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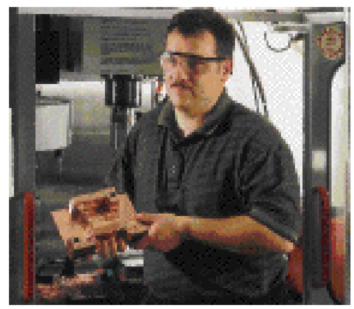
# The masters' rounds of metalworking

*High speed cutting helps golf club maker to score big*

Since introducing the first metalwood to the market in 1979, Taylor Made has become a leading supplier of golf clubs to the ever growing ranks of professional and amateur golfers worldwide. The company's corporate campus in Carlsbad, CA, features immaculately manicured putting greens, a driving range, and ultra-modern facilities for the 500 employees dedicated to shipping tens of thousands of superior quality drivers, metalwoods, irons, wedges, and putters each month.



**Jeff Blasius stands in front of a Haas VF-OE integrated with high speed machining software and an IBAG HFK-90 high speed spindle.**

In addition to the manufacturing, assembly, sales, marketing and executive staffs, the facility houses the industry's most enviable research and development, machining, and testing capabilities. Jeff Blasius, Taylor Made's senior tooling engineer, notes: "We can bring a club from a concept to a prototype to a proven product, ready for market, right here on our Carlsbad property."

One day, for example, Mr Blasius supervised the machining of a "master model" for the company's new Nubbins M6 putter. The club, like most others, began as a 2D drawing gleaned from a designer's concept. The engineering department added performance characteristics. A CAD designer then married both design and function to create a CAD model with predicted mass properties and performance variables.

From the CAD model, prototypes were cut out of stainless steel blocks. "At this point," says Mr Blasius, "we try the club out on our own putting green and give it to some tour players for feedback. How does it feel? Look? Handle? We get their input and make tweaks in the design. Once we're satisfied, we'll release the final results for tooling. This is the same procedure we follow for irons, putters, drivers, for all our clubs."

**Building a master**

Club manufacture involves the "lost wax" investment casting process that has been around for centuries and is still used in the jewelry industry. The process begins with the machining of what Mr Blasius refers to as a "master model." It looks just like a golf club head only that it is machined out of copper or aluminum and is slightly oversize to account for shrinkage in the casting process.

Master models are sent out to Taylor Made's casting vendors, where they are used to create composite epoxy molds. Wax is injected into the epoxy molds. After parting, the result is a wax model of the golf head that incorporates all the features of what will ultimately be the final club.

The wax model is then dipped in a ceramic slurry that is allowed to harden. It is dipped again into another slurry that is a bit thicker. This dipping-and-hardening procedure is repeated for up to five days. In the end, the ceramic is heated and the wax poured out, leaving a hollow ceramic shell that has the detailed shape of the golf club head on the inside.

Now, molten metal--for Taylor Made it is titanium or stainless steel--is poured into the ceramic mold. After the metal cools and hardens, the brittle ceramic is tapped and broken off. The new club head has various molding runners, trees and gates cut off and then it is polished, typically by hand. In the case of metalwoods, the sole plate and body are welded together and the weld is ground and buffed.

All club heads are masked, painted with special enamel, cured and baked. The heads are then attached to shafts and undergo Taylor Made's stringent balancing, testing, and quality control procedures. The clubs are carefully packaged and shipped.

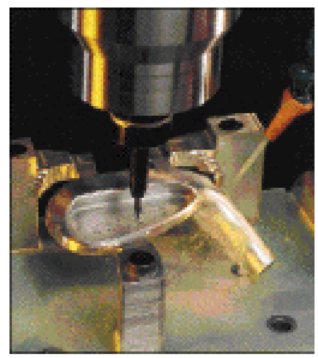
"It is important to remember," says Mr Blasius, "that it takes about 10 days of dipping, polishing, and finishing to bring each club to completion. Every club is skillfully crafted for performance and design aesthetics. But, they all begin with the 'master models' in our machine shop."

**A matter of perfection**

Considering that there are five or six dozen current Taylor Made club offerings at any given time, with an extensive range of loft, lie, and styling differences, the demand for a steady procession of master models is acute. There are 11 different models of Nubbins putters, for example, with more models in the design phase. A master model is required for each model, for each vendor. Some club heads are dual- or even triple-sourced, requiring a master model for each source.

Molds typically can run 10,000 to 20,000 shots before they need repairs or replacement. A master model can be reused many times over to make and repair the molds.

"Every master model must be perfect," says Mr Blasius. "Any errors, imperfections or blemishes on the master could conceivably, if not caught, be repeated on tho usands of clubs. We also have the time factor to consider. Between prototyping and making the master models, our machining department is under pressure from the marketplace to achieve higher and higher productivity while maintaining very demanding quality standards."



**Engraving a master model for a new club head is done on a Haas VMC with IBAG's "Plug and Go" spindle.**

About a year ago, Mr Blasius brought the principles of high speed machining on-line in his department to help reach this productivity requirement.

"For a putter like the Nubbins Model M6," says Mr Blasius, "we would need about two hours to finish machine the master model and another two hours for hand work after machining. With hundreds of master models and prototypes coming through here, reducing our per-part time, if substantial, would be a tremendous benefit."

Mr Blasius had been doing his homework in the technology marketplace. Dedicated machines were not the answer, since fast part changeover was essential.

"It wasn't about buying more machines and it wasn't about working harder," he says. "It was about working smarter. I like to adapt and adopt the best technologies for my dollar and for my hour. High speed machining seemed the way to work smarter. "Getting high speed spindles and high speed control systems without giving up the versatility of the machines we had became the obvious conclusion."

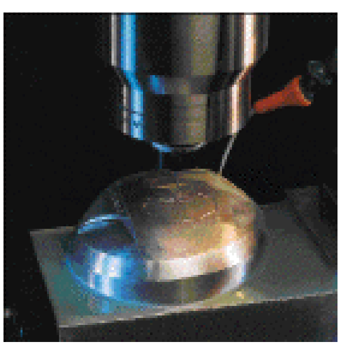
**Spindle strategy**

His machining versatility includes six Haas vertical machining centers, ranging in model sizes from VF-OE to VF-4. Looking to the high speed spindle arena, his own research directed his attention to IBAG North America in North Haven, CT. Back-and-forth applications discussions led to his purchase of an IBAG 3-hp model HFK-90 "Plug and Go" spindle that delivers 40,000 rpm.

"A far cry from conventional speeder heads," he says, "the HFK-90 is a complete high speed spindle system with its own electric drive motor and supply cabinet with power, lubrication, and cooling sources. What's especially good for us is that it has a CAT 40 taper adapter so I can plug it into the main spindle of any of my machining centers--a VF-OE, the VF-4--wherever the high speed spindle is needed, I can just 'plug and go,' the way IBAG said I could."

The spindle system was originally integrated by IBAG on one of the Haas VF-OE VMC's with a Creative Evolution control system developed for high speed machining applications. Since then, Mr Blasius has had the rest of his Haas VMC's upgraded for the IBAG spindle with Haas' own high speed machining software.

Using a standard two-flute, solid carbide, 0.25´´ ball mill, Mr. Blasius finish machines the M6 putter master model at 40,000 rpm and with a feedrate of 200 ipm. Previous to the high speed spindle, it was done at 10,000 rpm and 50-ipm feedrate. Finish machining has been cut from two hours down to 40 min.



**Though the single flute tool is only 0.008´´ dia at the tip, the company rarely breaks a tool.**

"What's equally impressive," he says, "is the finish achieved at the higher speeds. Hand work, which had taken at least two hours, is now done in 20 min. We've tightened up our stepovers with the smaller tool, tightened up our tolerances, and get a much better finish over the entire copper alloy master model."

**Beating a handicap**

Another key operation involving these master models is the engraving that identifies the club model and puts in the Taylor Made logo with any other design markings called for. Here, a tool with a solid carbide shank that tapers to an 0.008´´ dia tip with a single drafted flute is used in the HFK90 spindle.

"Dialing in the tool geometries is very important," says Mr Blasius. "We do our engraving at 40,000 rpm. Because of the exceptional rigidity of the IBAG spindle, we rarely break a tool. Before, we sent this work outside along with handmade templates. It was costly and very time consuming. And if we had done it here, in-house, we'd have to 'worry' the metal off very slowly with a conventional pantograph milling machine."

Even prototypes have seen a change for the better in terms of manufacturing speed and precision. Using a titanium aluminum nitride (TiAlN) coated cutter, stainless steel prototype club heads are cut "dry" with the IBAG at up to 20,000 rpm and 150- to 200-ipm feedrate without tool breakage and with excellent results, according to Mr Blasius.

"Machining time is no longer a handicap to productivity," he says. "Our task is to approach high speed machining with the thirst for knowledge and the commitment to the process that we have for every new technolology. At Taylor Made, we are doing just that. Everyone here is onboard. It is no longer a question of 'Do we use high speed machining?,' but rather, 'To what level can we take this capability?'"

**For more information from IBAG North America, North Haven, CT, circle 399.**
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