Strip Transport Digital Twin

A strip transport digital twin simulates the process, equipment and control systems across a whole processing line based on the properties of the strip, the design of the equipment and regulation, and setup of the control. High-density recorded process data is used to tune the model for higher accuracy. Strip transport digital twins have proven valuable in a variety of applications related to tension setup and regulation, production capability, strip tracking, tension-related defects, roll wear and slip, equipment failures, and drive overloads. Digital twins are useful on both existing lines and in the design of new equipment.

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Introduction

Selecting Appropriate Tension

As has been discovered by anyone who has ever needed to wrap excess paper towels back onto the roll, tension is critical to strip transport. Tension suppresses the natural tendency of the strip to off-track due to camber or roll misalignment. Without tension, it would be impossible to track the strip on-center through a process or mill and wind a solid coil.

For this reason, maintaining appropriate tension control in each section of a processing line is vital for reducing delays, avoiding quality defects and producing acceptable coils. Selecting tension setpoints requires a careful balance based on strip properties, process requirements, available motor power and tension in neighboring sections.

For example, more tension is necessary on heavy strip cross-sections than light cross-sections. Higher tensions improve tracking and reduce coil collapse. Lower tensions reduce strip breaks, edge cracking and coil inner diameter buckles. Very low tensions are necessary in furnaces to control creep, and in dunk tanks and free loops to maintain a catenary. Finally, the tension in any given section is limited by the tension in each neighboring section plus the available motor power and bridle friction between the sections.

Implementing Tension Control

Having selected appropriate tensions for each section of the processing line, it is then necessary to set up the control system to implement them. The tension control system starts with assigning a speed master for each zone of the line. A line will have multiple speed zones if there are accumulators or free loops allowing speed differences. The speed master is a single machine or motor equipped with speed feedback that sets the target line speed. All other drives on the line will directly or indirectly work in reference to the speed master(s).

For example, other rolls within the speed master bridle will typically torque following the master roll. An elongation-controlled bridle will work at a fixed speed difference from the speed master. An entry section bridle is a secondary speed master controlled to hold accumulator carriage position. Other bridles may be controlled to a torque reference or a tensiometer tension reference. In sections where there are low-power, driven rolls, they may be controlled to a speed reference with droop to account for speed