Superheater Duty and Surface Area (LMTD)

Superheater duty from saturated to final steam temperature, flue gas outlet temperature and surface area by LMTD for counterflow or parallel flow (IAPWS-IF97).

Method: LMTD method; IAPWS R7-97 IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam flow	50,000	kg/h
Steam pressure (absolute)	66.000	bar
Final steam temperature	485.00	°C
Flue gas flow	216,000	kg/h
Mean specific heat of the flue gas	1.2500	kJ/(kg·K)
Gas temperature entering	950.00	°C
Overall heat transfer coefficient From the overall-coefficient calculator or the boiler maker, on the same surface as the area (usually the outside tube surface); radiant superheaters need a different method.	70.000	W/(m²·K)
Flow arrangement	Counterflow	
Steam inlet temperature (0 = dry saturated) Leave at 0 for a single superheater fed with dry saturated steam from the drum. For a secondary stage or after an attemperator, enter the steam temperature entering this stage (at or above saturation).	-273.15	°C
LMTD correction factor for the bank arrangement 1 for pure counterflow or parallel flow. Cross-flow and multi-pass banks: read F from the charts for the arrangement (Bowman, Mueller and Nagle; TEMA), typically 0.85 to 0.98.	100.00	%

Calculated results

Parameter	Value	Unit
Surface area needed	234.51	m²
Superheater duty	8,362.7	kW
Gas temperature leaving	838.50	°C
Log mean temperature difference	509.44	K
Saturation temperature at the steam pressure	281.88	°C

Formula and method

$$\dot{Q} = \dot{m}_s\,(h(p, T_{s,2}) - h(p, T_{s,1}))$$

$$T_{g,2} = T_{g,1} - \frac{\dot{Q}}{\dot{m}_g c_{p,g}}$$

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1 / \Delta T_2)}$$

$$A = \frac{\dot{Q}}{U F LMTD}$$

Variables

$\dot{m}_s$	steam flow	kg/s
p	steam pressure	Pa
$T_{s,2}$	final steam temperature	K
$\dot{m}_g$	gas flow	kg/s
$c_{p,g}$	gas specific heat	J/(kg·K)
$T_{g,1}$	gas temperature in	K
U	overall coefficient	W/(m²·K)

arr	counterflow or parallel flow	–
A	surface area	m²
$\dot{Q}$	duty	W
$T_{g,2}$	gas temperature out	K
$LMTD$	log mean temperature difference	K
$T_{s,1}$	steam inlet temperature; dry saturated (T_{sat}, enthalpy h_g) when entered as 0	K
T_{sat}	saturation temperature at the steam pressure	K
F	LMTD correction factor for the bank arrangement	–
h	steam enthalpy (IF97)	J/kg
$\Delta T_1, \Delta T_2$	end temperature differences	K

Method and standards

Steam duty from FireCAD's IAPWS-IF97 enthalpies between the inlet state (dry saturated, or the superheated inlet temperature of a secondary stage) and the final state; gas heat balance with a mean specific heat; LMTD for pure counterflow or parallel flow, multiplied by the correction factor F the user reads for a cross-flow or multi-pass bank.

Assumptions and limits

- The steam pressure is the same at inlet and outlet (the steam-side pressure drop is neglected). Dry saturated steam enters unless an inlet temperature is entered, for a secondary stage or after an attemperator; wet drum steam cannot be entered. Attemperator spray changes the steam flow: enter the flow through this stage.
- Constant U and gas specific heat. F is entered, not computed: 1 means pure counter or parallel flow; cross-flow and multi-pass banks have F below 1 and need more area.
- U and the area are on the same surface, usually the outside tube surface.

References

- LMTD method
- IAPWS R7-97 IF97

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/furnace-heating-surfaces/superheater-surface-area

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Reopens the calculator with the inputs of this report.