Digester Steam to Heat Chips and Liquor

Steam needed to heat chips, chip water and cooking liquor in a digester from charge temperature to cooking temperature by direct or indirect heating (IF97).

Method: Smook; Handbook for Pulp & Paper Technologists; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
OD wood	50,000	kg
Wood specific heat	1.3400	kJ/(kg·K)
Liquor and water (incl. chip water)	200,000	kg
Liquor specific heat	3.9000	kJ/(kg·K)
Charge temperature	70.000	°C
Cooking temperature	170.00	°C
Steam pressure (absolute)	12.000	bar
Heating	Direct steam (condensate stays)	
Heat loss share	5.0000	%

Calculated results

Parameter	Value	Unit
Heat required	89.158	GJ
Steam	43.190	t
Steam per OD tonne of wood	0.86379	kg/kg

Notes for this case

- Direct steaming dilutes the liquor with condensate; indirect heating through a liquor heater keeps it out.

Formula and method

$$Q = \frac{(W c_w + M_l c_l)(T_2 - T_1)}{1 - \varepsilon}, \quad m_s = \frac{Q}{h_g - h_c}$$

Variables

W	OD wood	kg
c_w	Wood specific heat	J/(kg·K)
M_l	Liquor and water (incl. chip water)	kg
c_l	Liquor specific heat	J/(kg·K)
T_1	Charge temperature	K
T_2	Cooking temperature	K
p_s	Steam pressure (absolute)	Pa
$\mathrm{heating}$	Heating	-
ε	Heat loss share	-
Q	Heat required	J
m_s	Steam	kg
m_s/W	Steam per OD tonne of wood	kg/kg
h_g	Enthalpy of saturated steam at p_s (IAPWS-IF97)	J/kg

h_c	Condensate enthalpy: liquid at T_2 (direct) or saturated at p_s (indirect)	J/kg

Method and standards

Sensible heat balance with IF97 steam enthalpies.

Assumptions and limits

- Uniform heating; constant specific heats.
- Direct steaming: the condensate stays and ends as liquid at the cooking temperature, h_c = h(p_s, T_2) from IAPWS-IF97. Indirect: the condensate leaves saturated at p_s.

References

- Smook
- Handbook for Pulp & Paper Technologists
- 3rd ed. (Angus Wilde, 2002)
- ch. 7–8 (digester heating, direct and indirect)
- Steam enthalpies from IAPWS-IF97

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/chemical/pulp-paper/digester-steam-heat-up

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.