Coolant, Clad and Fuel Temperatures with a Chopped Cosine Flux

Coolant outlet temperature and the height and value of the maximum clad surface and fuel centreline temperatures for a chopped-cosine axial power shape.

Method: Axial temperature distribution in a heated channel with a chopped-cosine heat flux

Input parameters

Unit system: SI

Parameter	Value	Unit
Peak linear heat rate (at mid-height)	30.000	kW/m
Heated length	3.6600	m
Extrapolated length of the cosine (≥ L)	3.9000	m
Coolant flow in the channel	1,080.0	kg/h
Coolant specific heat	5.8000	kJ/(kg·K)
Coolant inlet temperature	292.00	°C
Rod outer diameter	9.5000	mm
Coolant heat transfer coefficient	35,000	W/(m²·K)
Centreline-to-clad-surface temperature difference at the peak	1,200.0	K

Calculated results

Parameter	Value	Unit
Coolant outlet temperature	334.61	°C
Height of the maximum clad temperature above mid-height	0.79507	m
Maximum clad surface temperature	349.12	°C
Height of the maximum centreline temperature above mid-height	0.021622	m
Maximum fuel centreline temperature	1,542.2	°C
Channel power	74.137	kW

Notes for this case

• q'(z) = q'₀cos(πz/L_e), z from −L/2 to +L/2. Coolant T_m(z) = T_in + q'₀L_e/(πṁc_p)[sin(πz/L_e) + sin(πL/2L_e)]; each temperature T_m + q'(z)R peaks where tan(πz/L_e) = L_e/(πṁc_pR). Single-phase coolant with constant c_p and h; the fuel resistance comes from the peak ΔT entered.

Formula and method

$$T_m(z) = T_{in} + \frac{q'_0 L_e}{\pi \dot{m} c_p}\left[\sin\frac{\pi z}{L_e} + \sin\frac{\pi L}{2L_e}\right], \quad \tan\frac{\pi z_{max}}{L_e} = \frac{L_e}{\pi \dot{m} c_p R}$$

Variables

q'_0	Peak linear heat rate (at mid-height)	W/m
L	Heated length	m
L_e	Extrapolated length of the cosine (≥ L)	m
$\dot{m}$	Coolant flow in the channel	kg/s
c_p	Coolant specific heat	J/(kg·K)
T_{in}	Coolant inlet temperature	K
D	Rod outer diameter	m

h	Coolant heat transfer coefficient	W/(m²·K)
$\Delta T_{f,0}$	Centreline-to-clad-surface temperature difference at the peak	K
T_{out}	Coolant outlet temperature	K
z_c	Height of the maximum clad temperature above mid-height	m
$T_{co,max}$	Maximum clad surface temperature	K
z_f	Height of the maximum centreline temperature above mid-height	m
$T_{cl,max}$	Maximum fuel centreline temperature	K
P_{ch}	Channel power	W

Method and standards

Chopped-cosine channel analysis.

Assumptions and limits

- Single phase; constant properties; no cross-flow between channels.

References

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Report details

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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/chopped-cosine-channel-temperatures

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.