CFB Solid Residue: Spent Sorbent, Bed Drain and Fly Ash Capacity

Total solid residue of a CFB boiler from fuel ash and spent limestone ($CaSO_4$, free CaO, inerts), and design capacities for bed drain and fly ash handling (Basu).

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

Input parameters

Unit system: SI

Parameter	Value	Unit
Fuel feed	30.000	t/h
Ash in fuel, as fired	30.000	%
Sulphur in fuel, as fired	0.80000	%
Ca/S molar ratio	2.2000	
Sulphur capture	90.000	%
$CaCO_3$ in limestone	90.000	%
Bed drain design share of total solids	60.000	%
Fly ash design share of total solids Basu designs the fly ash equipment for 90 % of the total solids.	90.000	%
Capacity margin	25.000	%

Calculated results

Parameter	Value	Unit
Limestone feed	1.8315	t/h
$CaSO_4$ formed	0.91718	t/h
Free CaO	0.54573	t/h
Total solid residue	10.646	t/h
Bed drain design capacity	7.9845	t/h
Fly ash system design capacity	11.977	t/h

Notes for this case

- Basu: the actual bed drain share varies from 5 to 70 % (about 20 % for bituminous coal); design the drain for 50–70 % of the total and fly ash equipment for 90 %, each with a 20–30 % margin. Limestone inerts taken as non-volatile; unburnt carbon is not included.

Formula and method

$$\dot{n}_S = \frac{\dot{m}_f S}{32.06}, \quad \dot{m}_{ls} = \frac{(Ca/S)\dot{n}_S 100.09}{x_{CaCO_3}}, \quad \dot{m}_{CaSO_4} = \eta_S \dot{n}_S 136.14, \quad \dot{m}_{CaO} = (Ca/S - \eta_S)\dot{n}_S 56.08$$

$$\dot{m}_{res} = \dot{m}_f A + \dot{m}_{CaSO_4} + \dot{m}_{CaO} + \dot{m}_{ls}(1 - x_{CaCO_3})$$

Variables

$\dot{m}_f$	Fuel feed	kg/s
A	Ash in fuel	-
S	Sulphur in fuel	-
Ca/S	Ca/S molar ratio	-
η_S	Sulphur capture	-

x_{CaCO_3}	$CaCO_3$ in limestone	-
f_{bd}	Bed drain design share of total solids	-
f_{fa}	Fly ash design share of total solids (Basu: 90 %)	-
m	Capacity margin	-
$\dot{m}_{ls}$	Limestone feed	kg/s
$\dot{m}_{CaSO_4}$	$CaSO_4$ formed	kg/s
$\dot{m}_{CaO}$	Free CaO	kg/s
$\dot{m}_{res}$	Total solid residue	kg/s
$\dot{m}_{bd}$	Bed drain design capacity	kg/s
$\dot{m}_{fa}$	Fly ash system design capacity	kg/s
$\dot{m}_{bd}\$, \$\dot{m}_{fa}$	$= \dot{m}_{res} f(1+m)$ with $f = f_{bd}$ or f_{fa}	kg/s

Method and standards

Stoichiometric residue balance with Basu's design shares; molar masses from IUPAC atomic weights (S 32.06, $CaCO_3$ 100.09, $CaSO_4$ 136.13, CaO 56.08 kg/kmol).

Assumptions and limits

- Complete calcination; $CaSO_4$ the only sulphur product.
- Unburnt carbon in the residue is not included, so the residue is somewhat understated for fuels with high carbon loss.
- Everything in the limestone that is not $CaCO_3$ is taken as a non-volatile inert. $MgCO_3$ in dolomitic limestone loses its CO_2, so the residue is then slightly overstated.
- Ash and sulphur are on the as-fired basis of the fuel feed.

References

- Basu
- Circulating Fluidized Bed Boilers: Design
- Operation and Maintenance (Springer, 2015)
- ch. 6
- Bed Drain Capacity and sec. 6.5.7 (ash split) and the $CaCO_3$–$CaSO_4$ stoichiometry

Report details

Report reference	FCC-46J2-4Y06 (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/fluidised-bed/cfb-ash-split-bed-drain

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.