Technical Note

Low-Speed Operation of SEW Motors

Many inverter-driven applications require continuous motor operation at low speeds. Torque is the most important parameter when selecting the proper drive, since the torque available at a low speed may differ from the torque available at a higher speed. This document provides guidelines to calculate the maximum allowable torque.

Current produces torque inside an induction motor. Unfortunately, current also produces heat due to electrical losses inside the windings. Normally, a fan mounted onto the motor shaft rotates fast enough to provide sufficient airflow over the fins to cool the motor. However, if the motor speed is too low, the fan cannot remove enough heat.

Therefore, the only way to sufficiently cool the motor at low speeds is to reduce the current. Unfortunately, reducing the current also reduces the available torque. However, as long as the available torque is still greater than the load torque, the selection is valid.

Test results show that SEW motors are capable of producing the following continuous torque values based upon class F insulation and a maximum ambient temperature of 40°C (see also Figure 1).

- 100% of nominal torque from base speed to 300 rpm
- 50% of nominal torque at 0 rpm

Class H insulation does not permit a lower base speed. Even though class H insulation is capable of withstanding higher temperatures, a lower base speed @ 100% torque greatly increases the motor temperature and the risk of winding damage due to potential sparks.

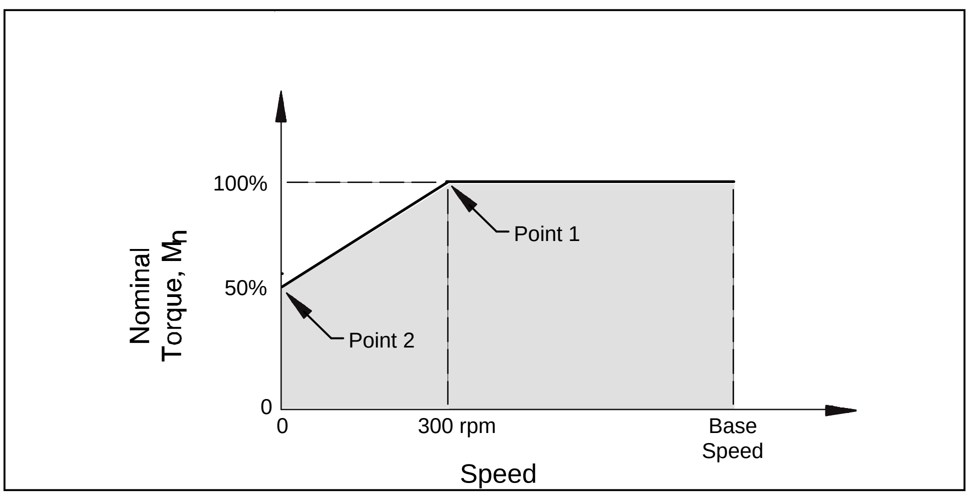

Figure 1: Continuous Motor Torque Versus Speed

Low Speed Torque

From Figure 1, M_n is the nominal torque that the motor produces under full load without an inverter. It is constant from base speed down to 300 rpm. The torque available between 0 and 300 rpm is linear and is determined as follows.

First, calculate the slope between 0 and 300 rpm, using the x-y coordinates of two known points where x equals speed and y equals torque.

Given:

Point 1: (300, 1.0 M_n)
Point 2: (0, 0.5 M_n)

$$\text{Slope} = \frac{\Delta\,\text{Torque Capacity}}{\Delta\,\text{Speed}}$$

Therefore,

$$\text{Slope} = \frac{1.0 - 0.5}{300 - 0} = \frac{0.5}{300}$$

Next, insert this slope, m, into the slope-intercept formula (y = mx + b), where:

b = 0.5 (torque at 0 rpm)
y = % torque at operating point
x = motor rpm at operating point

$$y = \frac{0.5}{300}x + 0.5$$

Finally, since y is a percentage of nominal torque, multiply y by the nominal torque to obtain the reduced torque, T_{Low}, available at low speed.

$$T_{Low} = \left(\frac{0.5}{300} \times \text{motor rpm} + 0.5\right) \times \text{Nominal Torque}$$

Figure 2: Low Speed Torque Formula

Example 1:

Calculate the torque available at low speed of the following gearmotor and determine if the gearmotor is capable of delivering the required load torque.

- FA37DT90L4
- Gear ratio = 19.27:1
- 7 rpm reducer speed
- 950 lb-in required load torque

Solution:

In this example, the torque available at low speed (T_{Low}) is unknown.

1. Calculate the nominal motor torque (T_N) at 60Hz, or look it up in the SEW Catalog.

$$T_N = \frac{63025 \times HP}{\text{Motor speed @ 60 Hz}}$$

$$T_N = \frac{63025 \times 2\,HP}{1720\,rpm} = 73.3\,lb\text{-}in$$

2. Determine the motor speed, using the ratio and output speed of gearbox.

$$\text{Motor rpm} = 19.27 \text{ x } 7\,rpm = 135\,rpm$$

3. Since the motor rotates at 135 rpm, it falls within the reduced torque range of figure 1. Therefore, it is necessary to calculate a reduced torque, using the formula in figure 2.

$$T_{Low} = \left(\frac{0.5}{300} \times 135 + 0.5\right) \times 73.3\,lb\text{-}in = 53\,lb\text{-}in$$

4. Calculate the output torque of the reducer from the motor torque.

$$T_{Gearbox} = (T_{Low} \times \text{ratio} \times \text{eff}) = (53\,lb\text{-}in \times 19.27 \times 0.97) = 990\,lb\text{-}in$$

The available torque (990 lb-in) is greater than the required load torque (950 lb-in). Therefore, the selected drive is acceptable for the application. See Figure 3 for a graphical illustration.

Example 2:

Calculate the minimum speed that the following gearmotor can continuously operate without a forced cooling fan.

- K77DV132S4
- Gear ratio = 45.16:1
- 9,500 lb-in required load torque

Solution:

This example is the opposite of the previous example. In this case, the low motor speed is unknown.

1. Calculate the nominal motor torque at 60Hz, or look it up in the SEW catalog.

$$T_N = \frac{63025 \times HP}{\text{Motor speed @ 60 Hz}}$$

$$T_N = \frac{63025 \times 7.5\,HP}{1720\,rpm} = 275\,lb\text{-}in$$

2. Determine the required motor torque at low speed, T_{Low}, from the load torque.

$$T_{Low} = \frac{\text{Load Torque}}{\text{Ratio} \times \text{Eff}} = \frac{9500\,lb\text{-}in}{45.16 \times 0.955} = 220\,lb\text{-}in$$

3. Rearrange the formula in Figure 2 and solve for motor rpm.

$$\text{Motor rpm} = \left(\frac{T_{Low}}{\text{Nominal Torque}} - 0.5\right) \times \frac{300}{0.5}$$

In this example,

$$\text{Motor rpm} = \left(\frac{220}{275} - 0.5\right) \times \frac{300}{0.5} = 180\,rpm$$

Therefore, the lowest speed at which the motor can operate continuously without overheating is 180 rpm, which yields 4 rpm at the gearmotor output (180 rpm / 45.16 = 4 rpm). See Figure 4 for a graphical illustration of this example.

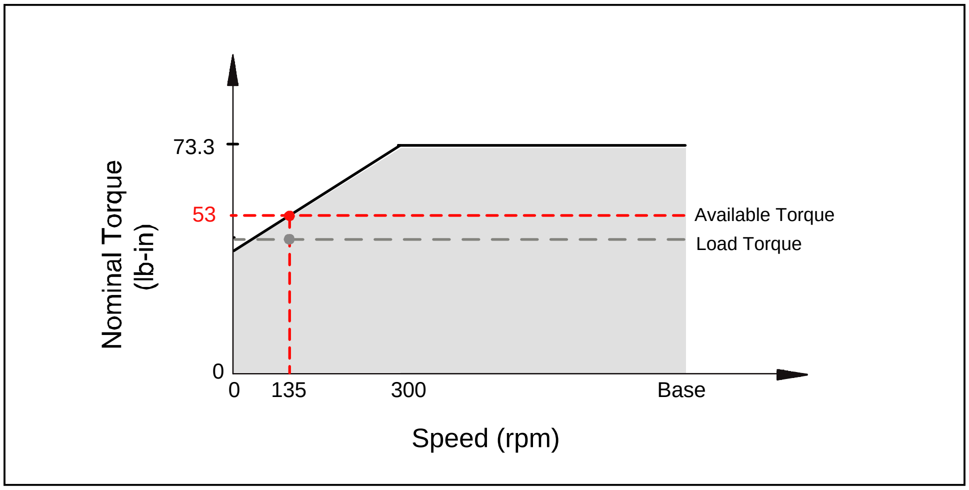

Figure 3: Illustration of Example 1

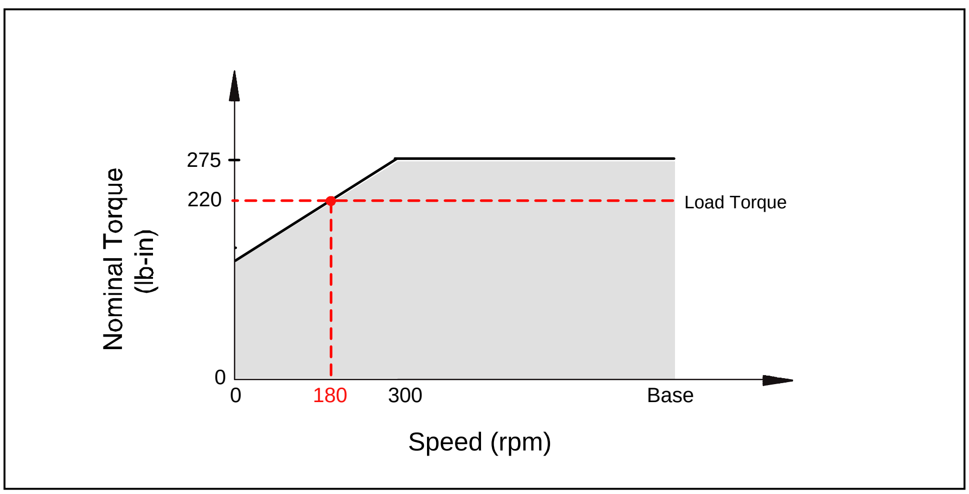

Figure 4: Illustration of Example 2