Supplementary Firing: Fuel Limit from Exhaust Oxygen

Maximum heat that can be fired in gas turbine exhaust from its oxygen content, the equivalent air, and the gas temperature rise, by Ganapathy's Eqs. (22)–(25).

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

Input parameters

Unit system: SI

Parameter	Value	Unit
Exhaust gas flow	249.48	t/h
Oxygen in the exhaust (by volume, wet basis)	14.000	%
Exhaust molar mass	29.500	kg/kmol
Fuel (Ganapathy Table 2.4: dry air per MMBtu fired, lb)	Natural gas (730)	
Fuel LHV/HHV ratio	90.000	%
Planned firing (LHV)	30.000	MW
Exhaust specific heat	1.1300	kJ/(kg·K)

Calculated results

Parameter	Value	Unit
Equivalent air in the exhaust	164.72	t/h
Maximum heat that can be fired (LHV)	131.21	MW
Planned firing as a share of the maximum	22.863	%
Gas temperature rise from the planned firing	383.10	K

Notes for this case

- Burners need some oxygen left: practical firing stops well short of the maximum. Ganapathy also gives a shortcut rule for gas and oil firing; it is not computed here.

Formula and method

$$W_a = \frac{W_g O \times 32}{0.23\, M_g}, \quad Q_{max} = W_a \frac{LHV}{A\,HHV}, \quad \Delta T = \frac{Q}{W_g c_{pg}}$$

Variables

W_g	Exhaust gas flow	kg/s
O	Oxygen in the exhaust (by volume, wet basis)	-
M_g	Exhaust molar mass	kg/kmol
A	Fuel (Ganapathy Table 2.4: dry air per MMBtu fired, lb)	-
LHV/HHV	Fuel LHV/HHV ratio	-
Q	Planned firing (LHV)	W
c_{pg}	Exhaust specific heat	J/(kg·K)
W_a	Equivalent air in the exhaust	kg/s
Q_{max}	Maximum heat that can be fired (LHV)	W
Q/Q_{max}	Planned firing as a share of the maximum	-
ΔT	Gas temperature rise from the planned firing	K

Method and standards

Ganapathy's oxygen balance; LHV/(A·HHV) ≈ 0.00124 for gas and oil.

Assumptions and limits

- Exhaust oxygen known; complete combustion.
- Exhaust oxygen must be above zero; a planned firing above the maximum is flagged, and its temperature rise then cannot be reached.
- The oxygen is by volume on the wet exhaust, consistent with the wet molar mass M_g in the volume-to-mass conversion.
- Table 2.4 figures are lb of air per MMBtu; the page converts them to SI.

References

- Ganapathy
- Steam Plant Calculations Manual
- 2nd ed. (Marcel Dekker, 1993)
- Q2.27
- Eqs. (22)–(25)
- and Table 2.4

Report details

Report reference	FCC-8Q4K-YMEW (the same inputs always give the same reference)
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Release checks	2 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/turbines-cycles/supplementary-firing-oxygen-limit

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.