Weaving fabric at unequalled industrial speed

Picanol partners with LMS Engineering Services to realize 15% productivity gain on next-generation rapier weaving machines

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Picanol, the leading weaving machine manufacturer, cooperated with LMS Engineering Services to realize higher productivity and enhanced noise and vibration standards on its next-generation rapier weaving machines. After providing support to Picanol's successful GamMax weaving machines, LMS optimized the new rapier driver mechanism for Picanol's upcoming rapier loom. Dynamic evaluations in LMS Virtual.Lab Motion helped Picanol and LMS engineers to reduce internal peak forces, avoid bearing wear-out, lower weight of oscillating parts, and extend the fatigue life of key parts. This enabled Picanol to significantly speed up the motion of the rapier as it travels through warp yarns, translating into 15% higher weaving productivity.

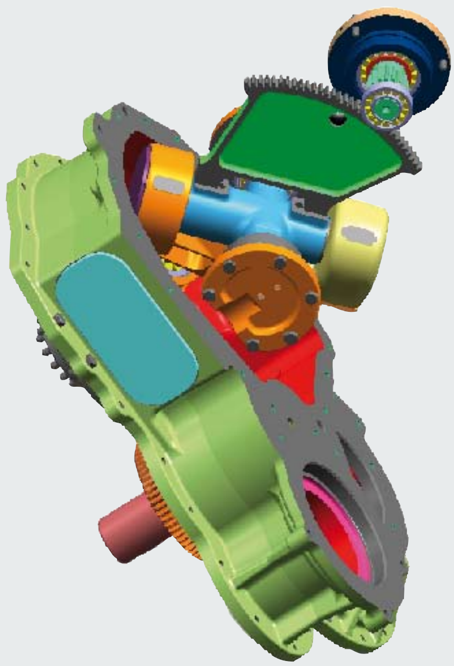
Why weavers win with Picanol

Industrial weaving mills running on hundreds of Picanol looms around the clock deliver a good part of the world's daily fabric production. Belgium's Picanol is a leading worldwide manufacturer of weaving machines and has currently over 110,000 weaving machines in operation at some 2,600 customers around the world. Large as well as small fabric manufacturers use Picanol weaving equipment to efficiently create high-quality fabrics, with few interruptions and easy changeovers to maintain high productivity. As fashion tastes and fabric preferences change frequently, manufacturers additionally require maximum weaving flexibility. To effectively respond to rapidly changing weaving requirements, Picanol's rapier weaving machines are designed to flexibly deal with short runs, different styles, colorful designs and diverse fabrics, including cotton, voile, crepe, wool, glass and Kevlar.

"Ultimately, it is all about money. The more machines a single weaver can manipulate, the lower the overall cost of ownership for the fabric manufacturer," Kristof Roelstraete, Director of Rapier Weaving Machine Development at Picanol headquarters in Ieper, Belgium, stated. "Our strategy is to develop qualitative equipment that features high weaving quality and operational reliability, translating into premium fabrics and rare weaving stops. In addition, the modular design and electronic control of rapier weaving machines additionally provide straightforward changeover procedures in case the loom is set up for a new article. To maintain top-market productivity and flexibility for our rapier weaving machines, we successfully developed and introduced a number of ground-breaking technical advances. One example is the patented Sumo direct-drive engine, which is controlled electronically, stops or slows down immediately if needed, and reduces overall power consumption with 10%."

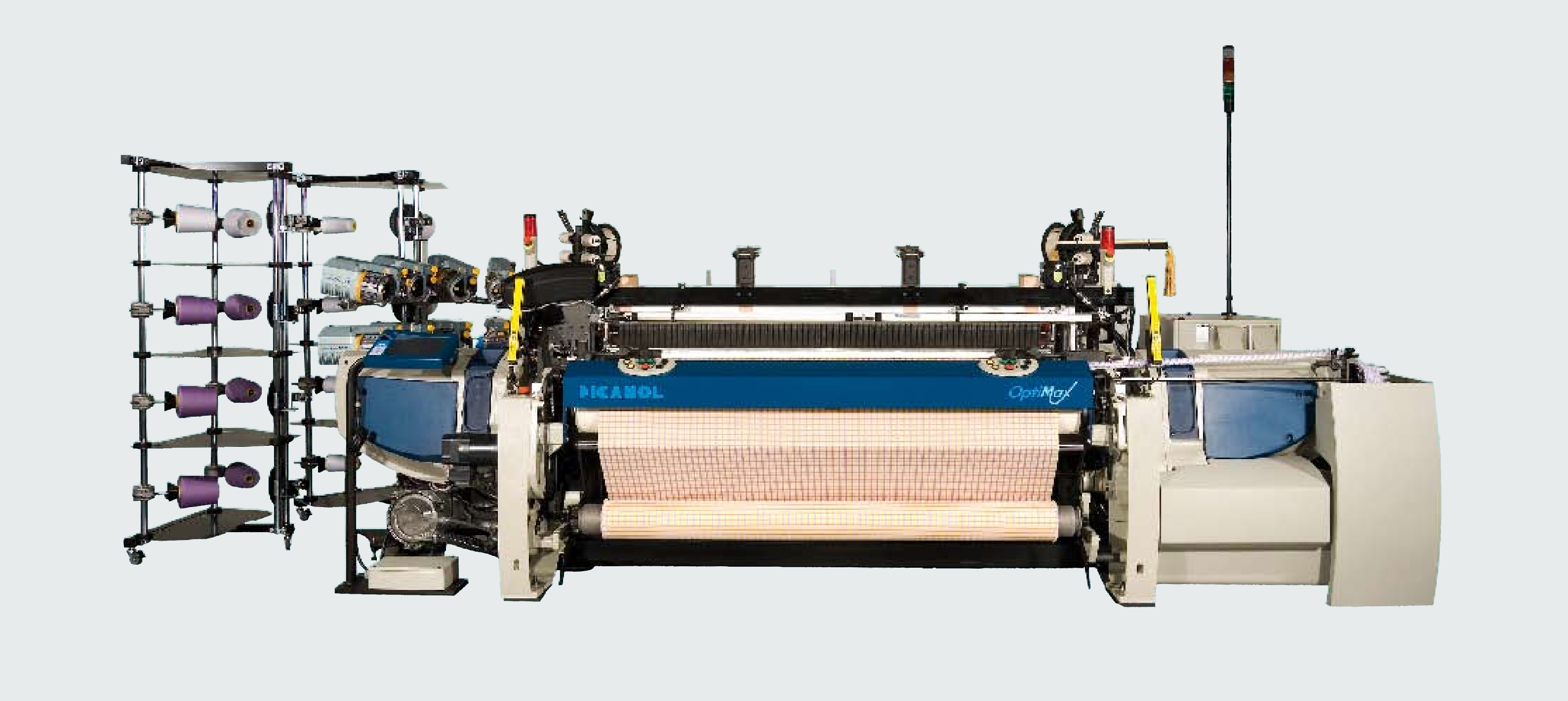
The start of a strategic partnership

Already in 2002, when Picanol finalized the development of its successful GamMax line of weaving machines, the company partnered with LMS to investigate the noise radiation performance of these rapier weaving machines. Picanol and LMS engineers were able to drill down to the individual operational noise sources through operational modal analysis, operational motion and deflection analysis as well as acoustic intensity and noise radiation measurements. First of all, measurements confirmed that maximum noise radiation occurred around 1,200 Hertz, a frequency that disturbs conversations in the area surrounding the weaving machine. They also retrieved that the nature of the excessive sound at this frequency was of a purely kinematic origine, and that it also coincided with



"Simulation eliminated at least one complete prototype iteration step, which firmly reduces both development duration and expenditure."

Kristof Roelstraete
Director of Rapier Weaving Machine Development at Picanol



the noise generated by gearwheel contact. The tests also indicated that during operation, bearing alignment and pretension showed the tendency to evolve unfavorably.

“More recently, with the development of the successor for the GamMax in 2004, Picanol decided to cooperate with LMS,” Kristof Roelstraete explained. “Joint engineering efforts performed early in development allowed us to increase productivity of our weaving machines, while keeping noise and vibration at acceptable levels. A key assembly in this regard is the revolutionary rapier driver mechanism, which drastically increased operational speed, and as a result raised noise radiation considerably. The circular motion of this mechanism drives the bidirectional linear movement of the rapier, a dedicated component that transports the lengthwise thread through stretched crosswise threads of the fabric being woven. LMS engineers fine-tuned the design of the rapier driver mechanism, and succeeded in reducing noise radiation significantly. This represented a major engineering challenge, as today’s industrial rapier weaving machines relentlessly move the rapier back and forth up to 25.000 times an hour. The staggering rapier accelerations involved in the weaving process even exceed engine piston acceleration of Formula 1 race cars!”

Better performance through virtual simulation

The extreme forces resulting from this high-speed motion put a lot of pressure on the entire rapier driver mechanism. LMS engineers modeled the rapier driver assembly and concurrently optimized subsystem performance characteristics in an effort to lower assembly weight, prevent component wear out, eliminate fatigue-life effects, and reduce acoustic radiation. In Picanol’s new compact rapier assembly design, the driving wheel applies circular motion to its connection with a fork element. This fork element holds a cross member piece that is restricted to pivoting in a fixed plane. Through the oscillating motion of the fork element, the cross member (and rapier wheel) successively pivots in clockwise and counterclockwise direction, ultimately pushing and pulling the rapier through crosswise threads at high speed. To reduce the aggressive dynamic forces involved, engineers applied rigid modeling to relocate the center of gravity of moving assembly parts. These actions included position, size, shape and weight modifications of parts.

As rapier driver assembly parts slightly deform during operation, a dynamic multibody model of the entire rapier driver mechanism was created. By modeling key components as flexible bodies using Finite Elements (FE), the effects of deflection and resonance were automatically taken into account when simulating the dynamic assembly load cases. “During operation, the deflection of parts slightly changed the location and orientation of the bearings, which introduced slight bearing misalignment and axial bearing forces,” Stefan Dutré, Program Manager at LMS Engineering Services, explained. “Simulations in LMS Virtual.Lab Motion allowed us to establish optimal bearing performance

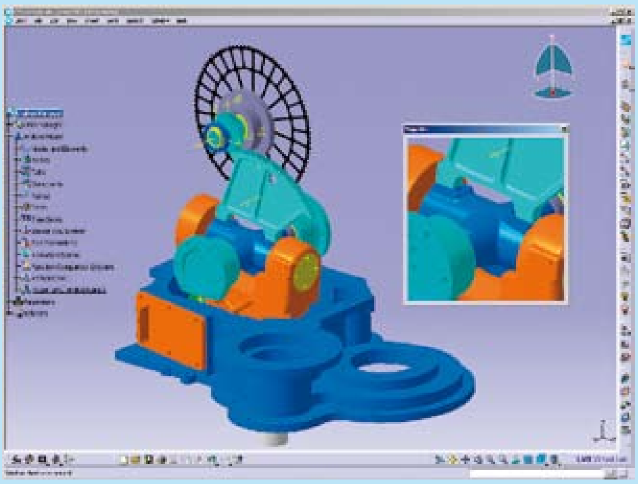
LMS Virtual.Lab Motion provided the foundation for realizing significant improvements in terms of durability and noise & vibration.

under real-life operating conditions. This was achieved by increasing bearing and housing stiffness, improving bearing alignment and applying appropriate bearing pretension. Dynamic motion simulations also helped us to trim down radial bearing forces through further weight reduction of moving and oscillating parts."

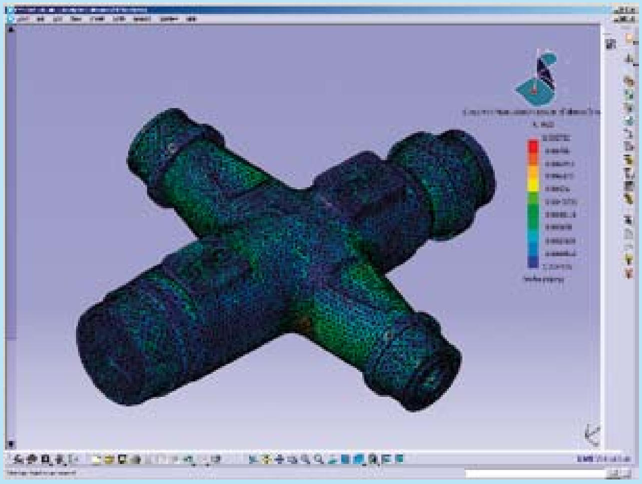
Extending fatigue life and reducing noise radiation

Simulations in LMS Virtual.Lab Motion also provided the basis for evaluating the fatigue life of rapier driver parts. From simulated dynamic internal loads, engineers were able to retrieve maximum local stress values for each FE-modeled component. Durability hot spots were identified for those locations facing stress variations that approximated or exceeded the material-specific endurance limit. To modify the design of key components for infinite life, the functional holes of these parts required repositioning and resizing. High durability standards are critical in keeping weaving machines running non-stop for a 7-10 year period, without parts that fail due to insufficient fatigue life.

Another important performance characteristic is the noise weaving machines radiate. One of the major noise sources is the rack-and-pinion transmission that is used as part of the rapier driver assembly. The toothed rack on the pivoting rapier wheel drives the linear motion of the rapier. "Each time the rapier reverses its direction of motion, the tolerance between rack and pinion teeth results in an impact excitation, which is characterized by a high-frequency bandwidth," Stefan Dutré commented. "The excitation systematically travels through the bearings and initiates vibrations of the housing structure, which in turn, radiates noise. To adequately resolve this, we created a dedicated multibody model in LMS Virtual.Lab Motion, which takes into account gear and rack/pinion tolerance as well as varying contact stiffness of teeth dynamically gripping into one another (mathematical model). We derived the dynamic bearing loads through multibody simulation and applied them to the FE model of the housing. Then, we took the average value of the resulting surface vibrations (displacements) as a measure for the radiated noise. As simulation results indicated, we reduced the noise radiation by increasing the damping of the housing structure, and by using more expensive gears produced with smaller tolerances and higher-quality tooth finishing techniques."



LMS Virtual.Lab Motion helped to trim down radial bearing forces through further weight reduction of moving and oscillating parts.



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Raising rapier weaving productivity with 15%

"The combination of realistic virtual simulation and in-depth testing know-how makes a big difference in designing better weaving machines," Kristof Roelstraete stated. "In the ongoing development process, technical excellence helped us raise the productivity of our next-generation rapier weaving machines with 15%. This performance boost is realized through higher machine speed and lower downtime, the ability to weave a wider variety of textiles, more flexibility in switching between articles, and lower weaving cost. In this regard, the contribution of LMS is highly appreciated. Advanced tests precisely indicated how machine performance could be further improved, and early-process simulation optimized the real-life operation of our new rapier driver mechanism. In addition, LMS Virtual.Lab Motion simulations provided the foundation for realizing significant improvements in terms of durability and noise and vibration. Altogether, simulation eliminated at least one complete prototype iteration step, which firmly reduces both development duration and expenditure." ■

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