Fuel Saving from Combustion Air Preheating

Efficiency gain and fuel saved when combustion air is preheated with heat recovered from the flue gas, from the fuel analysis, excess air and air temperatures.

Method: ASME PTC 4-2013 §5.15 (credit for entering air); 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
Gross calorific value of the fuel, as fired	18,600	kJ/kg
Air temperature now	30.000	°C
Air temperature after preheating	180.00	°C
Boiler efficiency now (on GCV)	74.000	%
Fuel firing rate	12,000	kg/h

Calculated results

Parameter	Value	Unit
Fuel saved, share	7.7345	%
Fuel saved	928.13	kg/h
Efficiency after	80.203	%
Efficiency gain (points)	6.2033	%
Heat returned in the air per kg of fuel	1,153.8	kJ/kg
Air preheater duty	3,846.0	kW

Notes for this case

- The saving assumes the flue gas can supply this heat: the gas leaving the boiler must be well above the hot air temperature and still leaves the stack at the same temperature as before.

Formula and method

$$B_a = m_a \left[h_{air}(T_{a,2}) - h_{air}(T_{a,1})\right] + \omega m_a \left[h_v(T_{a,2}) - h_v(T_{a,1})\right]$$

$$\Delta\eta = \frac{B_a}{GCV} \qquad \eta_2 = \eta_1 + \Delta\eta \qquad s = 1 - \frac{\eta_1}{\eta_2} \qquad \dot{Q}_a = \dot{m}_f B_a$$

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
GCV	gross calorific value	J/kg
$T_{a,1}$	air temperature now	K
$T_{a,2}$	air temperature after preheating	K
η_1	boiler efficiency now	–
$\dot{m}_f$	fuel firing rate	kg/s
s	fuel saved, share	–
$\Delta\dot{m}_f$	fuel saved, $s\,\dot{m}_f$	kg/s
η_2	efficiency after	–
$\Delta\eta$	efficiency gain	–
B_a	heat returned in the air per kg of fuel	J/kg
$\dot{Q}_a$	air preheater duty	W
m_a	actual dry air per kg of fuel	kg/kg
$h_{air}\$, \$h_v$	enthalpies of dry air and water vapour (Shomate)	J/kg

Method and standards

Actual dry air and its moisture per kg of fuel from FireCAD's combustion balance; the heat returned by the preheated air from NIST Shomate enthalpies of dry air and water vapour. The gain in efficiency equals that heat over the GCV, which assumes the flue gas leaves at the same temperature (the air heater takes the heat from gas that would otherwise be lost).

Assumptions and limits

- The heat comes from flue gas that would otherwise leave the stack; exit gas temperature unchanged.
- Same excess air before and after.
- The calculator does not check that the flue gas can supply the heat; the gas entering the air heater must be well above $T_{a,2}$.
- The air preheater duty $\dot{Q}_a$ uses the present firing rate; after the saving the fuel rate, and so the duty, is lower by the share s.
- A warning appears when the GCV differs from the Channiwala–Parikh estimate of the analysis by more than 15 %.

References

• ASME PTC 4-2013 §5.15 (credit for entering air)
• NIST Chemistry WebBook Shomate equations

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/boilers/combustion-air-preheat-saving

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.