External Fluid-Bed Heat Exchanger Duty

Heat absorbed by tubes in an external fluidised-bed heat exchanger from tube coefficient, area and LMTD (Basu Eq. 3.24), and the solids flow it needs.

Method: Basu; Circulating Fluidized Bed Boilers: Design; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Overall heat transfer coefficient of the tubes	300.00	W/(m²·K)
Tube outside area	800.00	m²
Solids in	870.00	°C
Solids out	700.00	°C
Steam or water in	400.00	°C
Steam or water out	540.00	°C
Solids specific heat	0.90000	kJ/(kg·K)

Calculated results

Parameter	Value	Unit
Mean temperature difference, well-mixed bed at the solids outlet temperature	222.71	K
Duty	53.451	MW
Solids flow for the temperature drop	1,257.7	t/h

Notes for this case

- FBHEs let the operator move heat between furnace and superheaters by controlling the solids flow through them.

Formula and method

$$\Delta T_m = \frac{(T_{s,out} - T_{w,in}) - (T_{s,out} - T_{w,out})}{\ln \frac{T_{s,out} - T_{w,in}}{T_{s,out} - T_{w,out}}}, \quad Q = H_{tube} A_0 \, \Delta T_m, \quad \dot{m}_s = \frac{Q}{c_s (T_{s,in} - T_{s,out})}$$

Variables

H_{tube}	Overall heat transfer coefficient of the tubes	W/(m²·K)
A_0	Tube outside area	m²
$T_{s,in}$	Solids in	K
$T_{s,out}$	Solids out, which is also the temperature of the well-mixed bed	K
$T_{w,in}$	Steam or water in	K
$T_{w,out}$	Steam or water out	K
c_s	Solids specific heat	J/(kg·K)
ΔT_m	Mean temperature difference between the bed and the steam or water	K
Q_{FBHE}	Duty	W
$\dot{m}_s$	Solids flow for the temperature drop	kg/s

Method and standards

Basu's Eq. (3.24), Q = H_tube A₀ ΔT, with a solids heat balance. The FBHE is a bubbling bed, which is well mixed: the whole bed, and the solids leaving it, are at one temperature, T_s,out. The steam or water in the tubes heats from T_w,in to T_w,out against that constant bed temperature, so the mean difference is the log mean of (T_s,out − T_w,in) and (T_s,out − T_w,out).

Assumptions and limits

- Well-mixed bed at the solids outlet temperature. A bed divided into compartments in series comes closer to counter-flow and absorbs somewhat more.
- An evaporator (water in and out at the same saturation temperature) is accepted.
- The bed must be hotter than the steam or water leaving the tubes.

References

- Basu
- Circulating Fluidized Bed Boilers: Design
- Operation and Maintenance (Springer, 2015)
- ch. 3
- Eq. (3.24): Q = H_tube A_o LMTD

Report details

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Release checks	2 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/fluidised-bed/fbhe-duty

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.