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- Trained in the proper care and use of protective equipment in accordance with established safety procedures.
- Trained in rendering first aid.

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2.4 Information regarding trademarks

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MICROMASTER ® is a Siemens registered trademark

2.5 Revisions/author

<table>
<thead>
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<th>Version</th>
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<tr>
<td>1.00</td>
<td>14.01.03 / Erstausgabe</td>
<td>Haßold</td>
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3 Introduction

When winding or unwinding various materials, different requirements are placed on the winder drive and the closed-loop winder control. When winding sensitive materials, e.g. foils or paper, where there is a danger that the material web could break or could be damaged, then at every point in time during the winding operation, it must be ensured that the web tension is kept constant. Generally this is achieved by sensing the diameter or calculating the diameter and detecting the tension with a dancer roll or tension transducer. As an alternative to sensing the tension, this can also be entered using the indirect closed-loop control. When selecting the correct closed-loop control version, it is important to know which material is to be wound, and the secondary conditions regarding the required control quality, material web velocity, diameter range and control range of the material web.

For extremely complex closed-loop winder controls which are used to wind sensitive materials with a high web velocity, we recommend the use of pre-configured solutions in conjunction with MASTERDRIVES or SIMOREG drives from Siemens with additional technological modules – for example T300 or T400 modules.

In addition to these complex closed-loop winder controls, there is also a series of applications which only require a very basic closed-loop winder control. For example this involves winding steel wire with a diameter greater than 1mm. In this case, in most cases it is sufficient to use the drive inverter to limit the winding torque.

The simplest closed-loop control version for winders is the torque limiting. In this case, it is not necessary to determine the diameter as the speed controller in the drive inverter goes to its limit and it is not necessary to have a speed setpoint input for the drive inverter which is corrected as a function of the actual roll diameter. An appropriate winder application to wind steel wires with a diameter of >1mm will be described in the following.

The following sketch provides a rough overview of the possible closed-loop control techniques when winding.
Introduction

MICROMASTER 440 – Basic Winder Drive for Steel Wire

Closed-loop control structure

- Indirect closed-loop tension control
- Direct closed-loop tension control
- Closed-loop constant V control
- Torque limiting

Tension sensing using a tension transducer
Tension sensing using a dancer roll

Fig. 1-1: Closed-loop control structures for winder drives

If the diameter of the wound material is to be determined, then the following techniques can be applied.

Determining the diameter

- Diameter sensing
- Diameter not determined
- Diameter calculation

- Diameter sensing with sensor
- Diameter sensing using a counter count No. of turns
- v/n diameter calculation
- Iterative diameter calculation

Fig. 1-2: Techniques to determine the roll diameter
4 Closed-loop control structure

The winder drive, described in the following text, is used to wind steel wire. In this case, the drive operates motoring and generally regenerative operation only occurs for brief braking ramps and for high moments of inertia of the winder. The DC link voltage controller, integrated in the MICROMASTER440, avoids overvoltage trips where the drive would then be shut down. This means that a braking resistor can be frequently eliminated. This is only required if, when quickly reducing the wire velocity with a full roll, the tension force $F_Z$ is too high as a result of its moment of inertia. The winder drive must provide the full torque at low speeds and large roll diameter. This means that under certain circumstances, the motor cannot be adequately cooled. Depending on the speed control range and the thermal reserves in the motor, it may be necessary to equip the motor with a separately-driven fan.

4.1 Operation as winder

With increasing diameter of the material being wound, the winding hardness (tension force $F_Z$ with which the wire is wound) should decrease in the same ratio so that the wire doesn't "cut-in" to the roll of wire ($F_Z \sim 1/D_W$).

The required winding torque $M_w$ of the drive is given by:

$$M_w = F_Z \times \frac{D_w}{2}$$

whereby:

- $M_w$ = actual winding torque at the load in (Nm)
- $F_Z$ = tension with which the steel wire is wound in (N)
- $D_w$ = actual roll diameter in (m)

As the roll diameter $D_w$ increases, tension $F_Z$ should decrease then the winding torque $M_w$, which the drive must provide, can remain constant. It is not necessary to enter a speed setpoint for the winder drive which is a function of the diameter. In this particular case, it is not necessary to sense the diameter or calculate the diameter. This means that only one possibility is required at the drive inverter to set the torque for the motor, and therefore the winding torque.
In order to keep the winding torque $M_W$ constant, closed-loop torque control or closed-loop frequency control with torque limiting can be used as control version in the MICROMASTER440. The closed-loop frequency control with torque limiting has the advantage, that if the wire breaks, then the winder drive does not accelerate up to the selected maximum frequency. If the latter closed-loop control version is used, the speed controller of the MICROMASTER440 drive inverter goes to its limit, the downstream torque limiting limits the torque and therefore the motor slip.

In the application described, the closed-loop torque control and limiting does not require high accuracy and the torque setpoint can be entered in an open-loop controlled fashion at zero speed to tension the wire. This is the reason that speed feedback is not required for this particular application.

For closed-loop frequency control with torque limiting, the frequency setpoint for the drive inverter must always be entered somewhat higher at the minimum roll diameter (= core diameter) (approx. 10%) than corresponds to the actual wire velocity, so that the drive inverter reliably goes into torque limiting with the larger slip.

As the roll diameter $D_W$ increases, the drive automatically runs slower at constant winding torque $M_W$ and decreasing tension force $F_Z$ as a result of the torque limiting. In this case, the continuous deviation between the frequency setpoint and actual value which is obtained does not play a role.

### 4.2 Operation as unwinder

The control structure described above is not suitable for an unwinder drive as in this case only a regenerative torque can be limited. However, when accelerating the unwinder while the system accelerates, the drive must provide a defined (motoring) accelerating torque. Otherwise, an inadmissibly high torque $F_Z$ would be obtained when starting, and the wire could, under certain circumstances, break. In this case it makes sense to provide a direct closed-loop tension control - e.g. using a dancer roll and the PID controller integrated in the drive converter.

This control version will be described as part of a subsequent application.
Parameter settings

Parameters can be set using the BOP / AOP operator panels or the DriveMonitor or Starter visualization programs. The Starter program offers a user-friendly way of carrying-out prompted commissioning which will also be described in the following steps.

5.1 Basic commissioning

To start, prompted commissioning should be initiated using the button "Reconfigure drive" in the menu <Configuration> (Steps 1 and 2). In this case, among other things, the rating plate data of the motor, ramp-up and ramp-down times, control mode and command and setpoint source should be set. "Vector control without sensor" should be selected as control mode. At low frequencies (<5Hz), in this case the torque limit and therefore the tension are permanently set. Pulse encoder feedback is required if a variable and precise torque must be entered, even at low frequencies. This means that tension $F_z$ can be set in a defined fashion down to zero speed. The appropriate parameter setting is then "Vector control with sensor". For example, the "Terminal strip" and "Analog input" or Profibus "CB at COM link" can be used as command and setpoint source. The setpoint is entered as frequency setpoint and must be approximately 10% higher than the wire velocity. If the frequency setpoint is entered using a ramp, then the ramp-up and ramp-down time in the drive converter must be set less than this ramp so that the winder can follow the process.
After the prompted commissioning, the motor identification (Step 3.) and saturation (Step 4.) must be determined in the <Configuration> menu.

5.2 Setting the application-specific parameters

After the drive inverter has been basically commissioned, the parameters, specific to the particular application, must be set. The following points must be taken into consideration:

- Torque limiting
- Setting the limit, open-loop/closed-loop controlled
- Torque boost in the open-loop controlled range at low frequencies

5.2.1 Torque limiting

In order to limit the motor torque when motoring and therefore the tension when winding, the fixed max. torque limit must be entered into the drive inverter in the menu <Limits> / <Torque> (Steps 1 and 2) (Step 3, a negative value is required for P1520 for clockwise direction of rotation / "Maximum torque" and P1521 for counter-clockwise direction of rotation / "Minimum torque"). Further, the effective torque limit can be variably entered from 0 Nm up to this upper limit value (P1520 / P1521). The source for the variable torque limit, e.g. analog input 2 or Profibus can be set in Step 4 (P1522 for clockwise direction of rotation / "Upper torque limit" and P1523 for counter-clockwise direction of rotation / "Lower torque limit"). For a counter-clockwise direction of rotation it should be observed that a negative value must be entered for the variable torque limiting (setting, e.g. using the ADC scaling P757-P760, Index 1 for analog input 2). The normalization of the variable torque limit is entered via the reference torque (P2003). In this case, a value of 100% at analog input 2 or Profibus corresponds to the value in P2003. The effective torque limit can be tracked using P1526 (Step 5). In this case it must be observed that here, at standstill, the value is in P2003 is displayed as maximum value, and in operation the actual value with P1520 / P1521 as maximum effective limit.
5.2.2 Setting the limit, open-loop / closed-loop controlled

In the sensorless mode, the MM440 drive inverter operates open-loop controlled in the lower frequency range. The reason for this is that the actual speed can no longer be precisely calculated in the drive inverter itself. In this open-loop controlled range, the motor torque is permanently set. It is not possible to additionally change this value, e.g. via an analog input. This means that it is desirable to reach the limit for the transition into the closed-loop controlled mode at frequencies which are as low as possible. In practice, depending on the drive power and the quality of the optimization, this is possible for frequencies between 1 and 5 Hz. The setting is made in the Expert list (refer to the Fig. below). In order to reach this, click-on <MICROMASTER_440> using the righthand mouse key and the Expert list selected (Step 1). The limits, with values of between 1 and 5 Hz are then entered using parameter P1755 (Steps 2 and 3). In this case it must be observed that a hysteresis (P1756) of 50% referred to P1755 is effective.
5.2.3 Torque boost in the open-loop controlled range and at low frequencies

This setting is made in the Expert list (refer to the Fig. below). In order to reach this, click-on <MICROMASTER_440> using the righthand mouse key and the Expert list selected (Step 1).

The torque in the open-loop controlled range and therefore the tension are set using fixed parameter values. If the frequency is kept constant in the open-loop controlled range, then the torque is entered, using P1610 (refer to the Fig. below, Steps 2 and 3) as a percentage of the rated motor torque. An accelerating torque can be additionally parameterized using P1611 (Steps 4 and 5) in order to accelerate moments of inertia. This is especially practical, if, when starting, the tension $F_Z$ in the wire is too low due to the accelerating component of the torque.
Secondary conditions and limitations

6 Secondary conditions and limitations

The closed-loop control version with torque limiting, described above, is the simplest way of implementing a closed-loop winder control function and is suitable for basic wire winders. If the control quality has to fulfill higher requirements, then a faster tension controller with tension actual value sensing, diameter sensing and supplementary functions are required. In order to be able to estimate the described closed-loop control versions when engineering an application, the secondary conditions/limitations for an application, which has already been implemented, are listed below.

Table 6-1: Technical data of an application example

<table>
<thead>
<tr>
<th>Description</th>
<th>Values</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire properties</td>
<td>Steel wire with D&gt;1mm</td>
<td>With the described closed-loop control technique, only possible with steel wire D&gt;1mm. If closed-loop dancer roll control is used (this has not been described here), control is possible with other wire materials down to below D=0.1mm</td>
</tr>
<tr>
<td>Wire velocity</td>
<td>Approx. 150m/min</td>
<td>With closed-loop dancer roll position control (this has not been described here) possible up to 2000m/min</td>
</tr>
<tr>
<td>Minimum roll diameter</td>
<td>0.4m</td>
<td>With the closed-loop control technique described here, a Dmax / Dmin diameter ratio of max. 4:1 is possible.</td>
</tr>
<tr>
<td>Maximum roll diameter</td>
<td>0.8m</td>
<td></td>
</tr>
</tbody>
</table>
### Secondary conditions and limitations

**MICROMASTER 440 – Basic Winder Drive for Steel Wire**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum tension force $F_{Zmin}$ at the minimum roll diameter</td>
<td>55N</td>
<td>For the closed-loop control techniques described, a tension force ratio $F_{Zmax} / F_{Zmin}$ of max. 5:1 is possible.</td>
</tr>
<tr>
<td>Maximum tension force $F_{Zmax}$ at the minimum roll diameter</td>
<td>270N</td>
<td></td>
</tr>
<tr>
<td>Tension force characteristic (winding hardness)</td>
<td>$F_z \sim 1/D_w$ decreases with increasing diameter</td>
<td>This is necessary so that for larger roll diameters the wire does not &quot;cut into&quot; the rolls.</td>
</tr>
<tr>
<td>Motor used</td>
<td>1.1kW, 4 pole with gearbox $i=14.48$</td>
<td></td>
</tr>
<tr>
<td>Drive inverter used</td>
<td>MM440 1.1kW, 400V with options: ♦ Profibus module ♦ Shield connectingplate ♦ Sub-chassis line reactor</td>
<td></td>
</tr>
<tr>
<td>Wire laying drive</td>
<td>Layed over an approximate width of approx. 0.5m</td>
<td>An MM420 drive is used to lay the wire over the width of the coil</td>
</tr>
</tbody>
</table>