Guide for AC Motor Selection

In this section, we will discuss the fundamental criteria involved in selecting small-size, standard AC motors such as induction motors and reversible motors.

Selection Procedure

1. Required Specifications
First, determine the basic required specifications such as operating speed, load torque, power supply voltage and frequency.

2. Calculate the Operating Speed
Induction and reversible motor speeds cannot be adjusted. Motor speed must be reduced with gearheads to match the required machine speed. It is therefore necessary to determine the correct gear ratio.

3. Calculate the Required Torque
Calculate the required torque for motor by the load torque.

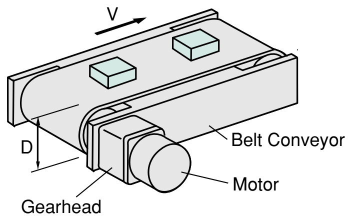
4. Select a Motor and Gearhead
Use the required torque and speed to select a motor and gearhead.

5. Confirm the speed
In a single-phase induction motor, starting torque is always lower than the rated torque. Therefore, to drive a frictional load, select the speed on the basis of starting torque. This will cause the actual speed to exceed the rated speed. Also, the motors are designed so that increases in motor temperature are at their lowest when operating close to the rated speed of rotation.

EXAMPLE 1

Here is an example of how to select an induction motor to drive a belt conveyor.
In this case, a motor must be selected that meets the following basic specifications.

Required specifications and structural specifications



Total mass of belt and work	$m_1=15$kg
Friction coefficient of sliding surface	$\mu=0.3$
Roller diameter	$D=100$mm
Mass of roller	$m_2=1$kg
Belt roller efficiency	$\eta=0.9$
Belt speed	$V=140$mm/s$\pm10\%$
Motor power supply	Single-Phase230V 50Hz
Movement time	Eight hours per day

1. Determining the Gearhead Reduction Ratio

Speed at the gearhead output shaft:

$$N_G=\frac{V\cdot 60}{\pi\cdot D}=\frac{(140\pm14)\times60}{\pi\times100}=26.7\pm2.7\ \text{[r/min]}$$

Because the rated speed for a 4-pole motor at 50Hz is 1200~1300 r/min, the gear ratio (i) is calculated as follows:

$$i=\frac{1200\sim1300}{N_G}=\frac{1200\sim1300}{26.7\pm2.7}=40.8\sim54.2$$

From within this range a gear ratio of $i=50$ is selected.

2. Calculating the Required Torque

On a belt conveyor, the greatest torque is needed when starting the belt. To calculate the torque needed for start-up, the friction coefficient (F) of the sliding surface is first determined:

$$F=\mu m_1\cdot g=0.3\times15\times9.8\fallingdotseq45\ \text{[N]}$$

Load torque (T_L) is then calculated by:

$$T_L=\frac{F\cdot D}{2\cdot\eta}=\frac{45\times100}{2\times0.9}=2550\ \text{[mN·m]}$$

The load torque obtained is actually the load torque at the gearhead drive shaft, so this value must be converted into load torque at the motor output shaft. If the required torque at the motor output shaft is T_M, then:

$$T_M=\frac{T_L}{i\cdot\eta_G}=\frac{2500}{50\times0.66}=75.8\ \text{[mN·m]}$$

(Gearhead transmission efficiency $\eta_G=0.66$)
Use a safety margin of two for the required torque, taking into consideration commercial power voltage fluctuation etc.

$$75.8\times2\fallingdotseq152\ \text{[mN·m]}$$

The suitable motor is one with a starting torque of 152 [mN·m] or more. Therefore, motor **5IK40GN-CWE** is the best choice. Since a gear ratio of 50 is required, select the gearhead **5GN50K** which may be connected to the **5IK40GN-CWE** motor.

3. Inertia load check

Roller moment of inertia

$$J_1=\frac{1}{8}\times m_2\times D^2\times2=\frac{1}{8}\times1\times0.1^2\times2=25\times10^{-4}\ \text{[kgm}^2\text{]}$$

Belt and work moment of inertia

$$J_2=m_1\frac{(\pi\times D)^2}{4\times\pi^2}=15\times\frac{0.1^2}{4}=375\times10^{-4}\ \text{[kgm}^2\text{]}$$

Gear head shaft load inertia

$$J=J_1+J_2=400\times10^{-4}\ \text{[kgm}^2\text{]}$$

Here, the **5GN50K** permitted load inertia is:

$$J_G=0.75\times10^{-4}\times50^2$$
$$=1875\times10^{-4}\ \text{[kgm}^2\text{]}$$

Refer to page A-21 to confirm this calculated value.
Therefore, $J<J_G$, the load inertia is less than the permitted inertia, so there is no problem.

Since the motor selected has a rated torque of 300 [mN·m], which is somewhat larger than the actual load torque, the motor will run at a higher speed than the rated speed. Therefore the speed is used under no-load conditions (approximately 1470r/min) to calculate belt speed, and thus determine whether the product selected meets the required specifications.

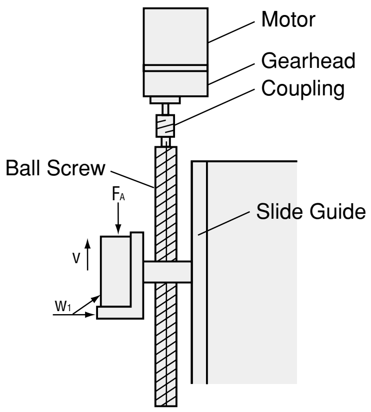
$$V=\frac{N_M\cdot\pi\cdot D}{60\cdot i}=\frac{1470\times\pi\times100}{60\times50}=154\ \text{[mm/s]}$$

(Where N_M is the motor speed)
The motor meets the specifications.

EXAMPLE 2

This example demonstrates how to select a motor with an electromagnetic brake for use on a tabletop moving vertically on a ball screw.
In this case, a motor must be selected that meets the following basic specifications.

Required and structural specifications



Total mass of table and work .... m_1 = 30kg
Table speed .... V = 12±2[mm/s]
Ball screw pitch .... P_B = 5[mm]
Ball screw efficiency .... η = 0.9
Ball screw friction coefficient .... μ_0 = 0.3
Friction coefficient of sliding surface
(Slide guide) .... μ = 0.05
Motor power supply .... Single phase 230V 50Hz
Ball screw total length .... L_B = 800[mm]
Ball screw shaft diameter .... D_B = 20[mm]
Ball screw material
................................Iron (density ρ=7.9×10³kg/m³)
Distance moved for one rotation of ball screw ....A = 5[mm]
External force ....F_A =0[kg]
Ball screw tilt angle ....α=90°
Movement time ....
Brake must provide holding torque Intermittent operation, five hours per day. Load with repeated starts and stops must be held.

1. Determining the Gear Ratio

Speed at the gearhead output shaft:

$$N_G = \frac{V \cdot 60}{P_B} = \frac{(12 \pm 2) \times 60}{5} = 144 \pm 24 \text{ [r/min]}$$

Because the rated speed for a 4-pole motor at 50Hz is 1200~1300r/min, the gear ratio (i) is calculated as follows:

$$i = \frac{1200 \sim 1300}{N_G} = \frac{1200 \sim 1300}{144 \pm 24} = 7.1 \sim 10.8$$

From within this range a gear ratio of (i) = 9 is selected.

2. Calculating the Required Torque

F, the load weight in the direction of the ball screw shaft, is obtained as follows:

$$F = F_A + m_1 \cdot g\ (\sin\alpha + \mu \times \cos\alpha)$$
$$= 0 + 30 \times 9.8\ (\sin 90° + 0.05 \times \cos 90°)$$
$$\fallingdotseq 300 \text{ [N]}$$

Preload F_0:

$$F_0 = \frac{F}{3} = 100 \text{ [N]}$$

Load torque T_L:

$$T_L = \frac{F \times P_B}{2\pi\eta} + \frac{\mu_0 \times F_0 \times P_B}{2\pi} = \frac{300 \times 5}{2\pi \times 0.9} + \frac{0.3 \times 100 \times 5}{2\pi}$$
$$= 289 \text{ [mN·m]}$$

This value is the load torque at the gearhead drive shaft, and must be converted into load torque at the motor output shaft. The required torque at the motor output shaft (T_M) is given by:

$$T_M = \frac{T_L}{i \cdot \eta_G} = \frac{289}{9 \times 0.81} = 39.6 \text{ [mN·m]}$$

(Gearhead transmission efficiency η_G = 0.81)
Use a safety margin of two for the required torque, taking into consideration commercial power voltage fluctuation etc.

$$39.6 \times 2 = 79.2 \text{ [mN·m]}$$

To find a motor with a start-up torque of 79.2 [mN·m] or more, select motor **4RK25GN-CWME**. This motor is equipped with an electromagnetic brake to hold a load. The gearhead with a reduction ratio of 9 that can be connected to motor model **4RK25GN-CWME** is **4GN9K**.

3. Load inertia check

Ball screw moment of inertia

$$J_1 = \frac{\pi \times \rho \times L_B \times D_B^4}{32}$$
$$= \frac{\pi \times 7.9 \times 10^3 \times 0.8 \times (0.02)^4}{32}$$
$$= 0.99 \times 10^{-4} \text{ [kgm}^2\text{]}$$

Table and work moment of inertia

$$J_2 = \frac{m_1 \times A^2}{4\pi^2}$$
$$= \frac{30 \times 0.005^2}{4\pi^2}$$
$$= 0.19 \times 10^{-4} \text{ [kgm}^2\text{]}$$

Gear head shaft total load inertia $J = 1.18 \times 10^{-4}$ [kgm²]

Here, the **4GN9K** permitted load inertia is:

$$J_G = 0.3 \times 10^{-4} \times 9^2$$
$$= 25.1 \times 10^{-4} \text{ [kgm}^2\text{]}$$

Refer to page A-21 to confirm this calculated value.
Therefore, $J < J_G$, the load inertia is less than the permitted inertia, so there is no problem.The same as for selected Example 1, there is margin for the torque, so the rotation rate is checked with the no-load rotation rate (about 1470 r/min).

$$V = \frac{N_M \cdot P}{60 \cdot i} = 13.6 \text{ [mm/s]}$$

(where N_M is the motor speed).
This confirms that the motor meets the specifications.