Reciprocating Compressor Calculation

Project: ____________ Part/Position: ____________ Prepared by: ____________

Sample document - numeric values are only included in the purchased Pro export.

Overall assessment: OK - the discharge temperature t_2 stays within the guideline for oil-lubricated reciprocating compressors.

Inputs

Type of compression	– – –
Delivered volume flow V_2 (at p_2 and suction temperature)	– – – m^3/h
Suction pressure p_1 (absolute)	– – – bar
Discharge pressure p_2 (absolute)	– – – bar
Suction temperature t_1	– – – °C
Number of stages z	– – –
Specific gas constant R_s	– – – J/(kg·K)
Specific heat capacity c_p	– – – J/(kg·K)
Isentropic exponent kappa	– – –

Assessment

Criterion	Value	Limit	Status
Discharge temperature t_2 (guideline)	– – – °C	– – – °C	● within guideline

Delivered quantity and power

Compression power P	– – – kW
Mass flow m	– – – kg/h
Suction volume flow V_1	– – – m^3/h

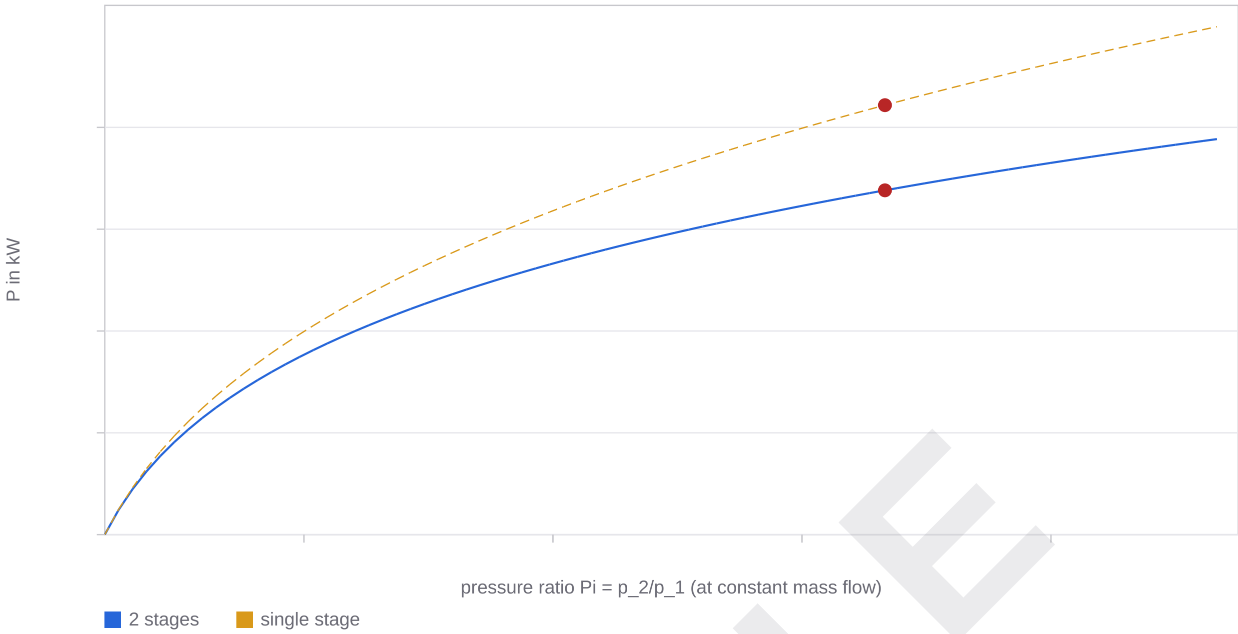
Multi-stage compression with intercooling

Intermediate pressures	– – – bar
Pressure ratio per stage Pi_St	– – –
Single-stage power	– – – kW
Saving against single stage	– – – %

Characteristics

Pressure ratio Pi = p_2/p_1	– – –
Pressure ratio per stage Pi_St	– – –
Process exponent m	– – –
Power per stage	– – – kW
Total cooling duty Q	– – – kW
of which during compression	– – – kW

Compression power over the pressure ratio



Notes

Pressure ratio per stage Pi_St = – – –: reciprocating compressors usually run at about 3 to 4 per stage, consider one more stage.

Calculation basis

Mass flow and suction volume flow: the delivered volume flow V_2 refers to the discharge pressure p_2 at suction temperature T_1, that is to the state after aftercooling. The ideal gas equation of state p·V = m·R_s·T therefore gives the mass flow m = p_2·V_2/(R_s·T_1) and from it the suction volume flow V_1 = m·R_s·T_1/p_1.

Discharge temperature and technical work: every reversible compression follows p·v^m = const with the process exponent m (isothermal m = 1, isentropic m = kappa, polytropic m = n), which gives T_2 = T_1·(p_2/p_1)^((m-1)/m). A compressor is an open, flow-through system, so the governing quantity is the technical work w_t (integral of v dp) and not the boundary work of a closed system: isothermal w_t = R_s·T_1·ln(p_2/p_1), isentropic w_t = c_p·(T_2-T_1), polytropic w_t = n/(n-1)·R_s·(T_2-T_1). The compression power is P = m·w_t.

Multi-stage compression: if the gas is cooled back to suction temperature between the stages, the total power is smallest when all stages share the same pressure ratio. For z stages Pi_St = (p_2/p_1)^(1/z), the intermediate pressures are p_i = p_1·Pi_St^i and the total power is P = z·m·w_t(Pi_St). For two stages the optimum intermediate pressure is exactly the geometric mean p = sqrt(p_1·p_2).

Cooling duty and swept volume: if the gas leaves the compressor at suction temperature again after inter- and aftercooling, its enthalpy is unchanged; the first law for the open process then gives Q = -P. From the speed n_D and the volumetric efficiency lambda follows the required swept volume V_h = V_1/(n_D·lambda). Sign convention: work and heat supplied to the gas count positive, heat removed is therefore negative.

Validity: ideal gas with temperature-independent heat capacities, reversible compression without friction, valve and flow losses, without clearance volume and leakage; with several stages complete intercooling back to suction temperature. The output is the internal compression power, not the coupling or motor power. The classification of the discharge temperature (guideline – – – °C, critical from – – – °C) is an empirical value for oil-lubricated reciprocating compressors and not a verification against a standard. Source of the relations and the worked figures: Langeheinecke/Jany/Thieleke, Thermodynamik für Ingenieure, 6th edition, chapter 7.