Furnace Available Heat and Fuel Saved by Air Preheat

Available heat of natural gas firing at a flue exit temperature and excess air, with and without combustion air preheat, the fuel saved and the gross input.

Method: Trinks; Mawhinney; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Methane in the fuel gas	90.000	%
Ethane	5.0000	%
Propane	1.0000	%
Nitrogen	4.0000	%
Excess air	10.000	%
Flue gas exit temperature from the furnace	982.22	°C
Combustion air temperature (preheated)	426.67	°C
Air temperature of the base case	15.556	°C
Heat needed by the load plus furnace losses	2,000.0	kW

Calculated results

Parameter	Value	Unit
Available heat with preheated air (gross basis)	62.183	%
Available heat of the base case	47.690	%
Fuel saved against the base case	23.307	%
Gross fuel input with preheat	3,216.3	kW
Gross fuel input in the base case	4,193.8	kW
Fuel gas flow with preheat	287.80	Nm³/h
Gross calorific value of the gas	40.232	MJ/Nm³

Notes for this case

• Available heat is the gross heat of combustion less the heat carried out by the flue gas (from 25 °C, water as vapour) plus the sensible heat brought in by the air. No dissociation: above about 1,600 °C exit the real available heat is a little lower. Every furnace loss costs loss ÷ available heat in fuel (Trinks).

Formula and method

$$AH = \frac{GCV - \Delta H_{flue}(T_{ex}) - n_{H_2O} L_{25} + \Delta H_{air}(T_a)}{GCV}, \quad \text{saving} = 1 - \frac{AH_0}{AH}, \quad Q_{in} = \frac{Q}{AH}$$

Variables

y_{CH_4}	Methane in the fuel gas	-
$y_{C_2H_6}$	Ethane	-
$y_{C_3H_8}$	Propane	-
y_{N_2}	Nitrogen	-
EA	Excess air	-
T_{ex}	Flue gas exit temperature from the furnace	K
T_a	Combustion air temperature (preheated)	K
T_0	Air temperature of the base case	K

Q	Heat needed by the load plus furnace losses	W
AH	Available heat with preheated air (gross basis)	-
AH_0	Available heat of the base case	-
$1 - AH_0/AH$	Fuel saved against the base case	-
Q/AH	Gross fuel input with preheat	W
Q/AH_0	Gross fuel input in the base case	W
$\dot{V}_f$	Fuel gas flow with preheat	Nm³/s
GCV	Gross calorific value of the gas	J/m³

Method and standards

Available-heat balance on the gross basis.

Assumptions and limits

- Complete combustion; dry air.

References

• Trinks
• Mawhinney
• Shannon
• Reed and Garvey
• Industrial Furnaces
• 6th ed. (Wiley, 2004)
• ch. 5 (available heat, fuel saving by air preheat, Example 5.3)
• NIST Shomate gas enthalpies and IAPWS-IF97 latent heat (engine)

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/materials/steelmaking-foundry/furnace-available-heat-fuel-saving

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.