Windbox Oxygen with Flue Gas Recirculation (FGR)

Oxygen and other components in the windbox when flue gas is recirculated into the combustion air for NOx control, from air, FGR flow and gas analysis.

Method: Ganapathy; Industrial Boilers and Heat Recovery Steam Generators (Marcel Dekker, 2003); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Combustion air flow (dry)	54,102	kg/h
Recirculated flue gas flow	6,350.3	kg/h
Oxygen in air, by mass	23.200	%
Flue gas CO_2, % vol (wet)	8.2900	
Flue gas H_2O, % vol (wet)	18.170	
Flue gas N_2, % vol (wet)	71.070	
Flue gas O_2, % vol (wet)	2.4700	

Calculated results

Parameter	Value	Unit
Recirculation ratio (mass)	11.738	%
Windbox O_2, % vol wet	18.900	
Windbox O_2, % vol dry	19.283	
Windbox CO_2, % vol	0.90525	
Windbox H_2O, % vol	1.9841	

Notes for this case

- Argon is counted with nitrogen; air taken as dry.

Formula and method

$$\dot{n}_i = \frac{W_r w_{i,fg}}{M_i} + \frac{W_a w_{i,air}}{M_i}, \quad y_i = \frac{\dot{n}_i}{\sum \dot{n}}, \quad w_{i,fg} = \frac{y_{i,fg} M_i}{\bar{M}_{fg}}$$

Variables

W_a	Combustion air flow (dry)	kg/s
W_r	Recirculated flue gas flow	kg/s
$w_{O_2,air}$	Oxygen in air, by mass	-
CO_2	Flue gas CO_2, % vol (wet)	-
H_2O	Flue gas H_2O, % vol (wet)	-
N_2	Flue gas N_2, % vol (wet)	-
O_2	Flue gas O_2, % vol (wet)	-
W_r/W_a	Recirculation ratio (mass)	-
$O_{2,wb}$	Windbox O_2, % vol wet	-
$O_{2,wb,dry}$	Windbox O_2, % vol dry	-
$CO_{2,wb}$	Windbox CO_2, % vol	-
H_2O_{wb}	Windbox H_2O, % vol	-

Method and standards

Mass and mole balance of the air and recirculated gas, with the molar masses Ganapathy's example uses (CO_2 44.01, H_2O 18.015, N_2 28.013, O_2 31.999). The flue gas analysis is wet and normalised to 100 %.

Assumptions and limits

- Dry air; argon with nitrogen.
- The flue gas analysis must be wet (a dry analysis leaves out the water); an analysis not adding to 100 % is normalised with a note.

References

- Ganapathy
- Industrial Boilers and Heat Recovery Steam Generators (Marcel Dekker, 2003)
- ch. 3
- Example 8 (oxygen in the windbox with flue gas recirculation)

Report details

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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/combustion/windbox-oxygen-flue-gas-recirculation

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.