellet surface temperature	K
T_{max}	Pellet centreline temperature	K
ΔT_f	Temperature drop across the pellet	K

Method and standards

Series thermal resistances of a fuel rod.

Assumptions and limits

- Steady state; uniform generation; constant properties.

References

Radial conduction in a fuel rod with uniform heat generation

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/boilers-power-plant/nuclear-power/fuel-rod-temperature-profile

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.