Char Particle Burning Rate (Diffusion Limit) in a Fluidised Bed

Sherwood number (Halder–Basu), mass transfer coefficient and the diffusion-limited burning rate of a char particle in a fluidised bed (Basu Eqs. 4.7–4.10).

Method: Basu; Circulating Fluidized Bed Boilers: Design; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Char particle diameter	6.0000	mm
Local bed voidage	80.000	%
Gas–char slip velocity	1.0000	m/s
Gas density	0.31000	kg/m³
Gas viscosity	0.044000	cP
Oxygen diffusivity in the gas	2.0000e-04	m²/s
Oxygen partial pressure in the bulk gas	5.0000	kPa
Mean film temperature	900.00	°C
Mechanism factor (1 CO_2, 2 CO)	1.0000	

Calculated results

Parameter	Value	Unit
Particle Reynolds number	42.273	
Schmidt number	0.70968	
Sherwood number	6.0739	
Mass transfer coefficient, kg C/(m²·s·kPa O_2)	2.4910e-04	
Diffusion-limited burning rate	4.4837	kg/(m²·h)
Carbon burnt per particle	0.50710	g/h

Formula and method

$$Sh = 2\varepsilon + 0.69\left(\frac{Re}{\varepsilon}\right)^{0.5} Sc^{1/3}, \quad h_m = \frac{12\phi\, Sh\, D_g}{d_c R T_m}, \quad q_d = h_m C_g$$

Variables

d_c	Char particle diameter	m
$\mathcal{E}$	Local bed voidage	-
$U_g - U_c$	Gas–char slip velocity	m/s
ρ_g	Gas density	kg/m³
μ	Gas viscosity	Pa·s
D_g	Oxygen diffusivity in the gas	m²/s
C_g	Oxygen partial pressure in the bulk gas	Pa
T_m	Mean film temperature	K
ϕ	Mechanism factor (1 CO_2, 2 CO)	-
Re	Particle Reynolds number	-
Sc	Schmidt number	-
Sh	Sherwood number	-

h_m	Mass transfer coefficient (shown in kg C per m²·s·kPa O_2)	kg/(m²·s·kPa)
q_d	Diffusion-limited burning rate	kg/(m²·s)
$\dot{m}_p$	Carbon burnt per particle	kg/s

Method and standards

Basu's Eqs. (4.7)–(4.10); C_g in kPa, R = 8.314 kPa·m³/(kmol·K).

Assumptions and limits

- Diffusion control; spherical char; correlation fitted for 4–12 mm char (a warning appears outside).
- Gas density, viscosity and diffusivity are inputs; take them at the mean film temperature T_m so the set is consistent.
- The mechanism factor is 1 (CO_2 at the surface) or 2 (CO at the surface); a value between them represents a mixed product.

References

• Basu
• Circulating Fluidized Bed Boilers: Design
• Operation and Maintenance (Springer, 2015)
• ch. 4
• Eqs. (4.7)–(4.10) (Halder and Basu 1988)

Report details

Report reference	FCC-5WEK-VYVT (the same inputs always give the same reference)
Generated	17 November 2026, 19:48 UTC
Calculator	Char Particle Burning Rate (Diffusion Limit) in a Fluidised Bed
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
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/fluidised-bed/char-burning-rate-diffusion

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Reopens the calculator with the inputs of this report.