Motor configuring with SIZER and taking account of the utilization of the deployed third-party motor

Retrofit - replacement of a third-party motor

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Service & Support

Answers for industry.
Question

How can the motor utilization for an existing plant be checked in order to avoid an overdimensioning of the Siemens motor in the case of a retrofit?

Answer

To fully answer this question, follow the handling instructions and notes listed in this document.
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1 Retrofit Example

An existing motor should be replaced with a Siemens motor.

1.1 Existing situation

- Third-party motor designation with characteristic curve
- System properties, such as the mechanical system
- Load cycle

Data as example

- A 1FT7102-1AC7 is selected as "third-party motor"
- A ball screw is used as the mechanical system
  - Own weight of the spindle table = 1600 kg
  - Leadscrew pitch = 12 mm
  - Spindle diameter = 45 mm
  - Spindle length = 1018 mm
  - Friction torque = 10 Nm
- Load cycle - traversing profile has a trapezoidal form
  - Travel time = 1.25 seconds
  - Velocity = 30 m/min
  - Acceleration/deceleration = 10 m/s²

1.2 Required

- Optimum replacement of the 1FT7 "third-party motor" with a 1FK7 motor
2 Step Sequence

Creation of the third-party motor characteristic curve with the Excel tool

Input of the system properties / mechanical data in SIZER

Input of the load cycle

Use/increase the jerk limitation

Transfer the values calculated with SIZER, such as effective torque and maximum torque, to the Excel tool, see page 6

Do the operating points lie in the characteristic curve?

Further pursue with the motor wizard in SIZER

Is the moment of inertia max. 3-5?

Comparison with value in the Excel tool

Change the motor frame size, select high inertia / high dynamic

Is there a comparable order of magnitude?

Continue in SIZER with the selection of the motor module
3 Creation of the Third-party Motor Characteristic Curve

With the help of the enclosed Excel tool, transfer the key points of the given motor characteristic curve to the table of the Excel tool. One column for each S1 torque and maximum torque, see Figure 3-1.

An overview of the tool is shown on the following page, see Figure 3-2.

Open the tool:

Figure 3-1
3 Creation of the Third-party Motor Characteristic Curve

Figure 3-2

Input field
Result field

Transfer result from SIZER

from SIZER: motor => performance data

<table>
<thead>
<tr>
<th>Speed</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>2251 upm</td>
<td>21.4 Nm</td>
</tr>
</tbody>
</table>

Maximum point: 1250 upm 85.3 Nm

from SIZER: motor => gearbox data

<table>
<thead>
<tr>
<th>Motor moment of inertia</th>
<th>Inertia ratio J_Load : J_Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01824 kgm²</td>
<td>0.0081 kgm²</td>
</tr>
<tr>
<td>0.0081 kgm²</td>
<td>1.0 : 1</td>
</tr>
</tbody>
</table>

Input of the characteristic points

<table>
<thead>
<tr>
<th>Speed</th>
<th>S1 torque</th>
<th>Max torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>30</td>
<td>120</td>
</tr>
<tr>
<td>1250</td>
<td>28</td>
<td>120</td>
</tr>
<tr>
<td>1750</td>
<td>27</td>
<td>80</td>
</tr>
<tr>
<td>2500</td>
<td>21</td>
<td>56</td>
</tr>
<tr>
<td>3800</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>3000</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
4 Input of the System Properties / Mechanical Data in SIZER

The drive system properties and the given mechanical data are now entered.

4.1 Selecting the drive system properties

After a SIZER project has been created, specify the drive system properties. In the example described here, "1FT/1FK" was selected as motor category, and then select the "ball screw" system for the "Mechanical system" load type.

4.2 Defining the mechanical system

Enter the known application values, such as leadscrew pitch, in the "Mechanical Data" window. Enter the load cycle in the "Enter Traversing Curves" window.
Figure 4-2

**Mechanical system**

**Enter mechanical data**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Motor</th>
<th>Motor Module</th>
</tr>
</thead>
</table>

**Enter the load cycle**

**Input of the system properties**

- **Internal mass of the spindle table**: 1,600,000 kg
- **Leadcrew pitch**: 2 mm
- **Leadcrew diameter**: 25 mm
- **Weight compensation**: 1,015,000 kg
- **Countergear**: 300 mm
- **Specific coefficient of friction**: 0.02
- **Radian of inclination**: 0.01°
- **Diameter of the spindle drive**: 180 mm
- **Speed**: 2,500 rpm
- **Density**: 7,800 kg/m³
- **Specific weight of the motor**: 0.000000
- **Additional weight with respect to the motor**: 0.000000
- **Ratio of external inertia moment of mass**: 0.5
- **Maximum speed**: 2,500 rpm
- **Beyond the dimensionable**: 200

**Enter traversing profiles**

- **Max. velocity**: 1,500 m/min
- **Max. acceleration**: 1,500 m/min²
- **Max. deceleration**: 0 m/min²
- **Entry**: 1,200 mm/s
- **Max. speed**: 1,200 m/min
- **Max. force**: 0.000000 N
- **Max. torque**: 0.000000 Nm
- **Max. power**: 0.000000 kW
- **Max. load**: 0.000000 kg

Retrofit Third-party Motor with SIZER

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Motor

Because the motor's moment of inertia has a significant effect on the operating points, this inertia must be taken into account. One possibility for considering it is with the input of the value in the "Additional gearbox" field, Figure 4-4. The value 1 must be entered as transmission ratio and efficiency.

The calculated points, including the associated third-party motor inertia, are displayed in the Excel table at the "Motor shaft" column. Then click "Next" twice to open the "Performance data" view. These values can now be transferred to the Excel tool.
5 Transfer of the Values Calculated with SIZER to the Excel Tool

The Excel tool is located on page 6

- Green field: input field
- Blue field: result field

Enter the results from "Gearbox data" (moments of inertia) and "Performance data" (torque/speed) in the green fields.

Figure 5-1
6 Use of Jerk Limitation

Because the operating points do not lie within the motor characteristic curve of the third-party motor, an iterative loop must be performed. The customer must use a jerk limitation, because otherwise the third-party motor would be underdimensioned.

See step sequence, page 5

6.1 Querying the jerk values

If the jerk values are known, they must be taken into account for the traversing curve configuration.

6.2 Jerk values are not known

The jerk must be reduced until the operating points lie within the motor characteristic curve.

The following recommended values can be used as starting points:

<table>
<thead>
<tr>
<th>Ball screw</th>
<th>Linear motor</th>
<th>Belt drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>$J_{\text{max}}$: 300 m/s³</td>
<td>$J_{\text{max}}$: 150 m/s³</td>
<td>$J_{\text{max}}$: 100 m/s³</td>
</tr>
</tbody>
</table>

A rough estimate of the jerk is possible with the formula $R = \frac{a^2}{v^3}$.

$R$: jerk [m/s³]; $a$: acceleration [m/s²]; $v$: speed [m/s]

Taking account of the jerk in the "Enter traversing curves" view, see Figure 6-1.

Figure 6-1
New calculated values with jerk limitation to $j = 150 \text{ m/s}^2$

Transfer of the values to the Excel tool:

Figure 6-2

The operating points now lie within the third-party motor characteristic curve, Figure 6-2. The motor wizard can be continued with SIZER.

NOTICE

The "Additional gearbox" field, Figure 6-3, was used to consider the third-party motor inertia; the field must be deactivated for the further configuring!

Figure 6-3

In the example, the 1FT7102-1AC7 "third-party motor" could be replaced with a 1FK7103-2AC71.
7 Difference with/without Jerk Limitation

The representation of the load points / curve within the motor characteristic curve shows the influence of the jerk limitation.

7.1 Without jerk limitation

Without jerk limitation, a rectangular load curve characteristic results, see Fig. 7-1.

![Figure 7-1](image)

- Rectangular load curve characteristic
- Maximum current: 195.54 A
- Load current: 13.80 A

7.2 With jerk limitation - $j = 150 \text{ m/s}^2$

Jerk limitation results in a rounding of the load curve, see Figure 7-2. The speed of the maximum point moves left. If necessary, a motor with a lower rated speed can be selected. This reduces the current requirement so that a smaller converter/infeed can be used.

![Figure 7-2](image)

- Maximum speed: 2930.95 rpm
- Maximum current: 43.68 A
- Load current: 3.92 A

**Load data**

- M10: 1F17462-54C7-7777
- M11: 1F17462-54C7-7771

**Utilization**

- Thermal utilization: 114.3 %
- Utilization of the maximum possible torque: 100.0 %
- External moment of inertia / moment of inertia: 0.59
- Load speed / rated speed: 1.26
8 Summary

The difficult task for a retrofit is to replace a third-party motor with a Siemens motor. If the motor utilization of the currently-used third-party motor is not known, this normally results in an overdimensioning of the Siemens motor. A 1:1 matching of the Siemens motor characteristic curve with the third-party characteristic curve is very rare and so the next larger Siemens motor must be selected. This has the result that the dependent components, such as converters and infeed, may also be overdimensioned and so the costs for the overall system rise considerably. Consequently, the banning of the third-party vendor is only very difficult to achieve.

**Note**

Use the jerk limitation in SIZER. Especially if you determine that the used third-party motor cannot match the calculated operating points. Validation is possible with the supplied Excel tool.