Karlsruhe Institute of Technology

CFD study on a breadboard receiver with insert structure and sodium as heat transfer medium

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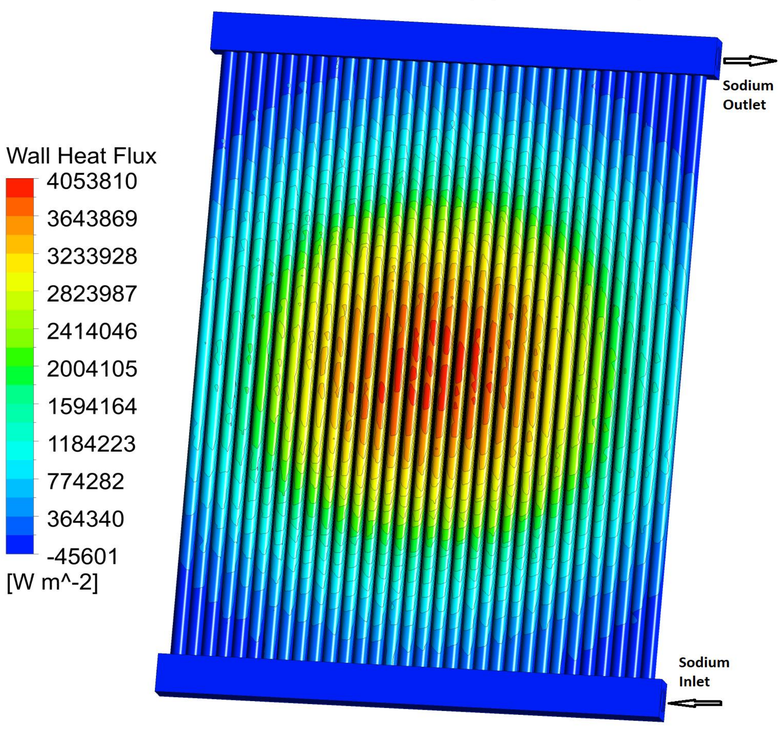
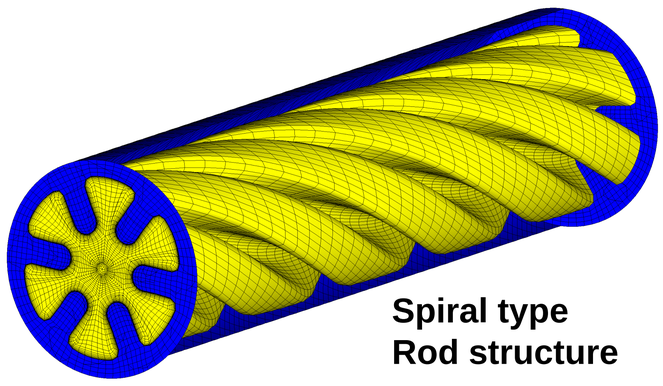
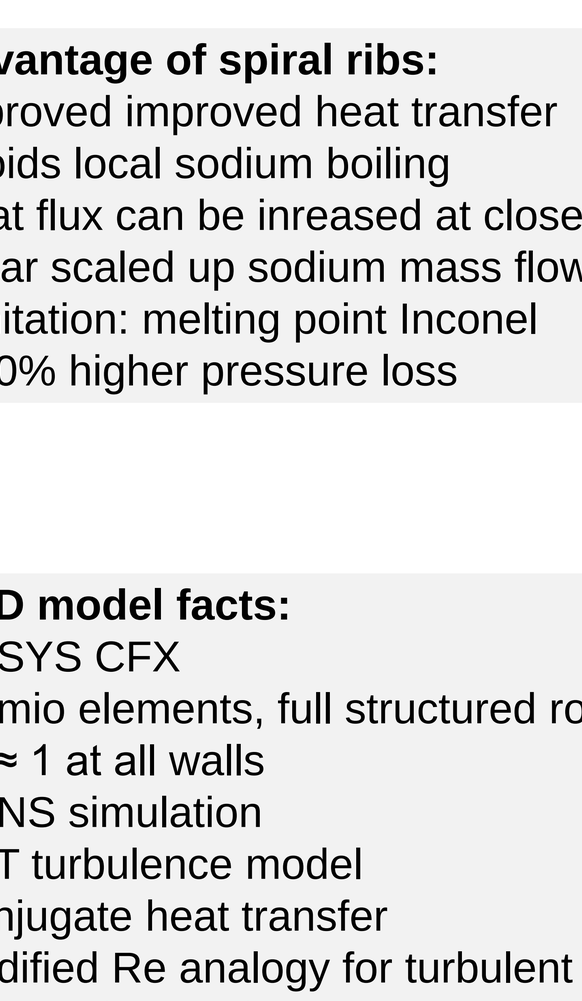
CSP heat flux (by Vast Solar)



Smooth pipes run into local boiling
Spiral ribs improve heat transfer significantly



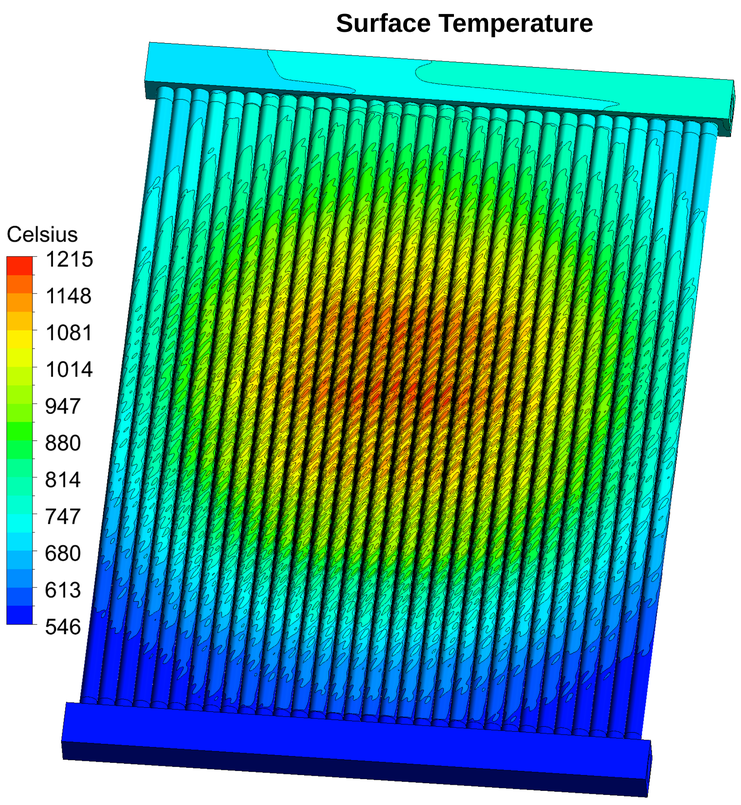
Spiral type
Rod structure



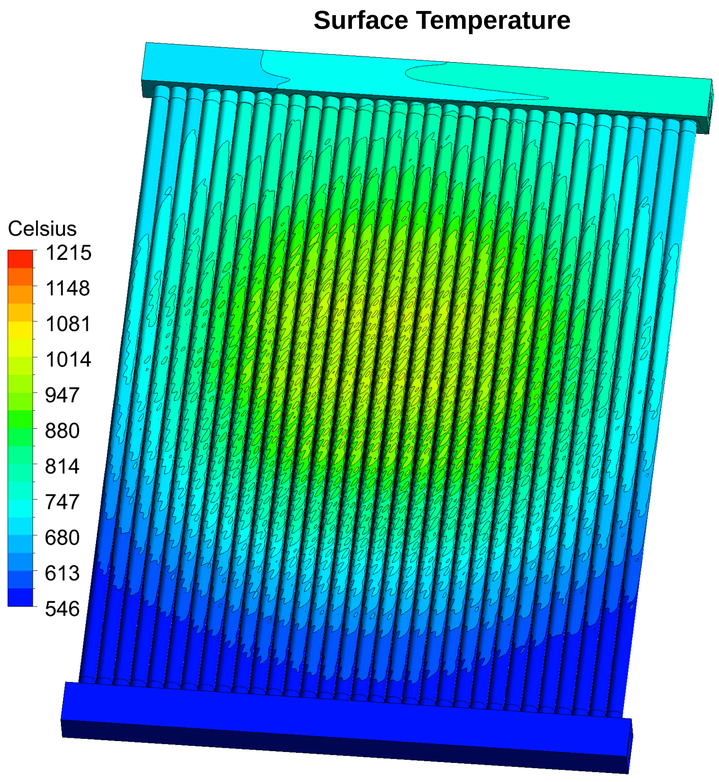
Fixed parameters:
550°C inlet temperature
750°C outlet temperature
P_{outlet} = 1 bar
Until 4.3 MW/m² CSP solar flux
6 kg/s sodium massflow
Until 1m x 1m irradiated area
Pressure as low as possible

Design parameters:
Material: Inconel 690 or Niobium
32 pipes, 1m, ⦰ 24 mm
1.5 mm wall thickness
Rods with spiral type ribs
Swirl transports cold sodium towards heat impact zone

Advantage of spiral ribs:
Improved improved heat transfer
Avoids local sodium boiling
Heat flux can be inreased at closely linear scaled up sodium mass flow
Limitation: melting point Inconel
~ 50% higher pressure loss

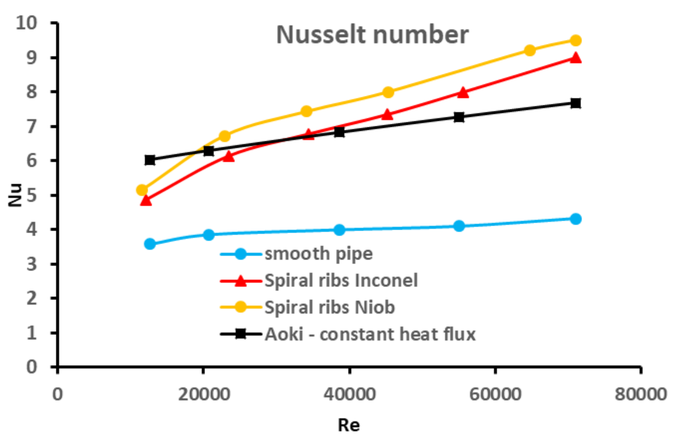


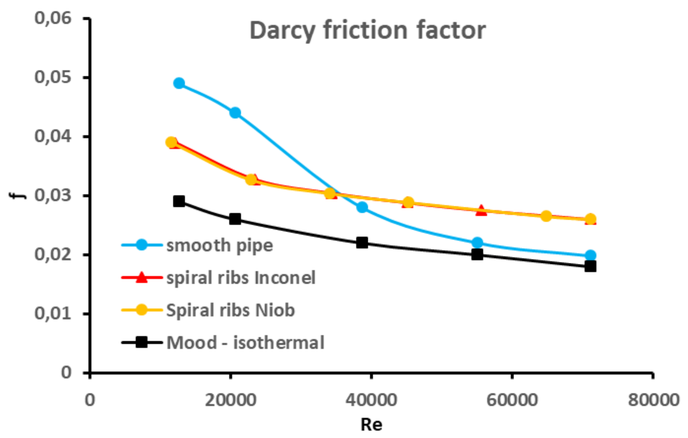
Inconel 690



Niobium

CFD model facts:
ANSYS CFX
70 mio elements, full structured rods
$Y^+ \approx 1$ at all walls
RANS simulation
SST turbulence model
Conjugate heat transfer
Modified Re analogy for turbulent heat transfer (Pr_t=1.5)
Additional radiative heat loss considered
Individual adjusted pipe massflow by pressure loss coefficients





	Inconel690	Niob
Melting point [°C]	1350	2477
$T_{max,surface}$ [°C]	1215	1029
$T_{max,sodium}$ [°C]	871	861
λ [W m^{-1} K^{-1}]	25	58-72
Total power [MW]	1.46	1.48