Coal Drying in the Mill: Primary Air Temperature Needed

Water evaporated and heat needed to dry coal in a pulveriser, and the primary air temperature at the mill inlet that gives the chosen mill outlet temperature.

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)
Mill outlet temperature wanted	70.000	°C
Primary air (dry) to coal ratio	2.0000	kg/kg
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
Water evaporated in the mill	3.9796	t/h
Heat taken by drying and heating the coal	3,147.6	kW
Primary air flow, dry	60.000	t/h
Primary air temperature needed at the mill inlet	250.91	°C

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

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

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

$$h_a(T) = h_{da}(T) + x_a h_{v,ig}(T)$$

$$\dot{m}_a = r\,\dot{m}_c, \quad \dot{m}_a[h_a(T_{in}) - h_a(T_o)] + P_m - Q_l = Q_c$$

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, ash included, as a constant mean value	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
γ	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
$\mathcal{W}$	water evaporated per kg raw coal	kg/kg
T_o	mill outlet temperature wanted	K

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.

Assumptions and limits

- Steady state; tempering air is assumed already mixed into the primary air.
- The primary air flow and the air to coal ratio are on dry air; the humidity entered is carried as vapour and adds to the heat the air brings (about 2 % at 0.013 kg/kg).
- No allowance for seal air or leakage.
- The evaporated water is valued as vapour at 1 psia (the ASME PTC 4 flue-gas convention), not at the actual partial pressure in the mill; the difference is small.
- A warning appears when the inlet air would need to be above 400 °C.

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/coal-drying-in-mill

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.