Spirit Aerosystems using predictive maintenance and retrofit to keep gantry mills flying

Systematic predictive maintenance and controls upgrades yield big results in cost-savings and productivity for this leading aerospace contractor

In the face of these economic times and the resulting budget tightening, many aerospace component suppliers are seeking ways to improve their productivity and bottom line results. At Spirit AeroSystems in Wichita, Kan., a primary supplier to Boeing and other aircraft builders, the strategy to accomplish those goals has been in place for decades. Ed Fenn and his team of retrofit/machine shop specialists are among the many reasons for this situation. Through a systematic predictive maintenance program and continuous upgrades to the controls, motors, drives and other components on the huge multi-axis gantry mills that produce many of the structures here, Spirit has realized substantial productivity gains without the capital investment of new machine tool purchases.

Under the direction of Fenn, the facilities manager for retrofit/machine shop operations, over 275 retrofits of various machine tools have been performed since Fenn helped establish the group, shortly after joining Spirit (Boeing at the time) in 1982. As he explains, "I was at Sony for 5 years and saw the way they operated, with an ever-watchful eye on process standards and quality. When I joined this company, Boeing had the Continuous Quality Improvement (CQI) in place, which gave me further insights into the methods we could employ to get more systematic in our machine evaluation processes." Fenn proudly refers to the evolution of that process as "a lump of coal becoming a diamond, which is what our company's process has become today."

He further details the process as a ground-up standards development, beginning with the key people on his team. Rich Henley, lead mechanical technician, and Mike Spencer, lead electrical technician, along with Ed's assistant, Nicole Jay, keep the process as streamlined as possible. Every retrofit planned or in progress and every machine tool in the facility, approximately 575 currently, is monitored under a predictive maintenance program. Through this program, all machine parameters of wear,

Spirit welding shop where various support structures are fabricated

Cincinnati gantry mill produces long aero structures. This machine has been retrofit several times

uptime, routine maintenance and even environmental impact are closely monitored, with an eye on the day when a planned retrofit or complete overhaul of the machine will be required. By doing this, Spirit has conserved millions in new capital expense, while actually improving the performance of its machine tool fleet.

Several Cincinnati (now MAG/Cincinnati) gantry mills are key to the manufacture of the large metal aircraft components, as well as materials handling structures such as nacelles, which are also made in-house at Spirit. Originally equipped with Siemens ACRAMATIC controls, the forerunner to the advanced SINUMERIK 840D CNC platform that is now used on most of the machine tools here, these gantry mills machine the majority of the metal parts made, primarily from various grades of aluminum, titanium and tool steels.

"Because we have periodically upgraded our machine controls, along with the motor and drive packages, gear boxes, spindles, encoders and column structures on our gantry mills, we have tracked better productivity numbers on all of them," Fenn explains. "This is the result of newer controls, which have faster processing speeds, as well as the higher accuracy positioning drives, linear motors and encoder technologies we utilize. To be honest, we ask very little from our suppliers, as we maintain a substantial data base of information on all available technologies."

To further increase machine accuracies, Spirit was the first company in the industry to run a NURBS control, which is the basis for Transformation Orientation (TRAORI), the machine tool process that allows the highly precise volumetric compensation machining, so critical in aerospace part production. Since the typical machined metal part in this industry has few, if any, straight lines, there is a continuous need for extremely accurate, five-axis simultaneous transformations across the workpiece surface. This ensures a to-spec part with acceptable finish characteristics, executed and monitored for accuracy in real time. Spirit led the way, according to Ed Fenn, in the implementation of this technology, on the machine tools here. Today, this type of technology is found on all the Cincinnati and Henri Liné (now Forest Liné) five-axis and six-axis machines at Spirit, all of which have been retrofit by the team here, some of them several times.

"On some of the largest machines at Spirit, such as our Brötje riveters, used to join the fuselage to the spars and ribs, all the axis and ancillary equipment control capability of the Siemens SINUMERIK 840D comes into play," Fenn said in regards to the power and flexibility of the CNC technology currently used for nearly all his group's retrofits. Other non-metal cutting equipment such as riveters, hydraulic presses and robotic materials handling devices equipment often get retrofitted with this CNC, as well as Siemens PLC's and other control gear.

In creating the run simulation programs for evaluation, Fenn typically uses online tools such as WebEx and pcAnywhere for monitoring and vendor communications. This enables his team to predetermine the best solutions for the machine and process involved in a proposed retrofit.

Boeing has been especially aggressive in encouraging its parts suppliers and machine builders to engage in the use of this technology for overall process improvement strategies. Since Fenn maintains all necessary documentation for each machine tool on the resident CNC, the individual operators can always access the documentation on any machine. This protocol further closes the loop on what Fenn sees as a critical requirement.

"Unless we have input from everyone, including the operators, the retrofit program would suffer. My team greatly benefits from knowing what works and what does not work on a machine, in every area, from the control set-up to the access ways surrounding the electrical cabinet and even the part fixturing," Fenn explained.

He demonstrated the result of this vital exchange on three identical gantry mills in one of the plants here. One of the mills was newly built, while another was retrofitted by an outside contractor and Fenn retrofitted another and his Spirit crew had done the most recent one, without external assistance. Crediting his team entirely, Ed noted the retrofit design work, component selection and "common sense solutions" employed in their work product were the result of this interaction between builder, control supplier, other vendors and especially the Spirit machine operators.

In process, there is also constant evaluation of the machine tool performance at Spirit. Through the onboard CNC, the VLAN and ICS protocols employed here, all machine parameters, including vibration and thermal characteristics, are monitored and entered into a data base for evaluation by the CBM team engineers. As an example, the stresses on even a simple component such as a way cover are monitored for predictive maintenance and eventual retrofit. In total, over 25,000 points are monitored throughout this 11,119,000 square-foot campus. "It is the dedication of the team that makes the system seem not as complicated as it is" Fenn observed, considering the entire monitoring process is done by seven techs in a fairly compact control room. As a side note, in that same room, Spirit also employs another Siemens development, the Apogee® building automation systems software, to monitor HVAC, lighting and campus-wide energy consumption, as part of the company's ongoing green initiative.

Total metrics off the Siemens CNC architecture, for example, are maintained by the campus-wide control system at Spirit, with constant monitoring of every aspect of all machine performance, conducted by a relatively small group of highly skilled IT technicians in the master control room. Monitoring of machining processes in real time is possible for further documentation of the machine's performance, as needed. This set-up has been especially useful in monitoring the newest technologies used at Spirit, namely, the composite fiber tape laying machines that build up the fuselages for the Boeing 787 and other aircraft structures made here. Spirit houses the fiber tape-laying machine running in a clean-room environment to produce composite sections for the aerospace industry. This massive machine tool required 610 cubic yards of concrete to be poured for the base. Then, the building was erected around the installed machine.

Highly sophisticated reliability and condition monitoring equipment is used on the machine tools throughout these Spirit facilities and has been for over 10 years, according to Ed Fenn. He worked with Siemens engineers in Germany, when Siemens was developing its now popular ePS system of predictive maintenance. This vendor sought out the input of customers such as Spirit, though the system Fenn currently uses is highly proprietary, dedicated and integrated for all the control platforms used on the various machine tools throughout the campus, including the new, recently installed and older legacy systems.

For cost comparison, the typical retrofit project on a large gantry mill at Spirit might run $1,000,000 or more, but that amount typically represents only about 30-40 percent of the cost of a new machine. According to Fenn, "We keep the steel and replace everything else," though he noted a recent retrofit of a Z-axis column on a Henri Liné five-axis machine required an investment of about 50 percent of the new machine cost. However, "The performance we are getting is every bit as good as a new machine's," he noted. Strategically, the Spirit retrofit team has a goal of making a machine work at peak efficiency for 10 years, following the retrofit, unless newer available technology or machine damage mandates an earlier date for repair or replacement of onboard components.

As a precursor to the retrofit process, the team here at Spirit might engage in a variety of ancillary studies or software developments, from adaptive control schemes for a CNC to the material composition of a poured concrete foundation for a machine base, done to enhance stability and reduce vibration. Fenn notes that the onboard control is the top priority in gauging obsolescence on any machine at Spirit. "The control technologies have progressed so far and so rapidly in the last 20 years that we would be foolish to remain in a fixed time mode for retrofitting any machine we operate here."

Following the initial studies, a comprehensive assessment of the retrofit versus buy value proposition is conducted. Upon the decision to retrofit, the team develops a procurement package and initiates the buys through corporate purchasing. The scheduling of offline time for a machine tool at Spirit is a major responsibility, as the building of an aircraft fuselage requires the precise integration of many departments working in concert.

All machines on the Spirit campus have a five-year plan attached, with condition coding tags built into the machine's controller. Once a retrofit need is determined, the facility service request (FSR) is submitted and a return on investment is calculated. As Fenn observes, "We generate much better machine evaluations because we constantly assess the performance and condition of all machine components."

When the budget is finally released on the retrofit project, Nicole Jay, Ed Fenn's assistant, prepares the flow chart for cost, time,

Ed Fenn of Spirit AeroSystems heads the retrofit group.

Nicole Jay checks process status on the retrofit control.

materials, labor, quality checking and the full turnkey project completion schedule for presentation to the 40-person crew of this department, who have weekly status meetings to monitor progress.

To support the retrofit operations, a machine shop, motor/pump repair shop, fabricating/welding shop, inspection area and massive materials handling equipment to transition machines through the shop constitute this fully equipped and highly-skilled metalworking department. Fenn says his team members pride themselves on their ability to work in the most complex hardware/software arenas, as well as the world of heavy metal machining and fabrication. They also recently devised a simple system of labeling I/O modules inside the electrical cabinets for easier and consistent identification on any machine tool at Spirit, simplifying a rather tedious job for their maintenance crew. Ed is quite proud of the team "spirit" fostered here.

This department is not only responsible for affecting the repairs and retrofits, but also provides all paperwork back-up, software validation, environmental impact data, alarm code sequences, product lifecycle management data and full maintenance record-keeping. Spirit has implemented Siemens WinCC SCADA software and OPC interfaces to the machine controls to support the internal MDA of the control-monitoring platform developed here and to bring more consistency to the HMI for the operator. Ed Fenn's team is constantly striving to find simpler solutions for the translation of condition tags to their work orders, he notes.

As is true throughout the aerospace industry, composites technology is rapidly making a huge impact on machine builders, shop operations and controls personnel alike. Spirit is no exception and leads the way in advanced composites build-up and machining, according to Fenn. Not surprisingly, his retrofit team also plays a key role here, because there is a 25-year-old Cincinnati machine tool functioning perfectly on hard metal components that support the composite structures, having been retrofitted with new a control system, coolant system, hydraulics and all-new operator station. Another Cincinnati machine is on deck for retrofit with new ways, racks, control station, accelerometers and pressure transducers. The retrofit team also retrofitted the first Ingersoll fiber placement machine, partnering with Ingersoll as this machine produced the first sections of the Boeing 787, a total composite fuselage except for the spars and ribs.

As final testimony to the merit of this unique group of individuals, the Spirit retrofit team was actually considered for outside contracting to other local aerospace companies, as Wichita is home to numerous world players in aerospace, all producing parts for the industry. Though these plans never materialized, Fenn says it gave his team a great sense of worth and accomplishment to know their work was so much admired by the other aerospace companies in the area. "There is no denying that it gave us all a little bit of extra pride in what do here."

Fenn concludes by observing, "We pull the talent out of people and we always learn from our mistakes. Our only limitation is our imagination and, when tempered with rules, a better system always results."

Completed fuselage awaits transport to Boeing.

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