WebSim: Better Fabrics through Knowledge of Thread Forces

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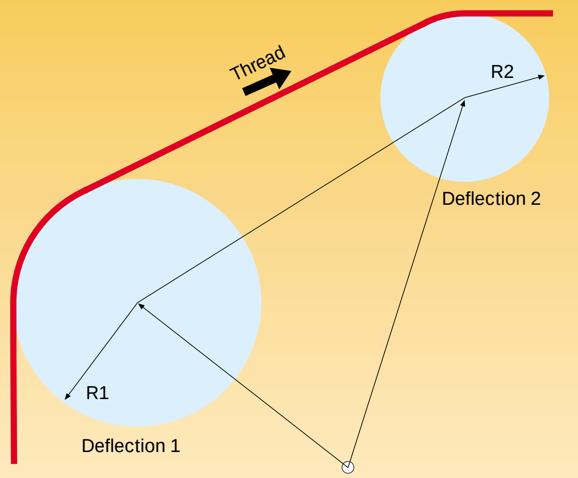
WebSim, developed by Sulzer Innotec, is a novel simulation program that provides answers to classical questions concerning machine dynamics in the weaving process, while at the same time calculating warp and fabric tensile forces. With this knowledge, both the weaving process itself as well as fabric quality can be improved, as it is thus possible to simulate the interactions between the thread and the machine components. WebSim can currently be used for the Sulzer Textil G6200 rapier and the M8300 multi-phase weaving machines.

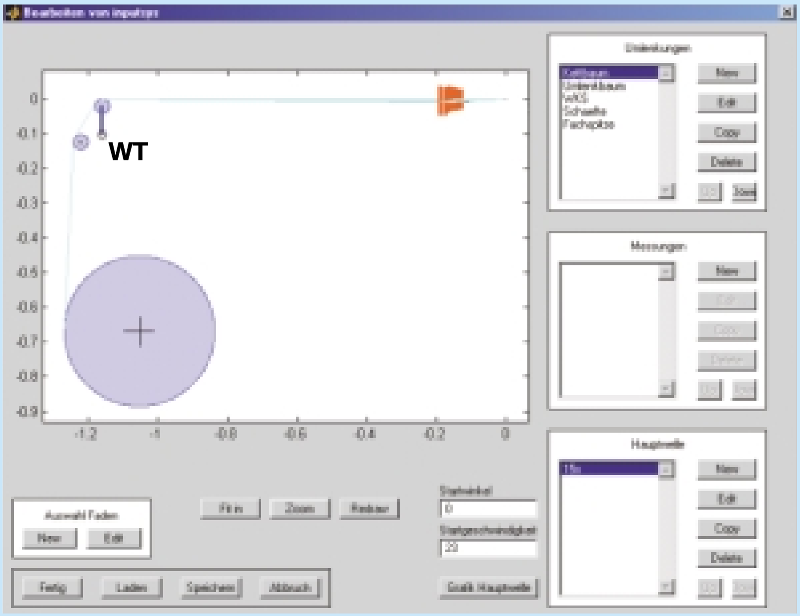


1 ■ The geometry of the deflectors determines the direction of the velocity vectors in the thread. WebSim, a program developed by Sulzer Innotec to simulate complex processes in the weaving process, also calculates the highly dynamic changes in force from thread run-on and run-off, or stick-slip caused by friction.

■ In the weaving process, warp threads are subjected to very high stresses. Depending on the style being woven and the weft insertion system, the loading in the threads changes approximately three thousand times during their journey from warp beam to finished fabric. Warp end breaks cause machine stoppages, resulting in loss of production. Moreover, sudden stops and restarts change the tensile forces in the warp threads, and these stoppages can lead to quality problems in the fabric. This is why simulation and calculation of warp thread forces has been an important topic in investigations of the weaving process.

COUPLED SIMULATION

The threads are not only subjected to high forces, but also exert them on the weaving machine, from static to 1600 N, which is equivalent to the force exerted by a 160 kg mass. These forces are the cause of dynamic loading of the warp tensioner and other components of the weaving machine. This complex process in fabric production can now be simulated for the first time by simultaneous modelling of threads, deflecting elements, and control influences. WebSim includes numeric models for the dynamics of all machine components which come into contact with warp ends or fabric. The movement



2■ *In the simulation program, almost all types of weaving machines can be put together from individual elements. The behaviour of the warp tensioner (WT) plays an important role in the dynamics of the classic rapier weaving machine modelled here.*

of the finished fabric is simulated as far as the cloth take-up, also taking the influence of inertia into account. The program models the friction processes on the rotating deflectors, which can also be combined with any desired controller or drive model.

WIDE CHOICE OF MACHINE COMPONENTS

The equations which describe the movement of the thread in the weaving machine are borrowed from fluid mechanics. If the thread is considered as a flowing continuum, it is an obvious step – analogous to Euler's equations for fluid mechanics – to calculate a mass and pulse balance in the longitudinal direction of the thread. This allows the thread forces and the velocities between two deflecting elements to be calculated.

The approach to modelling of the deflectors derives from classical many-body dynamics. The deflecting elements themselves are circular discs with a defined radius, which in the case of deflection around a point can also be zero. Deflecting elements may be driven or undriven (freely moving); control devices can be attached to them in addition. Driven elements perform movements dictated by the mechanics of the weaving machine. In this case, only the deflectors exert a force on the thread; the reaction of the thread forces is ignored. Examples of driven elements include the shafts used in conventional weaving machines for shed formation, or elements which replicate the action of the reed beat-up at the fell.

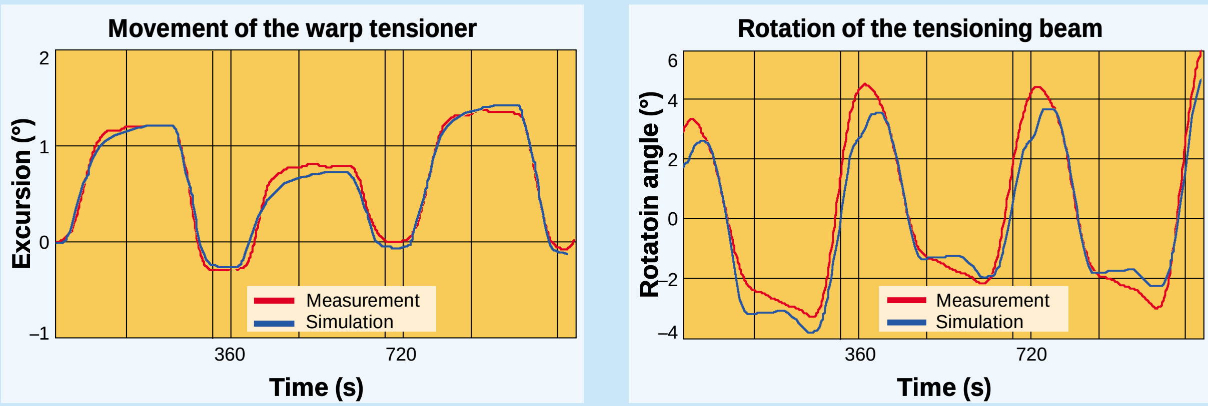
Undriven deflectors, e.g. warp tensioners or tensioning beams, change position under the influence of the warp and cloth forces, the inertia and the number of degrees of freedom being predefined.

Analogously, WebSim can also be used to simulate the rotational characteristics of the deflectors, be they freely rotating and inert, or controlled.

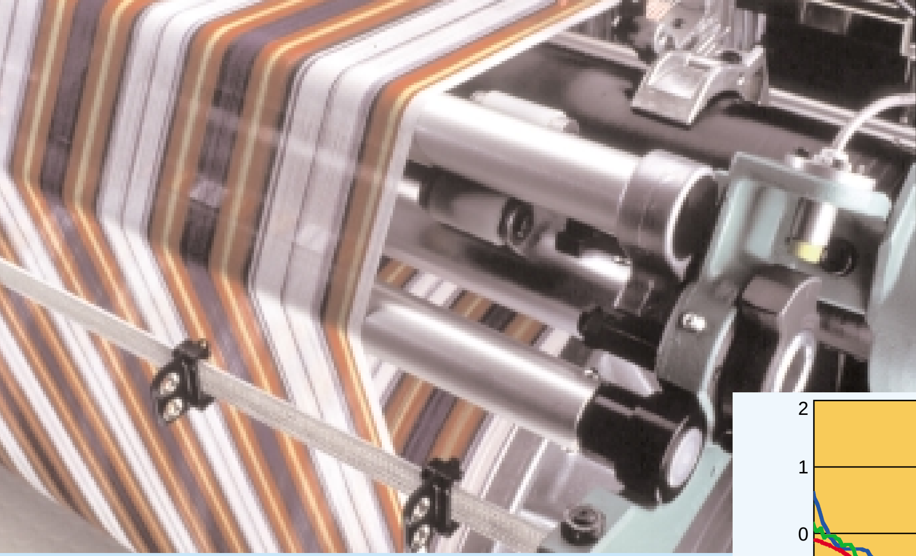
From the geometric and dynamic values of two neighbouring deflectors (Fig. 1■) and the movement equations for the elastic thread, the program calculates the parameters of the thread and its chronological differentiations.

SIMULATION OF ANY DESIRED MACHINE TYPE POSSIBLE

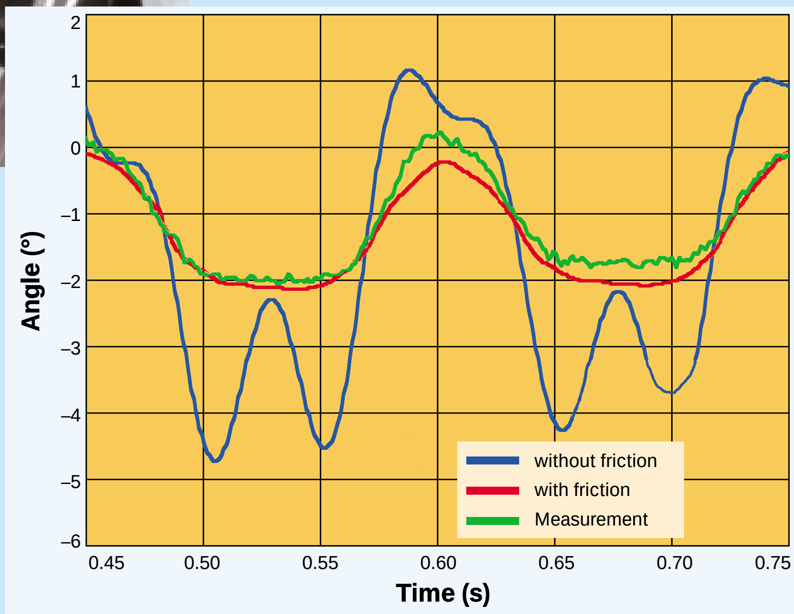
The overall model of a weaving machine comprises a combination of the individual elements described. WebSim's GUI (graphical user interface) is designed in such



3■ *The comparison with measurements shows the accuracy of calculations with WebSim. It is hoped that in future, data obtained from simulations which cannot be obtained by measurement can be used to optimize the machines.*

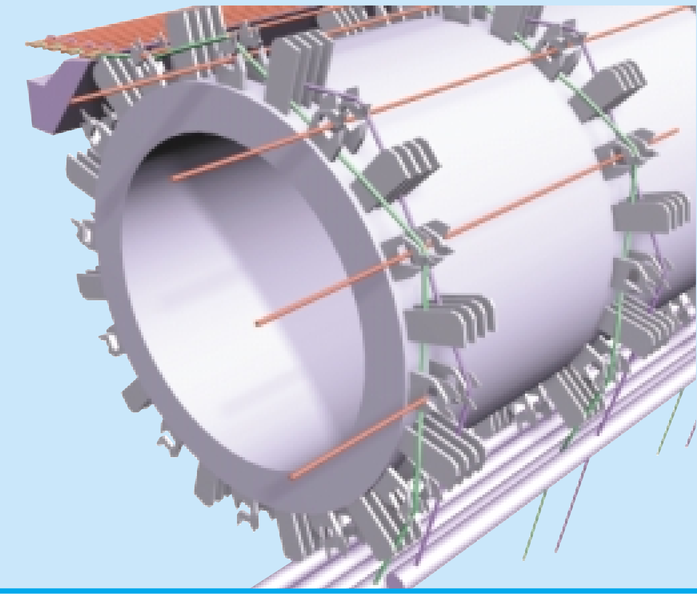


4■ *The effective thread forces influence the system dynamics of this warp tensioner, which consists of support tube, rolling fixtures and tension roller. Simulation with WebSim allowed the time courses of the relevant quantities to be represented.*



a way that any type of weaving machine can be put together by mouse-click (Fig. 2■). Other parameters, e.g. describing the dynamic properties of the thread, are entered via the keyboard. From these data, the program generates the determinative differential equations and calculates the chronological course of all internal state variables, such as thread force, thread velocity, or the positions of the freely moving deflectors.

5■ *The highly dynamic effects between the warp threads and the rotor, illustrated in the simulation of a modern multi-phase weaving machine.*



GOOD AGREEMENT WITH MEASUREMENT RESULTS

The results represent data which can either not be obtained at all from measurements or only at very high cost. Of course, it only makes sense to use such values to optimize weaving machines if it can be proved that the simulation replicates reality accurately enough. The simulation of a Sulzer Textil G6200 rapier weaving machine shows good agreement between measurement and calculation, as regards both the movement of the warp tensioner and the course of rotation of the roller, i.e. the tensioning beam (Fig. 3■). The rotation of the tensioning beam, which is modelled as a freely rotating element, is caused by transport of the warp. The results illustrate the link established between the thread forces and the weaving machine components.

PHYSICAL CONFIRMATION OF EMPIRICAL VALUES

As with other weaving machine components, empirical values have up to now played an important role in modelling the warp tensioners of classical rapier weaving machines. Adaptation to the requirements for different fabric qualities is also based largely on empirical values. The simulation data help broaden our understanding of the machine-dynamic processes which form the background for these traditional empirical values. Parametric studies in which, for example, the friction values in the warp tensioner are varied, show which values have a major and which a minor influence on the state variables of the warp and the machine components (Fig. 4■). The calculations with WebSim confirm the finding that the warp tensioner is the key component for understanding warp forces in conventional single-phase machines.

A simulation of the Sulzer Textil M8300 multi-phase weaving machine (Fig. 5■) also provided new insights, which will be helpful in the further optimization of these machines.

Multi-phase weaving machines have opened up new dimensions in weaving speed. With machines of this type, weft insertion rates of up to 6000 metres per minute are feasible. For the sake of comparison, a rapier weaving machine manages just about 1500 metres per minute. In future, simulation of machine startup and shutdown with different warp beam controller parameters is to be supported by a search for settings at which the force flow in warp threads is affected as little as possible by stoppages. This will result in higher fabric quality (Fig. 6■).

RECENTLY INTRODUCED IN PRACTICE

The simulation software WebSim was developed at Sulzer Innotec in a project lasting two-and-a-half years. It will be used by Sulzer Textil. Two areas of application are particularly important. First, the developers will use simulations to investigate concrete problems occurring in weaving practice, and will thus be able to suggest solutions to customers more quickly. Second, Sulzer Textil will use WebSim to improve the major components of weaving systems by parameter studies in the course of developing new weaving machines. A further aim is to use this tool to reduce the scope of testing necessary when establishing the correct parameter settings for special fabrics or new yarn materials. Ω

FOR MORE DETAILS

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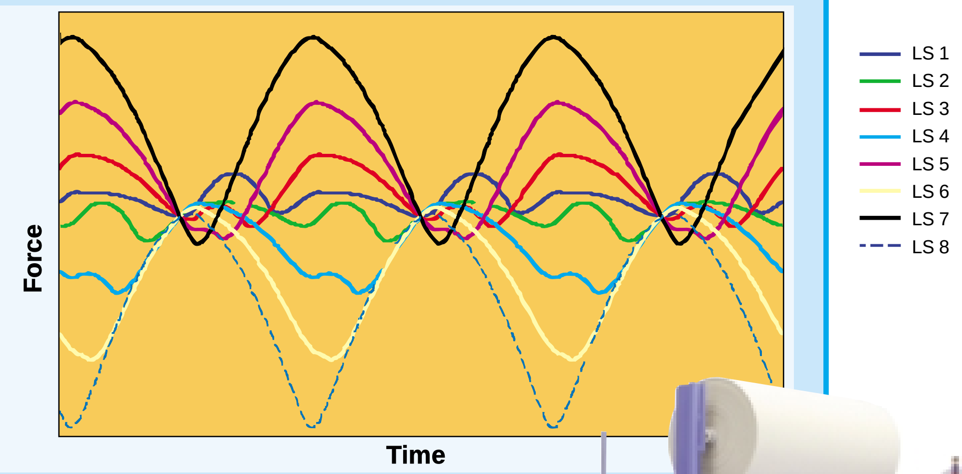

6■ *Using the WebSim program developed by Sulzer Innotec, Sulzer Textil can calculate the course of thread forces on the rotor of a multi-phase weaving machine.*