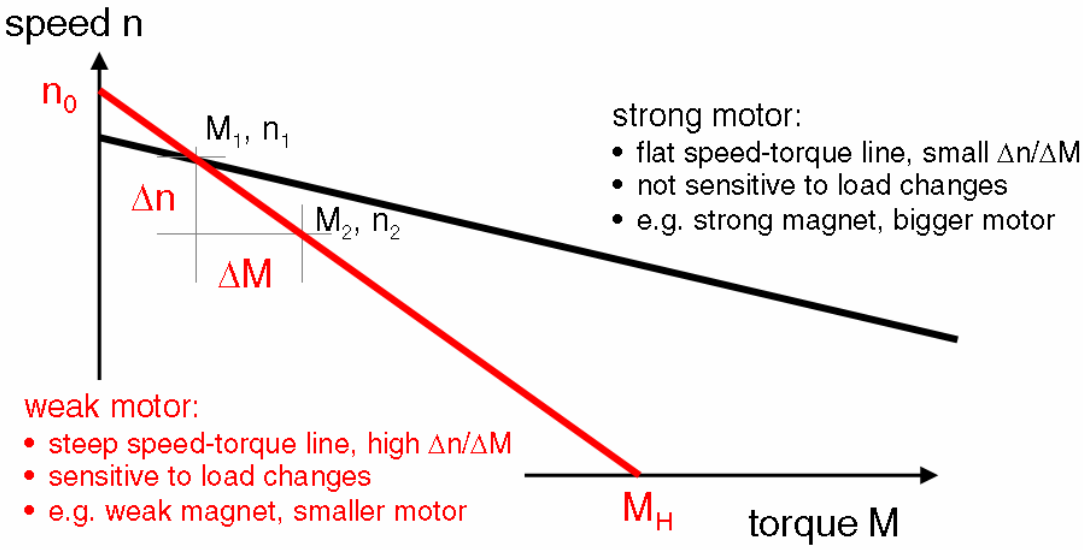
On the interpretation of the slope Δn/ΔM of the speed-torque line

The slope of the speed torque line is a measure of motor performance. A flat speed-torque line with a low value for the slope corresponds to a powerful motor in which the speed varies only slightly as the load increases. Less powerful motors have a steeper speed-torque line with a correspondingly higher value for the slope of the speed-torque line.



The slope of the speed-torque line is a motor constant which is determined solely on the basis of design variables: The geometric arrangement and dimensions of the winding and magnetic circuit and the resulting magnetic flux density in the air gap. The number of winding turns and the resistance of the winding also enter the calculation, however, their influence cancels over a series of windings if the total copper cross section in the air gap is equal. Thus, the slope of the speed-torque line may be considered a mechanical constant, which characterizes the motor type and not the individual winding with its electrical characteristics. Motors that have the same slope of the speed-torque line will exhibit the same response under load.

Relation with motor performance constant k

On larger motors, we frequently find as a comparative measurement for motor performance the constant k, which is indicated in $Nm/W^{1/2}$. A higher k value indicates a more powerful motor. The slope of the characteristic line in fact has the same meaning as k, and they are related by

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$$\frac{\Delta n}{\Delta M} \propto \frac{1}{k^2}$$

although Δn/ΔM is more practical for the calculations.

For example, a speed-torque line slope of 5 min^{-1}/mNm means that at constant voltage an increase in the required torque by 10 mNm results in a speed drop by $10 \cdot 5 = 50$ min^{-1}.

Determination of the slope of the speed-torque line

The slope of the speed-torque line of a motor can be calculated easily from the no-load speed n_0 and the stall torque M_H values which are usually listed in the motor data sheets. The following equation applies

$$\frac{\Delta n}{\Delta M} = \frac{n_0}{M_H}$$

If the motor data sheet is unavailable, the slope of the speed-torque line can be calculated from a measurement of the no-load speed n_0 at the motor voltage U and from the motor resistance R:

$$\frac{\Delta n}{\Delta M} = \frac{\pi}{30} \cdot \frac{R \cdot n_0^2}{U^2}$$

The electrical resistance R of the motor should thereby be determined by means of a current measurement with the motor shaft locked (starting current I_A).

$$R = \frac{U}{I_A}$$