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System Simulation Notes

Rock Bed Heat Storage

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2023/01/05

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Abstract

A rock bed is modeled as a porous medium ...

List of symbols

Variables

a	surface area	$[\mathrm{m}^2]$
A	area	$[\mathrm{m}^2]$
c_p	specific heat capacity	$[\mathrm{J/(kg{\cdot}K)}]$
$\dot{m}$	air mass flow rate	$[\mathrm{kg/s}]$

1 Packed bed material properties

Consider the packed bed heat store shown in figure 1. It is filled with spherical stones. Define the average *void fraction* $\bar{\varepsilon}$ as

$$\bar{\varepsilon} = \frac{\text{volume of empty space}}{\text{volume of solid media}} \tag{1}$$

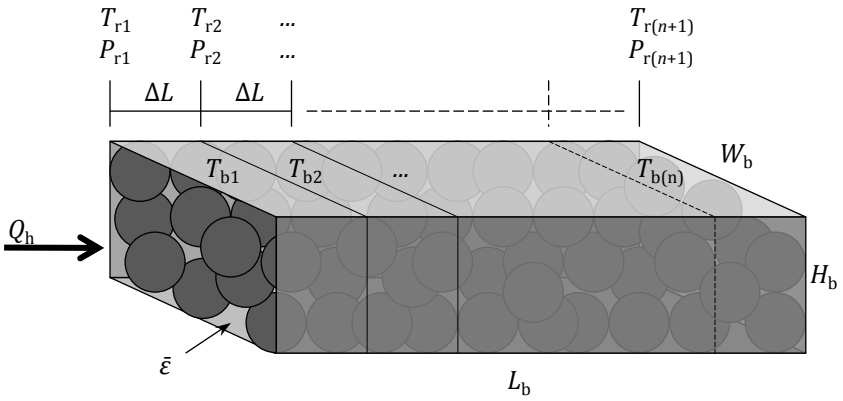

Figure 1: Packed bed heat store

Assume that the flow is uniform and one-dimensional through the bed. The projected flow area A_b perpendicular to the flow direction is

$$A_\mathrm{b} = W_\mathrm{b}\, H_\mathrm{b} \tag{2}$$

with W_b and H_b the bed width and height.

The different fractions of solids and air are given in table 1. Beasley and Clark (1984) give the average void fraction as a function of container diameter to particle diameter for uniform spheres.

Table 1: Fractions of air and solids in packed bed

	Air	Solids
Fraction	$\bar{\varepsilon}$	$(1-\bar{\varepsilon})$
Volume	$\bar{\varepsilon}\, A_\mathrm{b}\, L_\mathrm{b}$	$(1-\bar{\varepsilon})\, A_\mathrm{b}\, L_\mathrm{b}$
Mass	$\bar{\varepsilon}\, A_\mathrm{b}\, L_\mathrm{b}\, \rho_\mathrm{r}$	$(1-\bar{\varepsilon})\, A_\mathrm{b}\, L_\mathrm{b}\, \rho_\mathrm{p}$

2 Heat transfer between the bed and the air

3 Temperature change in the bed

4 Calculation procedure

References

Beasley, D.E. and Clark, J.A. (1984). Transient response of a packed bed for thermal energy storage. *International Journal of Heat and Mass Transfer*, vol. 21, no. 9, pp. 1659–1669.