Tunnel Kiln Heat Balance and Fuel per kg of Ware

Heat to fire ceramic ware in a tunnel kiln (ware, firing reactions and kiln cars) with losses, and the fuel per kg of fired ware.

Method: Heat balance of a counterflow tunnel kiln

Input parameters

Unit system: SI

Parameter	Value	Unit
Fired ware output	2,000.0	kg/h
Mean specific heat of the ware	1.0000	kJ/(kg·K)
Firing temperature	1,200.0	°C
Ware entry temperature	30.000	°C
Ware exit temperature	80.000	°C
Heat of firing reactions per kg of ware	400.00	kJ/kg
Kiln car and furniture mass per kg of ware	1.5000	
Specific heat of cars and furniture	1.0000	kJ/(kg·K)
Car exit temperature	100.00	°C
Flue gas and wall losses as a share of fuel heat	55.000	%
Fuel net calorific value	47,000	kJ/kg

Calculated results

Parameter	Value	Unit
Ware heat (net of heat recovered in the cooling zone)	450.00	kJ/kg
Car heat carried out	105.00	kJ/kg
Fuel heat per kg of ware	1,233.3	kJ/kg
Fuel rate	52.482	kg/h
Fuel per kg of ware	0.026241	

Notes for this case

• In a tunnel kiln the ware is heated to firing temperature and cooled again in counterflow with the combustion air, so most of its sensible heat is recovered: what remains is the heat it carries out at the exit and the heat absorbed by firing reactions (dehydroxylation of clay, decomposition of carbonates, less any exothermic oxidation). Kiln cars and furniture also leave warm. Flue gas and wall losses usually take half or more of the fuel heat. Typical totals are 1.5–3 MJ per kg of ware for heavy clay and tiles, more for sanitaryware and porcelain.

Formula and method

$$q = \frac{c_w(T_{out} - T_{in}) + h_r + r_c c_c(T_c - T_{in})}{1 - f_L}, \quad \dot{m}_{fuel} = \frac{q\,\dot{m}_w}{NCV}$$

Variables

$\dot{m}_w$	Fired ware output	kg/s
c_w	Mean specific heat of the ware	J/(kg·K)
T_{fire}	Firing temperature	K
T_{in}	Ware entry temperature	K
T_{out}	Ware exit temperature	K

h_r	Heat of firing reactions per kg of ware	J/kg
r_c	Kiln car and furniture mass per kg of ware	-
c_c	Specific heat of cars and furniture	J/(kg·K)
T_c	Car exit temperature	K
f_L	Flue gas and wall losses as a share of fuel heat	-
NCV	Fuel net calorific value	J/kg
q_w	Ware heat (net of heat recovered in the cooling zone)	J/kg
q_c	Car heat carried out	J/kg
q	Fuel heat per kg of ware	J/kg
$\dot{m}_{fuel}$	Fuel rate	kg/s
m_{fuel}/m_w	Fuel per kg of ware	-

Method and standards

Tunnel kiln.

Assumptions and limits

- Steady operation; losses as a share of fuel heat.

References

Heat balance of a counterflow tunnel kiln

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/chemical/ceramics-glass/tunnel-kiln-heat-balance

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.