

Useful formulas: Help yourself.

Most industrial processes require energy. Bringing energy into processes requires power and time. The following there are some simple, basic calculations that can give first estimations on required heating power. Additional application tests are always recommended and supported by Leister.

The following formulas are meant as rules-of-thumb. They can be employed as first estimations to plan equipment. The calculated values serve as approximate values. Losses are not considered.

Electric power, current and voltage

$$V = R * I$$

V = Voltage [V]
R = Resistance [Ohm]

$$P = V * I$$

I = Current [A]
P = Power [W]

Example single-phase:

V = 230V
P = 1 kW (e.g. LHS 21S CLASSIC, 139.869)

$$I = \frac{1000}{230} = 4.35 [A] \quad \rightarrow \text{single-phase}$$

$$I = \frac{P}{V} \quad \rightarrow \text{single-phase}$$

Example three-phase:

V = 3 * 400V
P = 6 kW (e.g. LHS 61S SYSTEM, 3 x 400 V / 6 kW, 142.496)

$$I = \frac{6000}{400 * \sqrt{3}} = 8.66 [A] \quad \rightarrow \text{three-phase}$$

$$I = \frac{P}{V * \sqrt{3}} \quad \rightarrow \text{three-phase}$$

Electrical output with voltage differences

$$P_{\text{act}} = \frac{V_{\text{act}}^2}{V_{\text{nom}}^2} * P_{\text{nom}}$$

Example:

V_{act} = 200V
V_{nom} = 230V
P_{nom} = 1 kW (e.g. LHS 21S CLASSIC, 139.869)

$$P_{200V} = \frac{200^2}{230^2} * 1000 = 756 [W]$$

P_{act} = effective Power [W]
P_{nom} = nominal Power [W]
V_{act} = effective Voltage [V]
V_{nom} = nominal Voltage [V]

Do not reduce voltage to control power with air heaters from the LHS PREMIUM or the LHS SYSTEM line!

Heating power calculated from air flow and temperature difference

$$P = c_{air} * \frac{1}{60000} * \dot{V} * \rho_{air} * \Delta T$$

- P = Power [kW]
 c_{air} = Heat capacity of air [kJ/kgK]
 \dot{V} = Air flow [l/min]
 ρ_{air} = Density of air [kg/m³]
 ΔT = Temperature difference [°C]
 $\frac{1}{60000}$ = Conversion factors due to chosen units

Specific heat capacity of air c_{air} : 1.005 kJ/kgK
 Density of air ρ_{air} : 1.204 kg/m³
 (at 20°C and 101.3 kPa)

Example:

Air flow \dot{V} = 1200 l/min
 Temp. of environment T_{start} = 25 °C
 Target temperature T_{end} = 500 °C

$$P = 1.005 * \frac{1}{60000} * 1200 * 1.204 * (500 - 25) = 11.5 [kW]$$

11.5 kW is the power required to heat the air to the target temperature.

For estimating the needed heating power, please consider: Your process may also need energy for other wanted or unwanted effects (losses etc.).

Heat loss via Isolation

$$\frac{Q}{t} = \lambda * \frac{A}{d} * \Delta T = P$$

- P = Power [W]
 Q = Heat energy [J]
 t = Time [s]
 λ = Heat transfer coefficient [W/m²*K]
 A = Surface [m²]
 d = Thickness of wall [m]
 ΔT = Temperature difference [°C]

Example:

Box made from Styrofoam
 Dimensions (H*W*T) = 0.5 m x 1 m x 1 m
 Wall thickness of box = 5 cm
 T inside box = 80 °C
 T outside box = - 20 °C
 Heat conductivity for Styrofoam = 0.05 W/mK
 The surface of the box is
 $A = 2 * (1 * 1) + 4 * (0.5 * 1) = 4 \text{ m}^2$

$$P = 0.05 * \frac{4}{0.05} * 100 = 400 [W]$$

400 W are required to hold the temperature inside the box on 80°C with an environment temperature of -20°C.