Heat Available in Flue Gas (Waste Heat)

Heat that can be recovered by cooling the flue gas of a boiler or furnace from one temperature to another, from the fuel analysis, excess air and firing rate.

Method: NIST Chemistry WebBook Shomate equations; ASME PTC 4-2013 (flue gas enthalpy)

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 now	180.00	°C
Flue gas temperature after recovery Above the acid dew point for sulphur-bearing fuels; above the water dew point unless the recovery unit is built to condense.	130.00	°C

Calculated results

Parameter	Value	Unit
Heat available	1,461.8	kW
Wet flue gas flow	98,034	kg/h
Mean specific heat of the flue gas	1.0736	kJ/(kg·K)

Notes for this case

- The fuel contains sulphur: keep the recovery surface above the acid dew point (acid dew point calculator).

Formula and method

$$\dot{Q} = \dot{m}_f m_g \left[h_g(T_1) - h_g(T_2)\right] \qquad \dot{m}_g = \dot{m}_f m_g \qquad \bar{c}_p = \frac{h_g(T_1) - h_g(T_2)}{T_1 - T_2}$$

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 now	K
T_2	flue gas temperature after recovery	K
$\dot{Q}$	heat available	W
$\dot{m}_g$	wet flue gas flow	kg/s
$\bar{c}_p$	mean specific heat of the flue gas	J/(kg·K)

m_g	wet flue gas per kg of fuel	kg/kg
h_g	enthalpy of the wet flue gas	J/kg

Method and standards

Wet flue gas quantity and composition from FireCAD's exact-ratio combustion balance; enthalpy by integrating the NIST Shomate heat capacities of each gas.

Assumptions and limits

- No condensation: water stays vapour. For cooling below the water dew point, use the condensing economiser calculator.
- Complete combustion; the sensible heat of fly ash and unburnt carbon carried in the gas is not included, which matters a little for high-ash fuels.
- A warning appears when T_2 is below the water dew point (taken at atmospheric pressure) and, for sulphur-bearing fuels, a reminder about the acid dew point.
- The Shomate fits for water vapour are extended below their NIST lower limit (500 K); FireCAD checks the error there is under 1 %.
- In US units the heat is shown in Btu/h.

References

• NIST Chemistry WebBook Shomate equations
• ASME PTC 4-2013 (flue gas enthalpy)

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/furnace-heating-surfaces/flue-gas-heat-available

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.