Zeolite calciner with the insulating effect of material at the wall

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Contents

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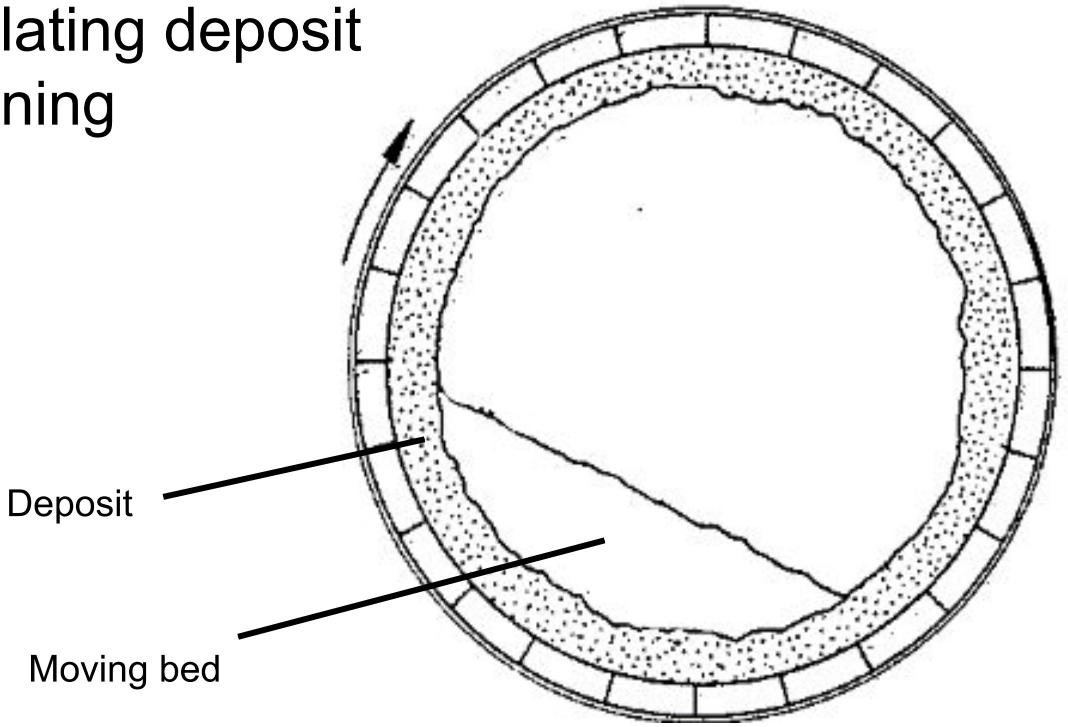
Problem context

Goal: heat zeolite to 600 ^{o}C

Problem

- Zeolite sticks to the wall
- Forms insulating deposit
- Slows calcining



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Goal of the project

- Model the steady-state temperature of the bulk along the length of the calciner
- Deliverable: Python application
- Investigate the influence of operation parameters on the heating of the kiln

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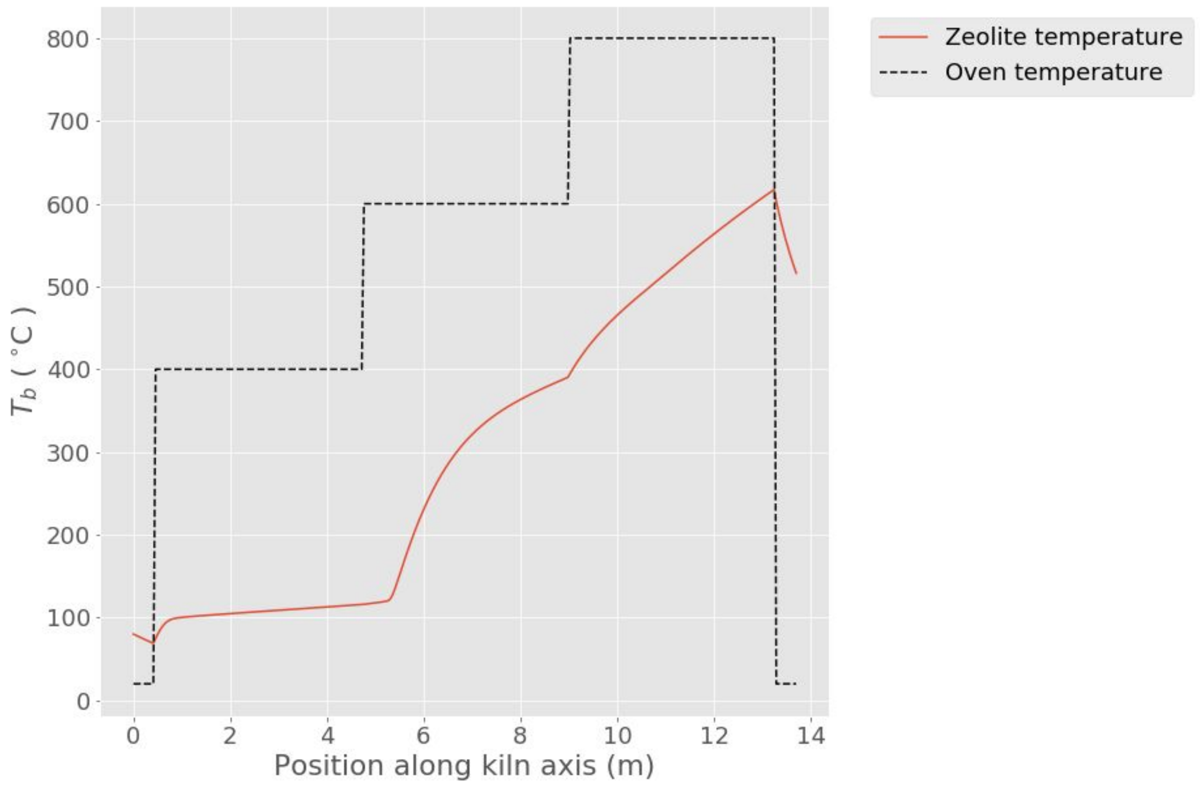
Typical outcome



Model explanation

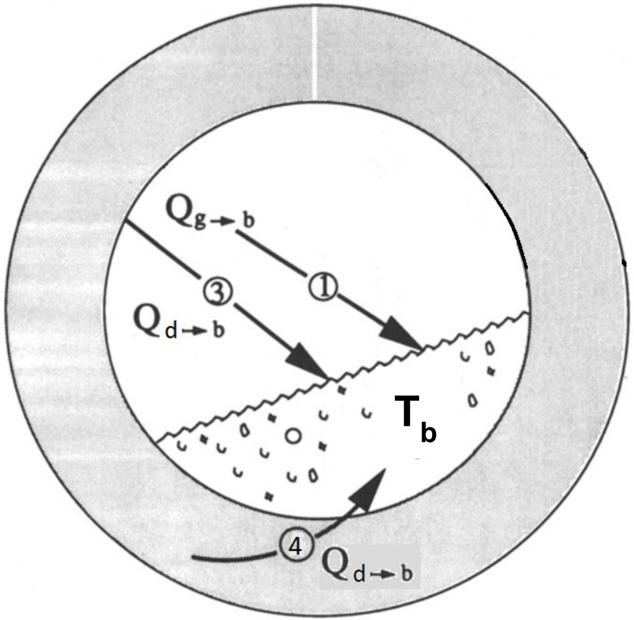
Steady-state thermal energy balance

$$\underbrace{c_1 \frac{dT}{dx}}_{\text{Convection}} + \underbrace{\cancel{c_2 \frac{d^2T}{dx^2}}}_{\text{Diffusion}} = \underbrace{Q_{\text{in}} - Q_{\text{out}}}_{\text{Source terms (Heat transfer paths)}}$$

Model explanation

Heat balance in zeolite bed:

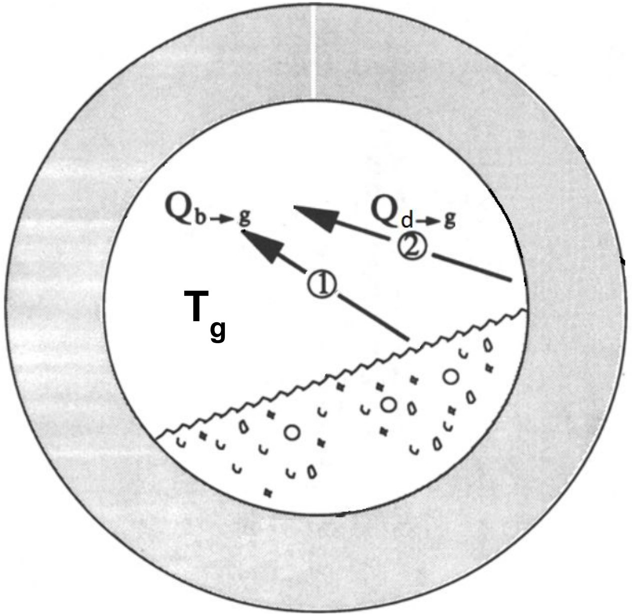
$$c_1 \frac{dT_b}{dx} = Q_{b,\text{ in}} - Q_{b,\text{ out}}$$



Model explanation

Heat balance in gas (air and steam):

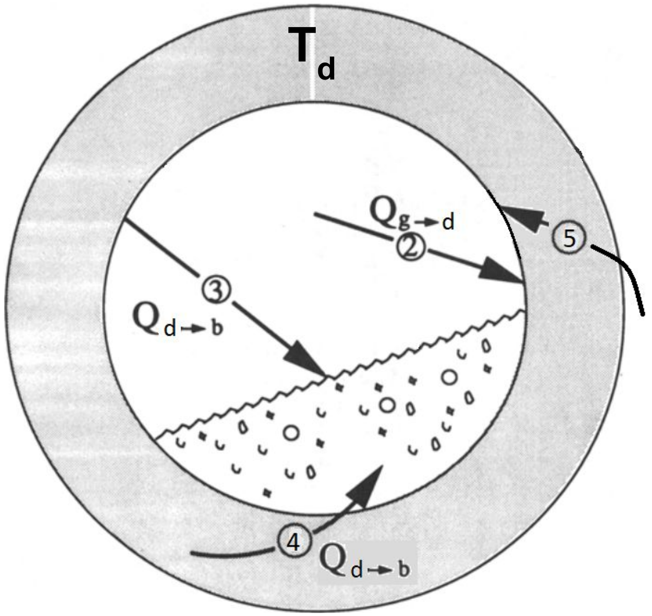
$$c_2 \frac{dT_g}{dx} = Q_{g,\,\mathrm{in}} - Q_{g,\,\mathrm{out}}$$



Model explanation

Heat balance in insulating zeolite deposit:

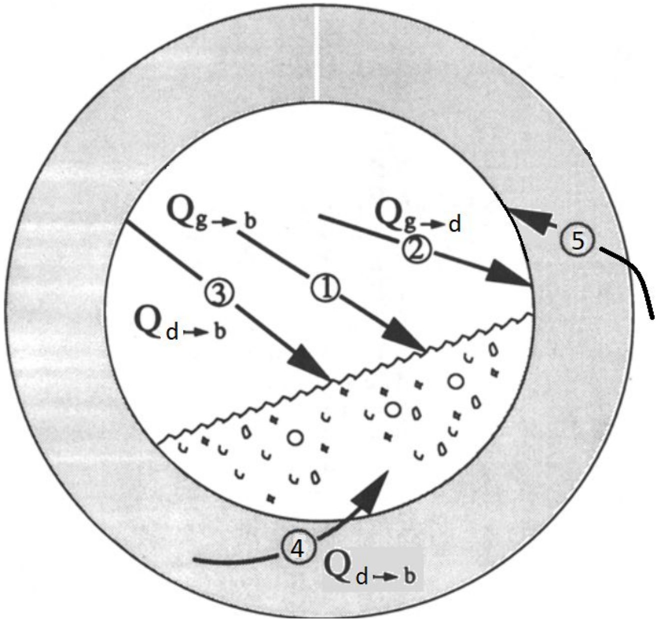
$$0 = Q_{d,\,\mathrm{in}} - Q_{d,\,\mathrm{out}}$$



Model explanation

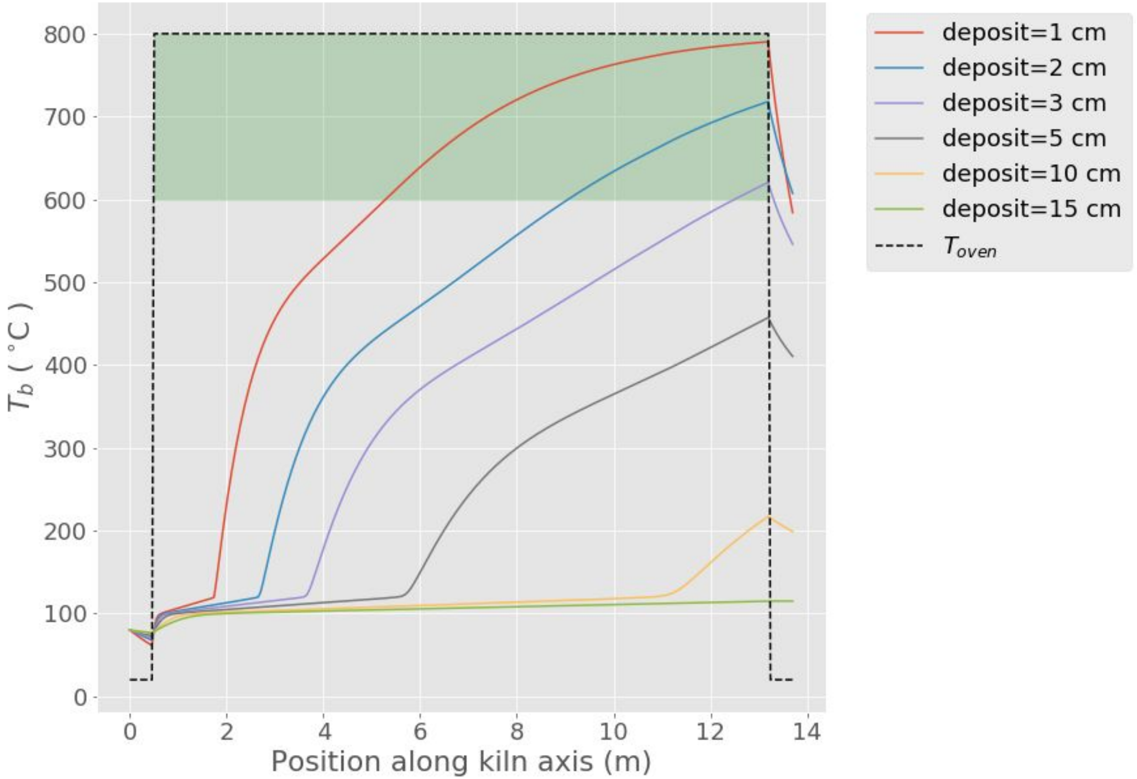
Together: system of differential-algebraic equations (DAE)

$$
\begin{cases}
c_1 \dfrac{dT_b}{dx} = Q_{b,\,\text{in}} - Q_{b,\,\text{out}} \\[2em]
c_2 \dfrac{dT_g}{dx} = Q_{g,\,\text{in}} - Q_{g,\,\text{out}} \\[2em]
\qquad 0 = Q_{d,\,\text{in}} - Q_{d,\,\text{out}}
\end{cases}
$$

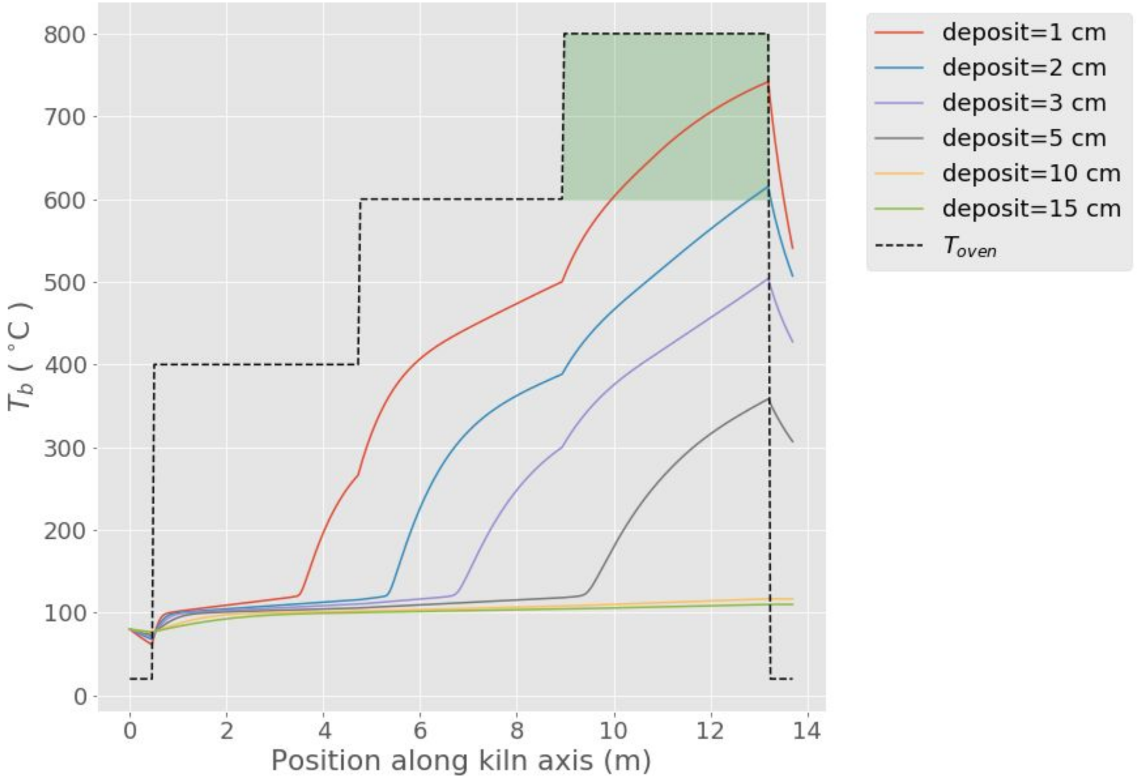


Results

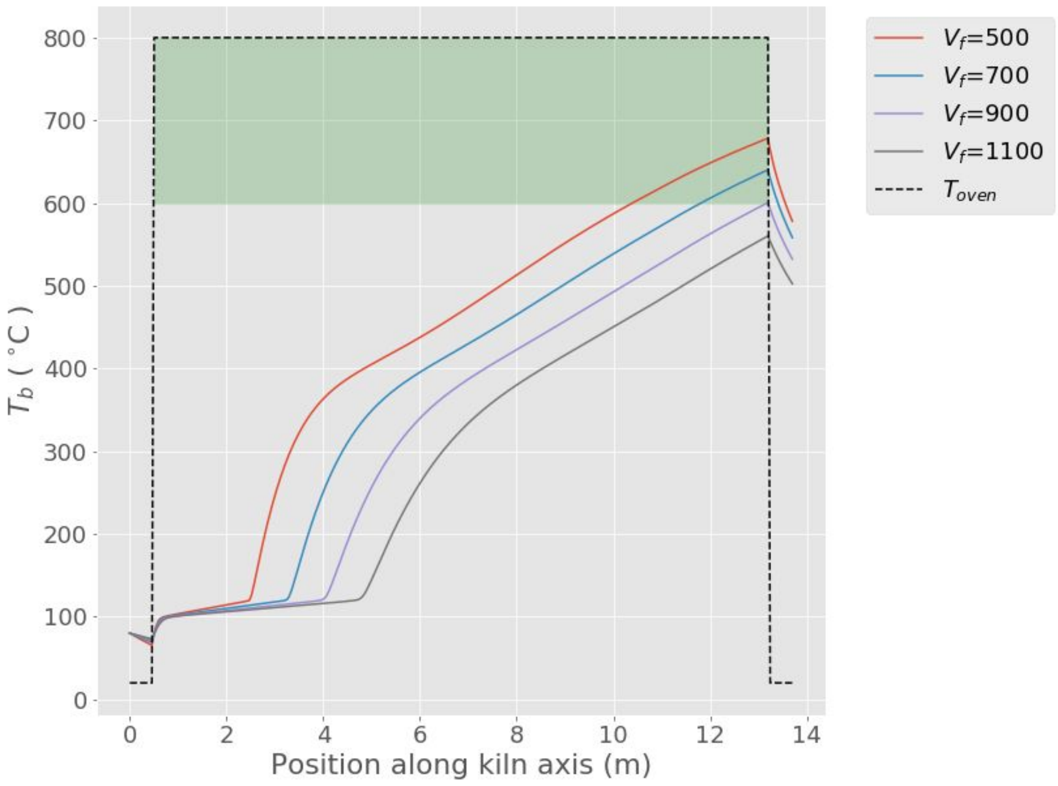
Parameter: thickness zeolite deposit (m)



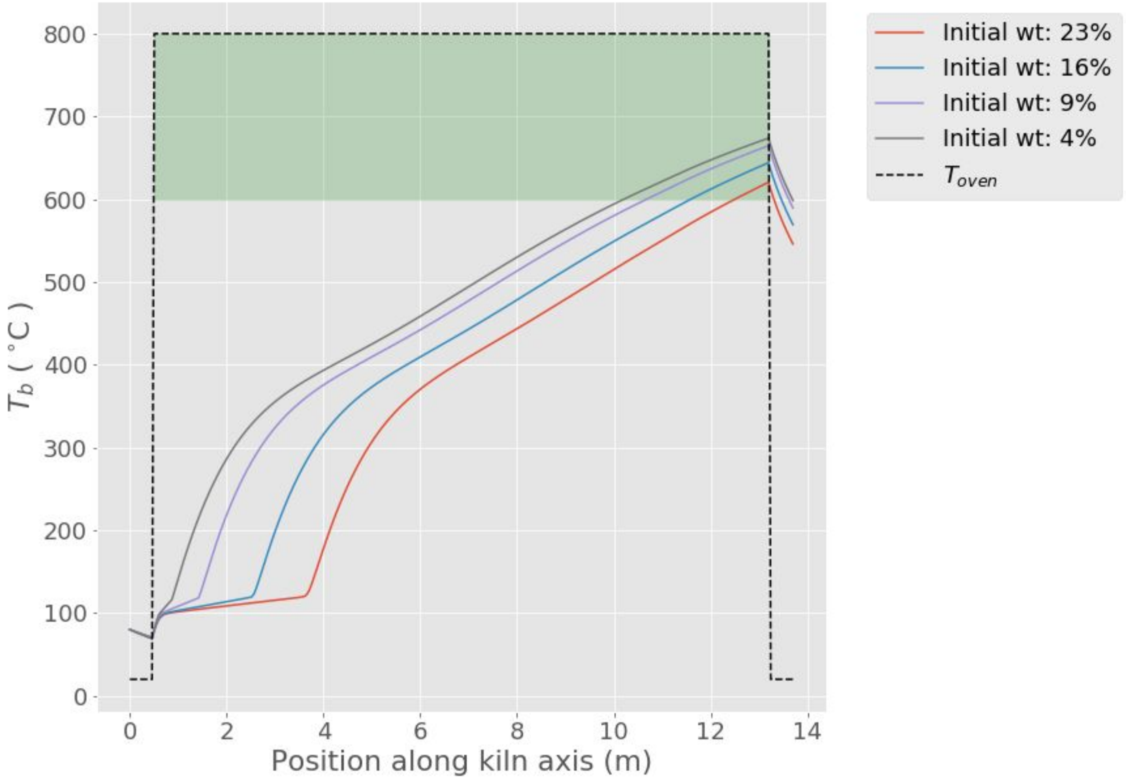
Optional: Varying Oven Temperature



Parameter: Feed rate (kg/h)



Parameter: Initial water content (wt%)



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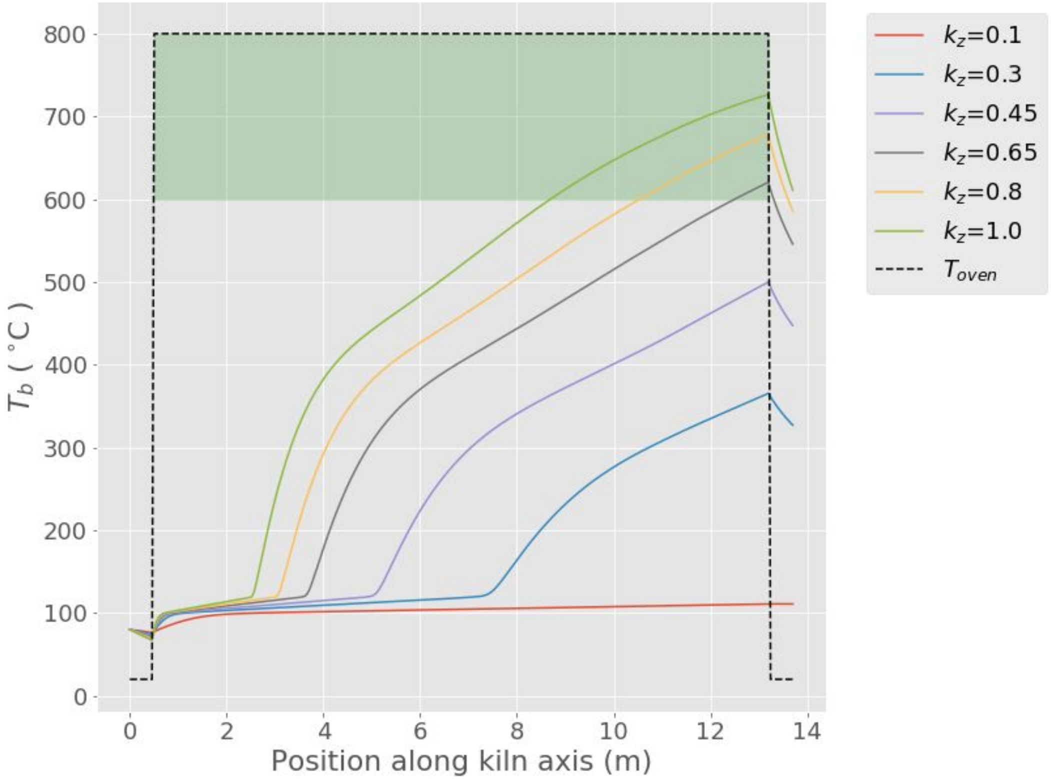
Parameter: heat conductivity Zeolite (W/m/K)



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Summary

- Developed 1D Model
- Significance of parameters:
  1. Deposit thickness
  2. Heat conductivity
  3. Feed rate
  4. Initial water content

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Recommendations

- Investigate experimental values of deposit layer
- High temperature of first burner chamber

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GitHub repository:

ZeoliteCalciner / model1D

https://github.com/ZeoliteCalciner/model1D

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Bed Height: Saeman model