Paddy Parboiling: Soak Water and Steaming

Hot water for soaking and steam for heating and steaming paddy in parboiling, from batch size, water ratio, temperatures and steam per kg for steaming (IF97 steam).

Method: Definitions and mass and energy balances; Steam latent heat from IAPWS-IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Paddy batch	10,000	kg
Soak water to paddy ratio	1.2000	kg/kg
Fresh water temperature	25.000	°C
Soaking temperature	70.000	°C
Paddy specific heat	1.8000	kJ/(kg·K)
Steaming steam per kg paddy	0.12000	kg/kg
Steam pressure (absolute)	4.0000	bar

Calculated results

Parameter	Value	Unit
Soak water	12,000	kg
Heat to the soak water and paddy	3.0709	GJ
Steam to heat the soak	1,439.5	kg
Steam for steaming	1,200.0	kg
Total steam	2,639.5	kg

Notes for this case

- Hot soaking at 65–70 °C cuts soak time from days to 3–4 hours; drain water carries heat that can be recovered.
- Soak heating steam is credited with its latent heat only (indirect heating, condensate leaving saturated). Steam sparged into the soak also gives up the condensate's heat down to the soak temperature, so less steam is needed (about 13 % less at 4 bar and 70 °C).

Formula and method

$$M_w = r_w M, \quad Q_s = (M_w c_w + M c_p)(T_s - T_1), \quad m_s = \frac{Q_s}{h_{fg}} + m_{st} M$$

Variables

M	Paddy batch	kg
r_w	Soak water to paddy ratio	kg/kg
T_1	Fresh water temperature	K
T_s	Soaking temperature	K
c_p	Paddy specific heat	J/(kg·K)
m_{st}	Steaming steam per kg paddy	kg/kg
p_s	Steam pressure (absolute)	Pa
M_w	Soak water	kg
Q_s	Heat to the soak water and paddy	J
m_1	Steam to heat the soak	kg
m_2	Steaming steam for steaming	kg
m_s	Total steam	kg

c_w	Water specific heat, 4 186.8	J/(kg·K)
h_{fg}	Latent heat of the steam at p_s (IF97)	J/kg

Method and standards

Sensible heat with IF97 latent heat.

Assumptions and limits

- No soak losses.
- The soak is heated indirectly: steam gives its latent heat h_fg and leaves as saturated condensate. If steam is sparged directly into the soak, the condensate also cools to the soak temperature and the steam needed is lower (about 13 % less at 4 bar and 70 °C).
- Water specific heat c_w = 4 186.8 J/(kg·K).

References

- Definitions and mass and energy balances
- Steam latent heat from IAPWS-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

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Reopens the calculator with the inputs of this report.