Pulveriser Mill Outlet Temperature and Air to Coal Ratio

Mill outlet temperature of a coal pulveriser from the primary air flow and temperature, coal feed and moisture, by a heat balance, with the air to coal ratio.

Method: Mill heat balance; IAPWS-IF97; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Raw coal feed to the mill	30.000	t/h
Total moisture of the raw coal	15.000	%
Moisture left in the pulverised coal	2.0000	%
Raw coal temperature	30.000	°C
Specific heat of the dry coal From the coal analysis or the mill maker.	1.2500	kJ/(kg·K)
Primary air flow, dry	60.000	t/h
Primary air temperature at the mill inlet	280.00	°C
Primary air humidity, kg water per kg dry air About 0.01 for temperate air, up to 0.02 to 0.03 for humid tropical air; from the psychrometric chart at the air intake.	0.013000	kg/kg
Mill grinding power (enters as heat)	0	kW
Heat lost from the mill casing and ducts	0	kW

Calculated results

Parameter	Value	Unit
Mill outlet temperature	87.908	°C
Primary air (dry) to coal ratio	2.0000	kg/kg
Water evaporated in the mill	3.9796	t/h
Heat taken by drying and heating the coal	3,354.6	kW

Notes for this case

- The mill outlet temperature limit depends on the coal's volatile matter (fire and explosion risk); check the mill maker's limit.

Formula and method

$$w = \frac{M_{in} - M_{out}}{1 - M_{out}}, \quad \dot{m}_w = \dot{m}_c w$$

$$Q_c = \dot{m}_w[h_v(T_o) - h_f(T_c)] + \dot{m}_c(1 - M_{in})c_c(T_o - T_c) + \dot{m}_c(M_{in} - w)[h_f(T_o) - h_f(T_c)]$$

$$h_a(T) = h_{da}(T) + x_a h_{v,ig}(T), \quad \dot{m}_a[h_a(T_{in}) - h_a(T_o)] + P_m - Q_l = Q_c$$

Variables

$\dot{m}_c$	raw coal feed	kg/s
M_{in}	total moisture of the raw coal	-
M_{out}	moisture left in the pulverised coal	-
T_c	raw coal temperature	K
c_c	specific heat of the dry coal	J/(kg·K)
P_m	mill grinding power, entering as heat	W

Q_l	mill casing and duct heat loss	W
$\dot{m}_w$	water evaporated	kg/s
Q_c	heat taken by the coal side	W
$\dot{m}_a$	primary air flow, dry air	kg/s
T_{in}	primary air temperature at the mill inlet	K
T_o	mill outlet temperature	K
r	primary air (dry) to coal ratio	kg/kg
h_v	water vapour enthalpy at T_o and 1 psia	J/kg
h_f	liquid water enthalpy	J/kg
h_a	humid air enthalpy per kg dry air: dry air plus x_a kg of ideal-gas water vapour	J/kg
x_a	primary air humidity, kg water vapour per kg dry air	kg/kg
h_{da}	dry air enthalpy	J/kg
$h_{v,ig}$	ideal-gas water vapour enthalpy	J/kg
W	water evaporated per kg raw coal	kg/kg

Method and standards

A heat balance on the mill: the hot primary air gives up heat between the mill inlet and outlet temperatures; with the grinding power (which ends as heat) it evaporates the surface moisture and warms the coal and the water left in it. The evaporated water leaves as vapour (IAPWS-IF97 at 1 psia, as ASME PTC 4 treats flue gas moisture); the primary air is humid: per kg of dry air it carries x_a kg of water vapour, and its enthalpy is dry air plus that vapour as an ideal gas from NIST Shomate data, the basis ASME PTC 4 uses for moisture in air. The outlet temperature is found by solving the balance.

Assumptions and limits

- Steady state; the primary air flow is dry air, and the humidity entered is carried as vapour.
- If the heat supplied exceeds the coal's need even at the inlet air temperature, the outlet is shown at that temperature with a note.
- Surface moisture removed is total moisture less the moisture left in the pulverised coal.
- No allowance for seal air or leakage.

References

• Mill heat balance
• IAPWS-IF97
• ASME PTC 4 (vapour at 1 psia)

Report details

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Release checks	3 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/fuel-ash-handling/pf-mill-outlet-temperature

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.