*Application Story: Chiron/Turbocam*

# Five-axis Machining with Speed, Accuracy, Automation and Control...you can have it all!

As Rob Bujeaud, vice-president of manufacturing for Turbocam and its recently created high-production division, TAPS (Turbocam Automated Production Systems), explains, the company began with five-axis machining right from the start. "We perceived a market need for this type of service, where we could offer customers a complete turnkey package from engineering to application, software to machining programs, prototype to production runs, on a variety of complex parts. We began with a single machine and a vision in 1985. We believed that with ongoing integrity, investment and innovation, we could be successful in the market for the long run. Today, we make that scenario happen for our aerospace, automotive and commercial business partners, every day." Turbocam focuses its five-axis machining work on impellers, blades, blisks (bladed disks) and other mechanical components used in turbine engines, diesel engines, turbochargers, aerospace and power generation equipment, as well as medical devices such as heart pumps. The TAPS group does high-production runs, primarily aimed at the automotive sector, with similar work products.

Today, Turbocam operates facilities in Dover and Barrington, New Hampshire. The latter is scheduled for full production in the Fall of 2006. In both facilities, prototype and production work is performed on a variety of the machine tool industry's premier multi-axis machining centers as well as work cells created by the Turbocam engineering staff, headed by engineering manager Andrew Hussey.

The Barrington facility houses TAPS, at the core of which are recently installed work cells, each containing twin five-axis CHIRON Model FZ08KSM machining centers, fed by 250-capacity workpiece carousels and an ABB articulating robot. These work cells produce Type 2618 aluminum impellers for a diesel engine turbocharger. Andrew Hussey explains the machining process. "Aluminum stock is turned on CNC lathes and then loaded onto the carousels. The CNC onboard the machining centers, a Siemens SINUMERIK 840D, interfaces through our PROFIBUS network to the robot controller and the carousel to maintain the workpiece load/unload cycles on the machines. Each robot handles two CHIRON machines for virtually non-stop production, where the cells are programmed to run in fully unattended mode." As Hussey notes with considerable satisfaction, "We'd put our productivity curves up against any shop in the country." A large part of the success at TAPS can be attributed to the speed, accuracy, control and automation of these work cells, driven by the CHIRON machining centers, he says.

The Siemens SINUMERIK 840D CNC system offers a wide range of specialized functions for milling, drilling, turning, grinding and materials handling technologies. Its open architecture is said to increase productivity on the manufacturing floor, especially it he challenging segments of high-speed and five-axis machining.

The CHIRON FZ08KSM machine used in this application features a small 2.3 square meter footprint, fast chip-to-chip time of 1.9 seconds or less, rapid feed rate of 75 m/min, acceleration up to 2g, typical spindle rate up to 27,000 rpm, tool changes in 0.8 sec and, in this application, a two-axis NC rotary/tilt table, an ideal combination for the aluminum workpieces processed at TAPS, according to Hussey. The impellers run on these work cells measure approximately 4" diameter x 4" high and load/unload at the rotary table fixture via

**Above Left and Below:** CHIRON Model FZ08KSM five-axis vertical milling machines with Siemens SINUMERIK 840D CNCs are at the center of the work cells used by TAPS, the production group of Turbocam, in Barrington, NH. They produce diesel engine turbocharger impellers from Type 2618 aluminum, requiring many passes to machine the blades. Articulating robots feed workpieces from a 250-station carousel directly into the workpiece fixture on the CHIRON machine's rotary table.

**Above Right:** Siemens SINUMERIK 840D and SIMODRIVE 611U, the CNC and drive package onboard the CHIRON machining centers.

robot. Many passes are required to machine the impeller blades, so the speeds of the spindle, toolchanger and rotary table are all critical for optimum cycle time. Hussey also noted the advantages of the Siemens CNC and drive package, SIMODRIVE 611U, in this process. “The high speeds and five-axis movement can create non-linear machine motion that effects the accuracy of the cutting and the CNC/drive package helps to smooth out those kinematics. This is also an area where the CAMplete TruePath™ software compensates for non-linear machine motions.”

TruePath takes the APT or CL data as well as native CAM data such as MasterCAM .nci and OpenMind .pof and creates the CAM program, compensating tool path and communicating design intent in a manner comparable to a typical post-processor, with the added advantage of factoring the machine motions into the sequence. According to the developer, CAMplete Solutions, Inc., it provides everything needed to modify, analyze, optimize, simulate and post-process five-axis tool paths in a seamless five-view 3D environment. Tool path editing, vectoring, vector modification to avoid collision and machine over travel monitoring help to further reduce the time to first part.

While the actual run time per cycle is proprietary between TAPS and its customer, a diesel engine builder, Andrew Hussey comments that the reduction in run time exceeded 20%, compared to the production method and machines previously utilized for this application. He explains, “We track the production on every machine in the facility and compare the output by machine, by cell and by product produced. Since the materials we run vary considerably, it’s critical that we maintain these data, to facilitate the proper selection of machines for target projects. In the case of these impellers, we knew the CHIRON machines that we first saw at IMTS in 2004 and again at the 2005 EMO show were the answer, compared to other five-axis vertical milling centers on the market and even those brands in our shop.”

Despite the speeds involved, typical tolerances are better than +/- 0.002”. The vibration monitors, spindle accelerometers and laser position detectors onboard the CHIRON machines further aid in maintaining the extremely high accuracy on these complex milled parts. A custom washdown kit is installed on each machine, as the intricacies of the part make a total elimination of chip migration essential for process integrity.

The Siemens 840D with onboard ePS network server also monitors tool wear and overall machine maintenance, with WI-FI e-mail capability directly from the controller to CHIRON America in North Carolina as well as the machine builder’s factory in Germany.

Parts are checked on an in-house five-axis CMM at TAPS, before they are released to the customer.

As a unique collateral benefit to the work cell design at TAPS, there are heat exchangers on the fluid processing system that feed into evaporative coolers outside the building. The captured energy is also used to heat the walkways during the cold New England winters. The entire design and engineering work on this system was achieved by company personnel.

Regarding the overall operation of the machine controls, Andrew Hussey notes his operators and application engineers like the speed and the flexibility of the Siemens CNC, even compared to other brands in the shop. Hussey


**Left:** Touch probe validating dimensions on the finished product.

further notes that the open architecture of the CNCs onboard the CHIRON machines make them extremely adaptable to changes, auxiliary equipment add-ons and the attendant monitoring/tracking of data required thereby. "The CNC has a great ability to process data and remain flexible enough to accommodate our various automation set-ups. In conjunction with the CHIRON machine technology, we're getting the best possible combination available for this application."

Hussey and Bujeaud detail how a typical job flows through the TAPS engineering department. "We take the design data, PRO-E model or IGES file, then create our engineering model. It rarely happens that we get a machinable model from our customer, unless we've created it at our parent company (Turbocam). We analyze the customer model to determine the proper surface integrity and curvature to reduce surface deviation, designing the three-axis tool path, as well as the two-axis rotary table movements. Tool path placement is the result of our TruePath software and internal Turbocam coding. With this "clean data," we determine the tool position and tool axis vectors in an APT format with XYZ positions in 3D space. The approaches and retracts are automatically determined in the TruePath software, which is a real time saver. We are able to do the first runout on the actual production machine much sooner than in the past and with much more predictable results. We're even able to simulate the execution of the program on different materials, using our existing performance databases. The TRAORI (transformation orientation) feature of the SINUMERIK 840D also gives us great control over the entire process, because it's based on workpiece orientation rather than tool position in a predetermined program. This results in a more consistent finish and less chatter on the surface of the material, an absolutely critical factor in these turbocharger components." Both Hussey and Bujeaud cited the on-site training provided by CHIRON, as well as the update seminars offered by CHIRON and Siemens, as factors in determining their selection as vendors on this project. "The training on the application, the software and the servicing of the machine were all first-rate."

Turbocam processes a variety of aerospace, automotive and medical grade materials, including aluminum, magnesium, nickel-based alloys, titanium, 304, 416, 17-4 and 15-5 stainless, HP1318 surgical and various tool steels, as well as plexiglass impellers for the medical industry. ■


**Below:** Turbocam Engineering Manager Andrew Hussey inspects the operation of the CHIRON machine.

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