HRSG Efficiency on the ASME PTC 4.4 Basis

HRSG efficiency as energy to steam over gas energy above a reference plus duct-burner fuel (LHV), after the ASME PTC 4.4 definition with a mean gas c_p, using IAPWS-IF97.

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

Input parameters

Unit system: SI

Parameter	Value	Unit
Gas flow	63,503	kg/h
Gas inlet temperature (before any burner)	526.67	°C
Reference temperature for gas enthalpy	15.000	°C
Mean gas specific heat from T_ref to T_g	1.1100	kJ/(kg·K)
Duct burner fuel input (LHV)	0	kW
Steam flow	11,340	kg/h
Steam pressure (absolute)	14.803	bar
Steam temperature (0 or ≤ saturation = dry saturated)	-273.15	°C
Feedwater temperature	110.00	°C
Blowdown fraction of steam	2.0000	%

Calculated results

Parameter	Value	Unit
Gas energy above the reference	10,019	kW
Energy to steam and blowdown	7,357.9	kW
HRSG efficiency (PTC 4.4)	73.443	%
Steam temperature used	197.67	°C

Notes for this case

- PTC 4.4 bases the gas energy on the measured exhaust analysis and its enthalpy above the code's reference; a mean c_p from the same reference is used here. Firing raises system efficiency because it adds heat without adding air.

Formula and method

$$E = \frac{\dot{m}_s(h_s - h_{fw}) + b\dot{m}_s(h_f - h_{fw})}{W_g \bar{c}_p(T_g - T_{ref}) + Q_{f,LHV}}$$

Variables

W_g	Gas flow	kg/s
T_g	Gas inlet temperature (before any burner)	K
T_{ref}	Reference temperature for gas enthalpy	K
$\bar{c}_p$	Mean gas specific heat from T_ref to T_g	J/(kg·K)
Q_f	Duct burner fuel input (LHV)	W
$\dot{m}_s$	Steam flow	kg/s
p	Steam pressure (absolute)	Pa
T_s	Steam temperature (0 or ≤ saturation = dry saturated)	K
T_{fw}	Feedwater temperature	K
b	Blowdown fraction of steam	-

Q_g	Gas energy above the reference	W
Q_s	Energy to steam and blowdown	W
E	HRSG efficiency (PTC 4.4)	-
$T_{s,used}$	Steam temperature used	K

Method and standards

The efficiency definition of ASME PTC 4.4 (output over gas energy above the reference plus fuel input), with the worked form of Ganapathy Q4.38. PTC 4.4 takes the gas energy from the measured exhaust analysis and its enthalpy; here a mean c_p over T_ref to T_g is used instead, so the result is an estimate on that basis, not a code test result.

Assumptions and limits

- Mean c_p; steady state.
- The feedwater must be liquid at the steam pressure (at or below the saturation temperature); the heat to steam must be above zero. An efficiency above 100 % is shown with a warning.

References

- Ganapathy
- Steam Plant Calculations Manual
- 2nd ed. (Marcel Dekker, 1993)
- Q4.38 (HRSG efficiency on the ASME PTC 4.4 basis); IAPWS-IF97 steam properties

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/hrsg-waste-heat/hrsg-efficiency-ptc-4-4

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Reopens the calculator with the inputs of this report.