HRSG Steam Generation (Pinch and Approach)

Steam a heat recovery steam generator (HRSG) or exhaust boiler makes from gas flow and temperature, with pinch point, approach and stack temperature (IAPWS-IF97).

Method: Ganapathy; Steam Plant Calculations Manual; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Exhaust gas flow	360,000	kg/h
Mean specific heat of the gas	1.1500	kJ/(kg·K)
Gas temperature entering	550.00	°C
Steam (drum) pressure (absolute)	40.000	bar
Steam condition	Superheated at the temperature below	
Superheated steam temperature	400.00	°C
Feedwater temperature	105.00	°C
Pinch point (gas leaving evaporator minus saturation)	10.000	K
Approach (saturation minus economiser water outlet)	5.0000	K

Calculated results

Parameter	Value	Unit
Steam generated	55,743	kg/h
Stack (gas exit) temperature	176.86	°C
Total heat recovered	42.911	MW
Economiser duty	9.6024	MW
Gas temperature at the pinch	260.36	°C

Formula and method

$$T_{g,p} = T_{sat} + \Delta T_p \qquad \dot{m}_s = \frac{\dot{m}_g c_{p,g}(T_{g,1} - T_{g,p})}{h_s - h_{eco}}, \; h_{eco} = h(p, T_{sat} - \Delta T_a)$$

$$\dot{Q}_{eco} = \dot{m}_s(h_{eco} - h_{fw}) \qquad T_{st} = T_{g,p} - \frac{\dot{Q}_{eco}}{\dot{m}_g c_{p,g}} \qquad \dot{Q} = \dot{m}_s(h_s - h_{fw})$$

Variables

$\dot{m}_g$	exhaust gas flow	kg/s
$c_{p,g}$	gas specific heat	J/(kg·K)
$T_{g,1}$	gas inlet temperature	K
p	drum pressure	Pa
state	saturated or superheated	–
T_s	superheated steam temperature	K
T_{fw}	feedwater temperature	K
ΔT_p	pinch point	K
ΔT_a	approach	K

$\dot{m}_s$	steam generated	kg/s
T_{st}	stack temperature	K
$\dot{Q}$	total heat recovered	W
$\dot{Q}_{eco}$	economiser duty	W
$T_{g,p}$	gas temperature at the pinch	K
T_{sat}	saturation temperature	K
h_s, h_{eco}, h_{fw}	steam, economiser outlet and feedwater enthalpies (IF97)	J/kg

Method and standards

Pinch-point method as described by V. Ganapathy for HRSG performance; water and steam enthalpies from FireCAD's IAPWS-IF97; gas with a mean specific heat.

Assumptions and limits

- Single pressure, unfired; constant gas specific heat; no casing loss; no blowdown.
- The stack must stay above the feedwater temperature; otherwise the case fails, because the economiser cannot absorb the duty.
- The superheated steam must be below the gas inlet temperature. With the pinch fixed below the evaporator, the gas leaving the superheater is always above saturation, so no other profile check is needed.

References

• Ganapathy
• Steam Plant Calculations Manual
• 2nd ed. (Marcel Dekker, 1993)
• Q4.34 (HRSG design with pinch and approach); IAPWS R7-97 IF97

Report details

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Release checks	3 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/hrsg-waste-heat/hrsg-steam-generation

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.