Condensing Economiser Heat Recovery

Sensible and latent heat recovered by cooling flue gas below its water dew point, with the condensate formed and the efficiency gain, from the fuel analysis.

Method: IAPWS R7-97(2012) IF97 (saturation); NIST Chemistry WebBook Shomate equations; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Carbon	45.000	%
Hydrogen	3.5000	%
Oxygen	5.0000	%
Nitrogen	1.0000	%
Sulphur	0.50000	%
Ash	35.000	%
Moisture	10.000	%
Excess air	20.000	%
Air humidity (kg water per kg dry air)	0.013000	kg/kg
Fuel firing rate	12,000	kg/h
Flue gas temperature entering	150.00	°C
Flue gas temperature leaving Set by the coldest water available (return water or make-up).	45.000	°C
Flue gas pressure (absolute)	1.0132	bar
Gross calorific value of the fuel, as fired	18,600	kJ/kg

Calculated results

Parameter	Value	Unit
Total heat recovered	3,339.7	kW
Sensible heat	3,027.4	kW
Latent heat from condensation	312.28	kW
Water condensed	469.59	kg/h
Efficiency gain on GCV (points)	5.3866	%
Water dew point of the flue gas	46.409	°C

Notes for this case

- Condensate from flue gas is acidic: the condensing section needs stainless steel or another corrosion-resistant material and a neutralised drain.

Formula and method

$$\dot{Q}_s = \dot{m}_f \left[m_{dg}\,\Delta h_{dg} + m_w\,\Delta h_v \right] \qquad n_c = \max\left(0,\; n_w - n_{dg}\,\frac{p_{sat}(T_2)}{p - p_{sat}(T_2)}\right)$$

$$\dot{m}_c = \dot{m}_f n_c\, M_{H_2O} \qquad \dot{Q}_l = \dot{m}_c h_{fg}(T_2) \qquad \dot{Q} = \dot{Q}_s + \dot{Q}_l \qquad \Delta\eta = \frac{\dot{Q}}{\dot{m}_f GCV}$$

$$T_{dp} = T_{sat}\left(\frac{n_w}{n_w + n_{dg}}\,p\right)$$

Variables

$C\$, \$H\$, \$O\$, \$N\$, \$S\$, \$A\$, \$M$	ultimate analysis as fired, mass fractions	–
EA	excess air	–
ω	air humidity, kg water per kg dry air	kg/kg
$\dot{m}_f$	fuel firing rate	kg/s
T_1	flue gas temperature entering	K
T_2	flue gas temperature leaving	K
p	flue gas pressure, absolute	Pa
GCV	gross calorific value	J/kg
$\dot{Q}$	total heat recovered	W
$\dot{Q}_s$	sensible heat recovered	W
$\dot{Q}_l$	latent heat from condensation	W
$\dot{m}_c$	water condensed	kg/s
$\Delta\eta$	efficiency gain on GCV	–
T_{dp}	water dew point of the flue gas	K
$m_{dg}\$, \$m_w$	dry flue gas and water vapour per kg of fuel	kg/kg
$\Delta h_{dg}\$, \$\Delta h_v$	enthalpy drop of dry gas and vapour from T_1 to T_2	J/kg
$n_w\$, \$n_{dg}$	water vapour and dry gas per kg of fuel	kmol/kg
n_c	water condensed per kg of fuel	kmol/kg
$p_{sat}\$, \$T_{sat}$	saturation pressure and temperature of water (IF97)	Pa, K
h_{fg}	latent heat at T_2 (IF97)	J/kg
M_{H_2O}	molar mass of water, 18.015 kg/kmol	kg/kmol

Method and standards

Flue gas from FireCAD's combustion balance; sensible heat from NIST Shomate enthalpies of the dry gas and of all the water as vapour; condensate from Dalton's law with the gas leaving saturated at T_2; latent heat and saturation from IAPWS-IF97. The latent heat is taken at the outlet temperature, a small simplification against the gradual condensation between the dew point and T_2.

Assumptions and limits

- Gas leaves saturated at T_2 when below its dew point; no acid condensation counted.
- Water is all vapour at T_1; latent heat at T_2. Sensible heat uses ideal-gas Shomate enthalpies and the latent heat IF97; the two bases differ negligibly at near-atmospheric partial pressure.
- Equilibrium at T_2 gives the most condensate; a real economiser whose water inlet is above T_2 over part of the surface condenses less.
- For a gaseous fuel enter its analysis by mass in the ultimate-analysis boxes (natural gas, mostly methane: about 75 % C and 25 % H).
- A warning appears when the GCV differs from the Channiwala–Parikh estimate by more than 15 %.

References

- IAPWS R7-97(2012) IF97 (saturation)
- NIST Chemistry WebBook Shomate equations
- Dalton's law of partial pressures

Report details

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Software release	FireCAD Calc, release of 17 November 2026
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/furnace-heating-surfaces/condensing-economiser-recovery

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.