RWTH Aachen University, Institute for Textile Technology

Flexible harness control on a loom

Development of a test stand to optimize the heddle/harness system

The Institute for Textile Technology of the renowned RWTH Aachen is a recognized partner to the textile machinery construction sector. At RWTH, a harness test stand was developed in order to analyze and optimize the interaction of the heddle/harness system for the weaving process. The special challenge: Harness motion was to be able to be flexibly varied. For the electrical equipment to move the harnesses, RWTH Aachen completely used Siemens components. Siemens not only supplied the automation, but also supported RWTH when designing the drives, commissioning the test stand and the mechatronic optimization.

Technological task

The heddle/harness system is used to form the shed in the weaving process. A vertical play between the heddles and the carrier rail of the harness is absolutely necessary and is used among other things to thread the yarn, rectify yarn breaks – and compensate for tolerances in the high-speed weaving process. However, this play must be precisely dimensioned. Otherwise, this will result in rougher yarn, diminished weaving quality, negative effects on machine operation and increased energy usage. In order to improve the heddle/harness system, the interaction of the heddle play had to be analyzed. To achieve this, the Institute for Textile Technology of RWTH developed a measuring system, which acquires the relative motion of the heddles in the harness frame during high-speed operation. In parallel to this, a test stand was designed which allows the influencing parameters to be varied and simultaneously utilized in actual operation. This test stand was developed in close cooperation with Siemens.

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Test stand to vary parameters

To start, a requirement profile for the test stand was developed and subdivided into mandatory, reference and can criteria. The must criteria included the following: the static and dynamic relationships at the machine were to be emulated as close as possible to those in practice at realistic machine speeds of up to 1000 rpm and different motion profiles had to be emulated (with/without rest phase). After evaluating different methods, the components for the measuring system shown in Fig. 1 were selected. In addition, the noise was determined according to the envelope technique. The complete sensor system can be used in industrial weaving machines and can therefore be used in weaving mills. The team then drafted various test stand concepts and mirrored the requirements that had been drawn-up against these. The concept involving an industrial weaving machine with modified shedding formation device was finally selected, which guaranteed the best possible reference to practice. The weaving machine – equipped with single-motor drives to move the harness – is shown in Fig. 2. This design allowed the harness motion profile to be widely varied: e.g. a sinusoidal motion and motion with a rest phase (see Fig. 3).

Using this test stand and the measuring system, it was possible to analyze how the various parameters, e.g. machine speed, motion profile, warp tension level and harness type affect the relative motion of the heddles in the harness frame, the noise generated as well as the wear and the weave quality.

Drive equipment to move the harnesses

The automation configuration for the test stand is shown in Fig. 4. It comprises four servo motors and the drive system to control the motors. The test stand is operated using the SIMOTION Scout® engineering system. An operator panel is not required. All of the drive components are connected through DRIVE-CLiQ®, the uniform, digital interface system.

Highest dynamic performance required

In order to achieve the specified machine speeds of 1000 rpm, the harnesses must be accelerated at an extremely high rate. This is the reason that RWTH used 1FK7 HD (High-Dynamic) permanent-magnet synchronous motors to move the harnesses. These motors set themselves apart as they have a very low intrinsic moment of inertia and 300% overload capability. Further, two motors are coupled to one shaft for each harness (see Fig. 2). With the same total torque, the motors have a lower moment of inertia than a correspondingly larger single motor for each harness. A motor follows the torque of the coupled motor. The torques can be generated in absolute time synchronization as a result of the connection through the digital DRIVE-CLiQ interface system.

The test stand requires a total of four motors. These are controlled from two double motor modules from the SINAMICS S120 drive system. These motors are connected to a common DC link fed from a Base Line Module. The motors can exchange energy through the DC bus. As a consequence, the energy that is released when a motor brakes can be used by another motor to accelerate.

Motion control using cams connected in series

SIMOTION D from Siemens is used to control the drive to implement the motion profile that is required. The module is directly integrated into the drive line-up. SIMOTION also executes the PLC functions, which means that a separate, programmable logic controller is not required. What is especially worth mentioning is the fact that SIMOTION provides a wide range of motion control and technology functions, including a cam function. For the test stand, the motion of the harnesses is derived from a virtual master axis - and implemented in a user-friendly fashion using two electronic cams connected in series (see Fig. 5).
To start, the relationship between the machine angle of the loom and the harness position (height in millimeter) is defined. The associated angular position of the eccentric (in degrees) is then mapped at the gear unit output. Contrary to their mechanical peers, electronic cams can be quickly replaced and their cam shape can be configured as required. As a consequence, harness motion can be specified intuitively in a user-friendly fashion and the motion function of the harnesses can be varied over wide ranges. This is absolutely necessary in order to investigate the influencing parameters; however, this is either not possible or only possible with some restrictions at a conventional series loom.

Test support using user-friendly diagnostic options

The SIMOTION Scout engineering system combines the functions to parameterize, program, diagnose and document the automation under one user interface. As a consequence, Scout is not only used to dimension the drives, for commissioning and to enter different motion profiles, but is also used to operate the test stand. During the various investigations, the trace function turned out to be especially useful. Using this trace function, internal and external parameters – for example setpoint and actual speed and torque values - can be recorded in real time, archived and exported to other programs.

Interaction between technology and automation know-how

As a partner to the textile machine sector, Siemens also gets deeply involved when it comes to innovative topics at an early stage. Within the scope of this project, drive and automation solutions from Siemens were convincing from many perspectives:

- It was clearly shown: The product portfolio from Siemens fulfills the requirements of the textile sector - in a comprehensive and efficient fashion.
- The automation task was able to be completely realized using standard components. When compared to customized solutions, they offer advantages due to the fact that spare parts are available worldwide and cost efficiency as existing platforms can be used.
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