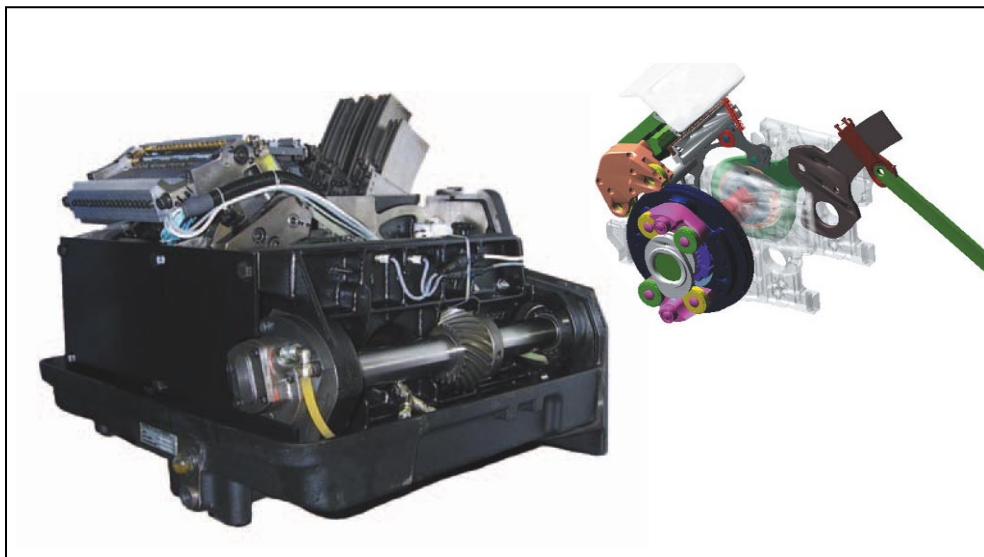


Fimtextile Weaves Simulation into Product Development Process

Complex Kinematic Simulation in the Textile Industry



Fimtextile designs, manufactures, and sells shedding motions (called dobbies and cam motions), which are fitted to weaving machines with rapier, projectile, or air- and water-jet weft thread mechanisms. The shedding motion is the device that moves the frames holding the warp thread in weaving machinery. These frames and their threads are reciprocated for every pass of the weft mechanism. For maximum weaving efficiency, the motion of the frames must be as fast and as smooth as possible.

There are two types of shedding motions: cam motions and rotary dobbies. Cam motions lift the loom's frames in a variety of ways depending on the kind of fabric to be produced and the quality required. The movement is directly transferred from the cam to the loom's frame by a roller lever. To meet the required shed opening (the space for the weft rapier or projectile), this lever is adjustable. Every cam has a fixed lift. To change the fabric being produced, the machine has to be stopped and the cam-pack, which consists of a number of cams, has to be changed. Conversely, a dobbie driver allows the weaving style to be changed by using a selection mechanism. The selection mechanism stops the loom frame in the position of maximum or minimum shed opening and an electro-magnetic system allows the user to change the fabric specification without changing any cam mechanisms.

The Technical Challenge

One of the main challenges in designing rotary dobbies is arriving at a good selection mechanism. There is a significant dynamic problem to solve for the selection mechanism: stopping the loom at a specific locked configuration in a quadrilateral frame moving at high speed. Also, significant inter-part impacts involved in this locking mechanism can cause problems in use. "MSC.ADAMS and MSC.Nastran are essential tools to simulate the precise way these impacts between the flexible components of our machines affect their performance," said Stefano Mazzoli, CAE project manager at Fimtextile, who works on this project with collaborator Gianmarco Gotti. "As is typical with textile machinery," continued Mazzoli, "our mechanisms have to work in a very small space and at a very high speed. The roller levers are 12 mm thick or less, so they are relatively thin compared to their length and correspondingly flexible."

The Fimtextile mechanisms are composed of cams, quadrilateral frames, ratchet gears, and levers. The main challenge is to define precise and fast mechanical movement in a relatively small space. This means either an optimization of existing mechanism topologies or a performance evaluation of new ones. Many of the

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Customer:

Fimtextile, Italy
www.fimtextile.it

Software:

MSC.ADAMS®, ADAMS/Flex, ADAMS/Durability, MSC.Nastran™

Summary:

Fimtextile used MSC.ADAMS and MSC.Nastran to analyze new machines and to optimize the dynamics of existing ones. They could simulate the performance and function of the shedding motions before building a prototype and therefore reduce the number of physical prototypes required to verify the design. By using MSC.Software Virtual Product Development tools for analysis and simulation very early in the conceptual design process, Fimtextile could optimize its products and design methodology to reduce design and development time and consequently reduce time-to-market.

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mechanisms work with contacts and impacts between very small parts. The small thicknesses also imply the use of elastic and flexible parts. Some parts such as the selection lever and the selector, are evaluated with FEM as springs, not rigid parts. They have to be characterized as elastic in order to create the necessary controlled displacements during the movement. It is not correct to define a model with rigid parts knowing that they are flexible; otherwise the simulation would be misleading and the physical mechanism would not work.

Simulation Offers the Solution

The designers need to build virtual models in order to simulate the mechanical performance under many different working conditions. This approach allows designers to understand potential weak points in the design and how to improve them. The decision to use Virtual Product Development software such as MSC.ADAMS and MSC.Nastran was made knowing that technological innovation was the only way that Fimtextile could produce more competitive, world-class products. No other software had the capacity to deal with the flexible components inside the Fimtextile machines.

Virtual analysis and simulation allow Fimtextile to produce significant virtual test data in a very short time, which reduces development time, improves product quality, and eliminates the need for many intermediate physical prototypes. “When we finally make a new physical prototype, we are confident that many of the potential problems are already solved and it will work as predicted,” said Mazzoli. “Another advantage of this approach is the ability to evaluate potential modifications to the mechanism and their effects on its performance. Testing alternative intermediate solutions with physical prototypes is prohibitively expensive just on the production side and they need long-term testing to be properly evaluated. By using virtual prototypes, every idea to improve our product is

evaluated; nothing is rejected as being too expensive to check out because we don't need multiple intermediate prototypes.”

The most important aspect of the Fimtextile design process is to be able to adapt designs very quickly to accommodate new and specialized customer requests. The company needs to have the right design process infrastructure to allow them to design extremely adaptable products that take into account their customer's changing needs over time. This can be achieved by controlling and minimizing the loads transmitted to the threads on the loom. It is also important to design every part of the machine in order to convey the most economical motion to the loom frames and to reach the best dynamic response of the whole system. “With MSC.ADAMS, it is possible to perform rigorous analysis and to optimize the distribution of all the kinematic loads from the rotary dobbie, or likewise a cam motion, to the woven thread,” said Mazzoli. It is not possible to simplify the analysis of such a complex system by trying to find approximations for the improvement of the system itself. “It is essential to use the most sophisticated tools in order to simulate properly every part that constitutes the system,” said Mazzoli. “Therefore we need to simulate the entire machine to compare the analytical behavior to the physical behavior.” To achieve the maximum benefit from these solutions, it is important that Fimtextile uses MSC.ADAMS and MSC.Nastran from the earliest stage of the conceptual design phase in order to reduce the number of modifications made to the physical prototypes. Changes made to the virtual prototype in the conceptual phase are much cheaper than changes to the physical prototype, and many different virtual tests can be made on every design iteration quickly and economically.

Using MSC.ADAMS, engineers and designers can examine dynamic models quickly and apply changes to optimize the mechanical aspects and the associated control systems. After the conceptual phase, the designers verify the physical behavior of the mechanism. “The ability to analyze a machine with flexible parts is the most important feature of the MSC.ADAMS and MSC.Nastran combination,” said Mazzoli, “All other approaches would be simplifications of the real model, because the behavior of these machines is strictly linked to their elasto-dynamic properties. This is the only way to perform rigorous analysis and simulation on the complex mechanisms that make up

textile machinery. We examined other products, but none of them were as useful to us as ADAMS/Flex.”

MSC.ADAMS provides added value to the Fimtextile engineers and designers in that they can now verify the dynamic conditions of the entire machine in a virtual way. ADAMS/Flex and ADAMS/Durability allow them to verify the effect of dynamics on the flexible components and the importance of flexible parts to the dynamics itself. These results are important for good component design. They are based on real stress-history during a duty-cycle instead of approximated loads. The complete interoperability between MSC.ADAMS and MSC.Nastran allows further structural analysis based on structural optimization of single components. “This is an important improvement in our knowledge of the machine behavior that allows us to evaluate the differences between the virtual and physical simulations,” said Mazzoli.

The Detailed Analysis

Geometry and mass properties for the simulations come from PTC's Pro/ENGINEER. All the materials are considered in their linear elastic range. The interaction between different components is considered as impacts with friction forces, so that the results consider all mechanical effects. The Fimtextile meshes are very well-defined in order to accommodate virtual strain gauges, which reflect the real ones used in the physical testing phase. This is a great example of virtual testing used to validate the virtual model and to increase data sharing with testing department. There are also some interface nodes to link flexible parts to rigid parts, and some spider webs that distribute loads coming from multi-body analysis to the nodes of the flexible body. In excess of 200 runs were performed for each machine optimization. Optimization is currently achieved by iterative techniques, but Fimtextile wants to start using a DOE (Design of Experiments) analysis.

MSC.Software products reduced Fimtextile's design time and reduced experimentation time on physical prototypes. By reducing testing time, Fimtextile could make more design iterations. Some analyses reduced the design time by several months. Overall, simulation improved Fimtextile's product stability and quality. The most significant outcome of the use of MSC.ADAMS is that for Fimtextile the 'virtual test' is now a reality.

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