Winding and unwinding paper, foils, wire, sheet steel or textiles is at first glance just an inconspicuous part of many technological processes. However, when looking at the situation in more detail, then it can be seen that this production step is frequently decisive when it comes to the product quality. It is precisely for this reason that winding and unwinding must be handled as simply as possible, or in other words, implemented as simply as possible.

Electronically controlled electric drives offer an extremely efficient possibility of implementing the widest range of winding tasks. And today, they are already an integral part of most modern production equipment and systems. Then why not take the configuring/engineering tools that are already available to implement winder tasks? The engineers from Siemens asked themselves precisely the same question - and the answer is a standard "winder" application that has been generated for the current generation of Sinamics S120 drives. This standard application can be used to quickly and flexibly address demanding tasks.

Implementing the winder application directly in the drive system has a basic advantage when compared to an external solution: It relieves the higher-level open-loop control of arithmetic tasks. As a consequence, resources are available for other tasks. Not only this, a control system with a lower performance can be used. In any case, a high proportion of the communication load between the control system and drive is eliminated. As a consequence, the associated faster response and cycle times can be more quickly and precisely realized in the open-loop control or closed-loop control, which increases the productivity and/or the winding quality, depending on the particular application.

Winding with and without sensors
A winder solution generally comprises a winder drive, a material web and possibly sensors. The task is to wind or unwind a material web with a defined tension, whereby the roll diameter continually changes. The electronic drive system calculates the actual diameter using several system variables and controls the motor speed so that the tension of the material web remains constant. To achieve this, the velocity of the material web and the winder shaft speed must be known. If the highest demands are placed on the performance and tension precision, then it makes sense to use additional sensors - for instance, a dancer role or tension transducer.

The standard application described here has been designed for so-called central winders with a central shaft to drive the roll being wound. Although, from a control perspective, this is more difficult to handle than for a surface winder, it is the more effective of the two as it is by far the simpler version from the mechanical perspective.

The standard application supports various control techniques, including indirect tension control (open-loop torque control), direct tension control with dancer roll and speed correction as well as the tension force control with torque limiting - respectively with speed correction (also refer to the box, Page 4). This means that this standard application addresses approximately 90% of all winder applications.

The so-called drive control chart (DCC) forms the basis for the standard application. This is a module of the graphic drive engineering tool “Starter” for the Sinamics S120 family. Based on this, the drive experts from Siemens have implemented a DCC chart for winder applications. Using this chart, relevant, multi-instance capable function blocks can be easily interlinked with one another by simply dragging them from a standard library and dropping them in the chart. Users only have to parameterize the specific parameters - for instance the material velocity and acceleration - and define the closed-loop control technique. The standard application prepa-
res all of the signals required to control the winder axis - such as speed, torque as well as torque limits - and then integrates the following winder-specific functions.

**Diameter computer**
This is used among other things to convert the web velocity into the corresponding motor speed. The actual diameter is obtained from the ratio of the web setpoint velocity and actual speed.

**Winding hardness characteristic**
This is used if the material tension should decrease as the diameter of the roll being wound increases. The winding hardness characteristic (also called tension taper characteristic) is dependent on the actual diameter. The maximum tension reduction at infinity or at the maximum diameter can be selected for the calculation.

**Controller adaptation**
Using this function, on one hand, the tension controller gain can be adapted as a function of the diameter, and on the other hand, the gain of the speed controller in the drive can be adapted as a function of the moment of inertia of the roll being wound. This means that even fully wound rolls can be dynamically moved in this fashion.

**Acceleration pre-control**
In order to be able to quickly respond to velocity changes, a compensation torque can be switched to the drive while accelerating and decelerating the material. This compensation torque is made up of the variable and constant moments of inertia. This prevents tension dips or excessive tension when the velocity changes. Acceleration pre-control is especially required for indirect tension control, but also for tension control using a tension transducer.

### Criteria for selecting a suitable control concept

<table>
<thead>
<tr>
<th>Regelkonzept</th>
<th>Indirect tension control (&quot;open-loop torque control&quot;)</th>
<th>Direct tension control with dancer roll and speed correction</th>
<th>Direct tension control with tension transducer via torque limits</th>
<th>Direct tension control with tension transducer and speed correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information regarding tension actual value sensing</td>
<td>No tension actual value sensing required</td>
<td>Intervenes in the material web routing, material can be stored</td>
<td>Sensitive to overload, does not intervene in the web routing</td>
<td>Sensitive to overload, does not intervene in the web routing</td>
</tr>
<tr>
<td>Roll ratio (D_{\text{max}}/D_{\text{Kern}})</td>
<td>Up to approx. 10:1, good (dv/dt) compensation and friction required</td>
<td>From experience, up to approx. 15:1</td>
<td>From experience, up to approx. 15:1, precise (dv/dt) compensation required</td>
<td>From experience, up to approx. 15:1, precise (dv/dt) compensation required</td>
</tr>
<tr>
<td>Tension range (Z_{\text{max}}/Z_{\text{min}})</td>
<td>Up to approx. 6:1 for good compensation of friction and (dv/dt).</td>
<td>Can only be changed for adjustable dancer roll support</td>
<td>Up to approx. 20:1 for precise (dv/dt) compensation</td>
<td>Up to approx. 20:1 for precise (dv/dt) compensation</td>
</tr>
<tr>
<td>Roll ratio, tension range (D_{\text{max}}/D_{\text{Kern}} \times Z_{\text{max}}/Z_{\text{min}})</td>
<td>Generally, up to 40:1</td>
<td>Depends strongly on the version of the dancer roll support, up to approx. 40:1</td>
<td>Up to 100:1, significantly depends on the tension actual value signal</td>
<td>Up to 100:1, significantly depends on the tension actual value signal</td>
</tr>
<tr>
<td>Web velocity</td>
<td>Up to 600 m/min for good compensation</td>
<td>Up to over 2000 m/min</td>
<td>Up to 2000 m/min for precise (dv/dt) compensation</td>
<td>Up to over 2000 m/min</td>
</tr>
<tr>
<td>Control concept preferably used for:</td>
<td>Sheet steel, textiles, paper</td>
<td>Rubber, cable, wire, textile, foil, paper</td>
<td>Paper, thin foils</td>
<td>Elastic material that can expand</td>
</tr>
</tbody>
</table>
Closed-loop control technique – precisely as required

Various tension control techniques are the technological core of the standard winder application. Indirect tension control is widely established, because in this case, sensors are not required. The mode of operation is as follows: The tension setpoint is multiplied by the actual radius of the roll being wound, and the result is directly input as torque limit value. This means that the motor torque linearly increases as the diameter increases and the tension is kept constant by overdriving the speed controller. An important factor is the precise compensation of the friction and acceleration torques so that the pre-controlled torque setpoint comes as close as possible to the required material tension.

Friction compensation
Friction losses can be simply compensated using a parameterizable polygon function with ten interpolation points. These are determined when commissioning the system. For Simatic S120 there is an option of automatically recording these.

Maneuvering and jogging
The maneuvering input can, for example, be connected with an analog input and therefore permits the web velocity setpoint to be adjusted as percentage. In the jog mode, a path velocity setpoint can be directly entered via the interface - or one of two fixed jog setpoints can be selected.

Web break detection
The web break detection is active when the tension control is switched-in and depending on the control type, is configured in various ways. After a web break, the diameter computer is stopped, tension operation is disabled and the tension controller enable is withdrawn.

With the functions that have been listed above, all of the necessary resources are available to efficiently implement individual winding applications – and all of this in a form that is simple to learn. As a consequence, even entry level personnel can generate central winders for demanding solutions without having to get to know the actual technology in detail – possibly a tedious task. Users who are already experienced in handling the tools can modify the DCC Chart – on which the standard application is based - as required. This allows them to directly implement very specific winding tasks directly in the drive.

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