# Calculation of Application Torques for Zürrer Gear Units

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## Table torques

The static torques given in the tables are based on uniform, smooth servo-operation and on wear or maximum flank load. In other words, these values are merely theoretic.

Considered calculating factors are:

| | | |
|---|---|---|
| load factor | = | 1.00 |
| operating time factor | = | 1.00 |
| safety coefficient | = | 1.00 |
| life cycle | = | 20`000 h |
| oil-sump temperature | = | 80 ° C |

Since, in practice, the applications are very diverse, it is essential to consider the given conditions by using the appropriate factors.
Under full load continuous running it is necessary to consider temperature limits! (The maximum oil – sump temperature of 80° C should not be exceeded).

### Load factor $B_K$

| drive | type of load from the machines to be driven | | |
|---|---|---|---|
| | uniform | medium shocks | heavy shocks |
| uniform | 1.00 | 1.25 | 1.75 |
| light shocks | 1.25 | 1.50 | 2.00 |
| medium shocks | 1.50 | 1.75 | 2.25 |

| **Operating time factor $B_D$** | | | |
|---|---|---|---|
| operating time | 2-8 h. | 8-12 h. | >12 h. |
| operating time factor | 1.00 | 1.20 | 1.35 |

### Safety coefficient S

The safety coefficient should be allowed for according to experience (S = 1.2 - 1.5).

### Efficiency

The gearing efficiency is given in the tables. For calculating the power it is indispensable to consider the power loss due to the following factors:

| | |
|---|---|
| shaft sealings | 2.5% each |
| ball bearings | 3.5% each |

| | |
|---|---|
| churn loss | 5% |
| coupling | 4% |

**The overall efficiency is calculated as follows:**

$\eta_g = \eta_z \times \eta_d \times \eta_w \times \eta_p \times \eta_k$

**Formulas for determining power and torque data:**

$$a = \frac{\upsilon}{t_b}$$ (m/s²)

$$F_u = m \times g + m \times a$$ (for lifting axle) (N)

$$F_u = m \times g \times \mu + m \times a$$ (for driving axle) (N)

$$T_{2erf.} = \frac{F_u \times d}{2000}$$ (Nm)

$$n_2 = \frac{\upsilon}{d \times \pi} \times 60000$$ (min$^{-1}$)

$$i_{Getr.} = \frac{n_1}{n_2}$$

$$T_{2zul.} = \frac{T_{2Tabelle}}{B_K \times B_D \times S}$$ (Nm)

**Condition $T_{2zul.} > T_{2erf.}$ must be fulfilled!**

$$P_{1erf.} = \frac{T_{2erf.} \times n_2}{9550 \times \eta_g}$$ (kW)

**Calculating example:**

values given:
lifting operation

| | | | |
|---|---|---|---|
| mass to be moved m | = | 150 kg | |
| speed $\upsilon$ | = | 1.95 m/s | |
| acceleration time $t_b$ | = | 0.3 s | |
| acceleration due to gravity g | = | 9.81 m/s² | |
| pitch-circle dia. of pinion d | = | 108.00 mm | (pinion on output shaft) |
| load factor $B_K$ | = | 1.25 | |
| operating time factor $B_D$ | = | 1.2 | |
| safety coefficient S | = | 1.2 | |

motor rpm $n_1$ = 3000 min$^{-1}$

**Calculation process**

$$a = \frac{v}{t_b} = \frac{1.95}{0.3} = 6.5 m/s^2$$

$$F_u = m \times g + m \times a = 175 \times 9.81 + 175 \times 6.5 = 2854.25 N$$

$$T_{2erf.} = \frac{F_u \times d}{2000} = \frac{2854.25 \times 108}{2000} = 154.12 \approx 155 Nm$$

$$n_2 = \frac{v}{d \times \pi} \times 60000 = \frac{1.95}{108 \times \pi} \times 60000 = 344.835 \cong 345 \min^{-1}$$

$$i_{Getr.} = \frac{n_1}{n_2} = \frac{3000}{345} = 8.6956$$

assumed SGH74/1 with $T_{2\ Tabelle}$ =290 at i= 8.75:1 and $n_1$ = 3000

$$T_{2zul.} = \frac{T_{2Tabelle}}{B_K \times B_D \times S} = \frac{290}{1.25 \times 1.2 \times 1.2} = 161 Nm$$

**Condition**

**$T_{2\ zul.} > T_{2\ erf}$ = 161 Nm > 155 Nm = fulfilled**

**Overall efficiency of gear SGH74/1 (single-sided output shaft):**

$\eta_g = \eta_z \times \eta_d \times \eta_w \times \eta \times \eta_k =$ 0.94 x 0.95 x 0.86 x 0.95 x 0.96 = 0.70

**Calculation of power requirement**

$$P_{1erf.} = \frac{T_{2erf.} \times n_2}{9550 \times \eta_g} = \frac{155 \times 345}{9550 \times 0.70} = 8 kW$$

It is, however, more useful to calculate the table value by means of the required torque and the according factors:

$$T_{2Tabelle} = T_{2erf.} \times B_K \times B_D \times S = 155 \times 1.25 \times 1.2 \times 1.2 = 279 Nm$$

This value allows now to select the appropriate gear in our catalogue (Take the next higher value).

## Symbols

| | | | |
|---|---|---|---|
| $a$ | = | acceleration or retardation | ($m/s^2$) |
| $B_D$ | = | operating time factor | |
| $B_K$ | = | load factor | |
| $d$ | = | pitch-circle dia. of pinion | (mm) |
| $g$ | = | acceleration due to gravitiy | ($9.81 m/s^2$) |
| $m$ | = | mass | (kg) |
| $n_1$ | = | gearbox input rpm | ($min^{-1}$) |
| $n_2$ | = | gearbox output rpm | ($min^{-1}$) |
| $t_b$ | = | acceleration time | (s) |
| $i$ | = | gear ratio | |
| $\nu$ | = | travelling / lifting speed | (m/s) |
| $F_u$ | = | peripheral force at the pinion | (N) |
| $P_{1\ erf.}$ | = | necessary gearbox input power | (kW) |
| $S$ | = | safety coefficient | |
| $T_{2\ zul.}$ | = | admissible torque | (Nm) |
| $T_{2\ erf.}$ | = | necessary torque | (Nm) |
| $T_{2\ Tabelle}$ | = | torque according table values | (Nm) |
| $\eta_g$ | = | overall efficiency | |
| $\eta_z$ | = | gearing efficiency | |
| $\eta_d$ | = | efficiency shaft seal | |
| $\eta_w$ | = | efficiency ball bearings | |
| $\eta_p$ | = | efficiency churning | |
| $\eta_k$ | = | efficiency coupling | |
| $\mu$ | = | coefficient of friction | |
| $\pi$ | = | 3.14159 | |

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