Automating a process for the perfect sail

atonline update

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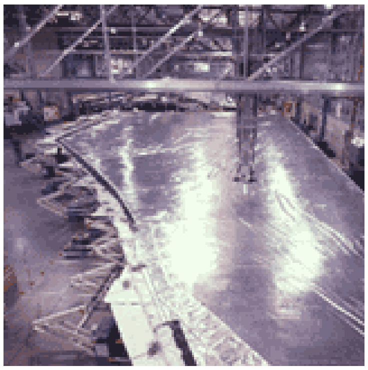

Sailors and boat builders discovered that the "best" shape for any boat sail can prove quite elusive, depending on wind speed, wind angle, waves, boat type and size - even weather and temperature. Still the vast complexity hasn't stopped the quest for finding the best formulae for the most perfect shapes.

In its fully extended "flying shape," a sail's design takes into consideration three-dimensional geometry issues like camber and twist, as well as the same drag and lift laws of aerodynamics that apply to airplane wings. The math jumps from plane geometry and linear equations to topology and double integral calculus.

Computers can help crunch these numbers and generate sail designs, but translating the data into a manufacturing process is something else entirely. North Sails Nevada, near Reno, has an integrated automaton approach in the fabrication of the most technically advanced sails available thanks to a total solution package from Siemens.

North Sails introduces 3DL sail making

Sail making is a totally integrated process using an "electronic mold". The process is called "3DL" because it is, among its many other positive attributes, a three-dimensional laminating process.

All the 3-D CAD/CAE files for each customer work order are uploaded to a central server. Interfaced to the central server is a R145 industrial computer from Siemens. The domain server and the computer work in tandem. Both the server and the industrial PC have individual tasks that relate to the operations of the process.

The industrial PC's main task is to provide the "modeling" information to the programmable logic controllers (PLCs) that are integrated into the process. The master PLC is a SIMATIC® S7-400. A SIMATIC S7-300 PLC controls the gantry operations used for the automated reinforcing yarn placement and heat curing of the lamination. ET-200 I/O modules from Siemens provide remote functionality. The computer, PLCs and all the field I/O devices communicate via PROFIBUS® over a LAN network.

The electronic mold shape is achieved by the master PLC directing over 200 critically positioned pneumatic pistons to act in concert to reach the "computer-conceived" flying sail shape on a portion of the dynamic work platform. This part of surface real estate is the mold area for the 3-D designed sail. The material used to provide the mold's working surface is pliable enough to conform to the computer-determined shape, but rigid enough to hold that shape throughout the lamination and curing process. The platform can accommodate any flying shape and size of a modern racing sail.

Once the flying shape surface is reached, the pistons lock into position. Sensors are then attached to an extended arm of the gantry moving along the surface, comparing all the polar coordinates to those stored in the computer. If any point on the surface does not match the computer model, an alarm is sounded and the piston or pistons responsible for that area of the mold are flagged. A SIMATIC TP37 remote display terminal at the mold location displays the error messages. Manual or automatic adjustments can be made when necessary via this terminal. Interlocks are brought into play if a manufacturing technician inadvertently tries to make any adjustments outside allowable limitations.

With the articulating mold in the proper shape, the process is now ready for laying down the bottom film layer of the lamination sandwich. The computer instructs the gantry arm, via the PLC communication, to mark the exact location on the mold's surface for positioning the laser-cut pieces of film. The exact content of the laminated sandwich being built depends on the specifications of each customer's order. In 1995, both of the America's Cup finalists used an aramid scrim on top of the hybrid carbon-aramid reinforcement fiber.

With the bottom layer of film in place, an armature suspended from the overhead gantry applies the yarn fiber to precisely match the anticipated loads of the sail. The movement of the armature is instructed by the S7-300 PLC. The threads are applied to the surface under uniform tension with an adhesive. A technician is suspended above the process in a hang glider-like harness to follow the process with close visual inspection as the process takes place.

Once the yarns and any other specified materials are applied for the insides of the sandwich, the second (top) film layer is applied. The whole assembly is covered with a large vacuum bag - kind of like shrink wrapping - to provide uniform compression over the entire surface of the laminate.

Next, the gantry head is removed and replaced with a radiant heating element that is contoured to closely matching the curved characteristics of the laminate shape. The PLC stored program moves the element from a "home position" on the mold to every position on the laminate surface so that its emitted heat can cure the layers of laminate. Because the "shininess" of the lamination changes with the heat application, it is easy to see when the correct amount of heat has been applied.

Prototyping and Commissioning of the System

The software and mechanical engineering aspects of the process took almost one full year before there was a working prototype. During the prototyping, PLCs, PROFIBUS modules, and all the sensors were added prior to the purchase of the industrial PC. The engineering staff was pleasantly surprised when the computer's initial setup screens (run via Windows-NT) detected the PROFIBUS, found all the devices, and configured itself to work with the devices "right out of the box." Thereafter, the final commissioning went very smoothly.

A duplicate computer, PLC, PROFIBUS configuration is maintained in the company's development lab. Simultaneous work can be done to refine and troubleshoot the system without interrupting the manufacturing process. Once changes to the system are determined to be needed or to provide additional enhancements, the programs can be communicated to the PLCs on the manufacturing floor.

Conclusions

Starting with the right sail shape is just the beginning. The trick is to hold that shape. Selecting the right materials for the sail composition is paramount, but equally important is the manufacturing procedure by which the sail is constructed. Conventional sails fabricated from sewn panels of material have inherently weaker areas along the seams. One-piece sails fabricated on articulating molds overcome this weakness.

Computer technology and high-tech prediction and modeling software programs have provided critical tools for designing faster sails. However, these tools are diminished in effectiveness if the manufacturing process fails to accurately reflect the design with precision accuracy. The articulating mold process pioneered by North Sails Nevada is the first process to fully marry the design process with the manufacturing process. The racing successes of its clients who are using the sails are a testimony to effectiveness.

Product Information: Siemens Automation Products