



◀ Ron Woodard measures a modular fixture at Toro.

Modular fixturing helps Toro's prototype welded assemblies-and their final manufacturing process-all at once.

By Tom Beard

Look at the pictures in this article and you'll see a lot of modular welding fixturing with a portable coordinate measuring arm in the middle. But the real story here is about welding prototype assemblies in a way that closely emulates the actual production process. At the Toro Company (Minneapolis, Minnesota), this technique allows product and process to be developed concurrently which, in turn, dramatically reduces the time and expense to get new designs into production.

You probably know Toro for their consumer products. Maybe you mow your lawn with one. But the company also makes a range of commercial products such as turf and golf course equipment, mowers with decks as large as 16 feet across, and more. Whether it's consumer or commercial work, Toro must be able to get new designs into field testing quickly, and they can't afford manufacturability problems when those products hit the plant floor.

The best example of how Toro executes this concept with fabricated assemblies can be found at the company's Tomah, Wisconsin, commercial products manufacturing facility. Across the street from the main plant is a product development center in which Toro fabricates welded prototypes. Where the welding workholders were once cobbled

together with little in the way of location references and the simplest of clamps, today they are made with precision modular fixturing that very closely emulates the performance of hard production tooling. And that's the difference between building a prototype that just proves out design functionality and one that proves out a manufacturing process at the same time. Here's how the Toro Company builds prototype welding tooling that performs just like the real thing.

Just Like Manufacturing

According to engineering manager Mark Schack, the whole product development process at Toro has undergone a major evolution over the last six years. Prototyping of chassis, suspension frames, deck housings and other weldments had progressed in a conventional manner. Design concepts were detailed, and then hand-built into working models used for functional testing only. After however many iterations were required to bring the working model to acceptable function, the design was finalized and turned over to manufacturing. Production tooling was built, and then a final pre-production test was run to see if the planned manufacturing process would deliver acceptable results in terms of quality and efficiency.

Sometimes it didn't. Shrink factors in the weld as well as thermally induced distortions in the overall assembly could be quite unpredictable at times. Extreme cases could necessitate further revisions to the design, modifications to the tooling, or both. At the heart of the problem was the conventional view that making prototypes was essentially a design function, separate and distinct from manufacturing, and that design development through manufacturing process development was necessarily a linear, sequential path.

Then they looked at it differently. "We began to evaluate pre-production versus after-production costs," says Mr. Schack. And the conclusion they came to was that if they could take a bit more care to develop prototypes within the context of how they could eventually be manufactured, they could head off a great deal of cost down the road. "If we could make prototypes like production parts," says manufacturing engineer Ron Ross, "we could make those changes earlier in the cycle, which is a lot less expensive than making them later on."

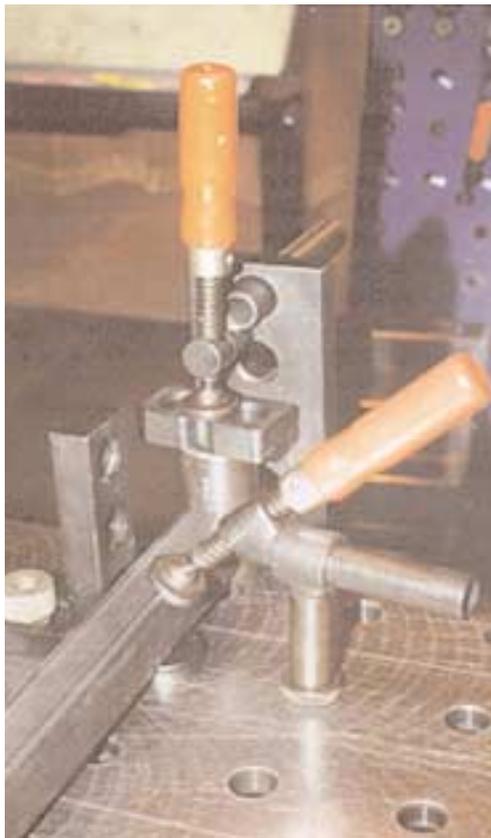
And so Toro began to scrutinize the way in which prototypes were fabricated. Typically, pieces to be welded were laid out on a common table top, positioned with C-clamps and at times even hand-held. It was a long, painstaking process that wasn't very accurate and that told them very little about how the assembly process might work in a production application. Or sometimes they could have suppliers produce prototypes that were beautiful specimens of TIG welding, but not the least bit representative of the MIG-welded parts that would be produced in their own plant, and thus unrevealing in terms of spotting very many potential production problems.

The answer for Toro was to find a means to tool their prototype welding in a way that would be representative of production welding, but that was also flexible enough to cost-effectively support custom manufacturing. Equally important, Toro needed a way to capture the valuable process information that was learned in prototype manufacturing so that it could be passed on both to the design function and to the eventual tooling manufacturer. And that's where the modular fixturing and portable CMM came in.

The Table

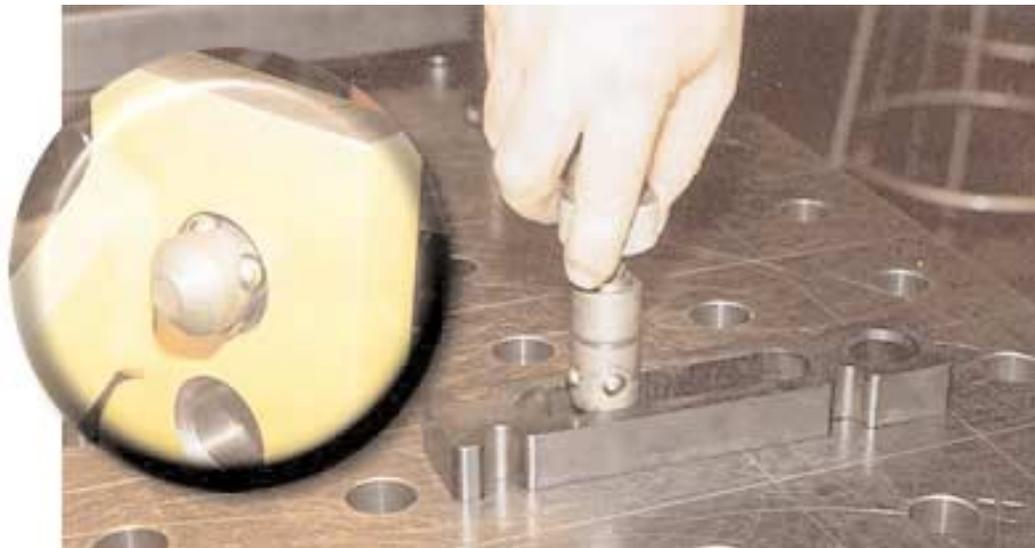
The central technical component of the prototyping process is what Toro's people simply call "The Table." More specifically, it's a Demmeler modular welding fixturing system, purchased from Bluco Corporation (Naperville, Illinois). Bluco, who is more widely known for their modular machining fixtures, is the U.S. representative of the German-made Demmeler modular system.

The system consists of a wide variety of reusable positioning and clamping components that are built up on a special worktable to suit the needs of a particular job. The 4 by 8-foot steel table (extendable to 4 by 12 feet) is manufactured with a grid pattern of mounting holes about 1.1 inches (28 mm) in diameter and spaced 3.9 inches (100



Clamps also slide into the table holes or in other modular components, and can be installed in seconds

mm) apart. Position of the holes are accurate to 0.0015 inch from one hole to the next, and 0.002 inch over the entire span of the table.



Ball-locking pins hold the modular workholding components in place.

The various fixturing system location and workpiece support components are affixed to the table with a rather ingeniously simple ball-locking pin. Rather than using a threaded hole, the table holes are straight bores with a chamfer on the bottom edge. The locking pin is simply inserted into a hole, and the cap is turned by hand. This action forces the balls out into the chamfer, pulling the pin snug. A hand tightening will hold fixture components firmly enough to maintain location for an initial layout position, and then a quarter turn of the cap with a hex wrench pulls the pin tight. To build fixtures, then, welding engineering technician Ron Woodard reviews the assembly drawing and then begins placing the various workholding components on the table, hand-tightening them in position. Typically, the critical positive location references are first established. Later he will position an array of clamps that also fit into the bored holes and that will be used to hold the workpieces in place. The tabletop does have an etched grid that helps facilitate the layout process. However, the holes do the same thing, with a true positive indication of primary location surfaces, and to a remarkably high degree of accuracy in the context of a welding process. Once Mr. Woodard is satisfied with the layout, he locks it all down and welds his first part.

The time it takes to build a modular fixture obviously depends on the complexity of the part. And Mr. Woodard sees a wide variety of jobs—from simple two-piece parts to complex assemblies with as many as 60 pieces. But for reference, for the setup pictured on the first page of this article, it took less than three hours to build the fixture and weld the first frame. To compare that to the old process,

says Mr. Woodard, they might be able to weld the first piece in a similar amount of time, but it wouldn't be very accurate. And the second piece would take the same amount of time, whereas with the modular fixture the second piece would take just minutes. Overall, says Mr. Ross, the use of modular fixturing in this fashion "cut welding time in half, and doubled quality."

Capturing Data

But the modular fixturing approach is about much more than just increasing the output of the prototyping department. It's also, now, about adding an element of control that carries through to production. That begins with an understanding of appropriate production processes, in which Mr. Woodard is generally well-versed. But he also relies on the support of

Ball-locking pins hold the modular workholding components in place tooling technician Jeff McGinnis, who is ultimately responsible for the design of production tooling. The two men often plan out new jobs together, and share the manufacturing knowledge gained from the prototyping process-information that Mr. McGinnis will also share with Toro's hard tooling supplier when the time comes.

It is right about here that the coordinate measuring arm begins to play a critical role. The portable "FaroArm"-manufactured by Faro Technologies (Lake Mary, Florida)- is first used as a tool to help with layout. Then Mr. Woodard uses the CMM to confirm and record the positions of all the critical location surfaces in the fixture setup. This data will

EMPHASIS: Fabrication



Ron Woodard verifies both the fixture and the welded workpiece with a table-mounted CMM.

prove extremely valuable when it comes time to build the hard tool- ing, or if it is likely that the modular fixture will need to be rebuilt somewhere down the road.

For the latter case, a template of the table has been created in Toro's CAD system. Moreover, the fixturing system vendor provides CAD templates of all the fixture components, so it's relatively easy to create a drawing of what ever is built. Mr. Woodard won't do this in all cases, but if he expects to rebuild the fixture, he'll document the workholder, sometimes with a full drawing and sometimes just with a digital photograph. That way, he knows the second fixture will be built exactly like the first.

Also very important, the CMM is used to measure the workpiece after the proto- type welding process is complete. That means Mr. Woodard can get immediate confirmation of whether the fixture and welding process are both delivering acceptable results. Having this documentation makes it much quicker and easier to work out solutions when the process needs to be improved because Toro has the means to expeditiously share the process and inspection data among all the people who can help solve a

problem. Consider, for example, a case where a proto- type has been welded, and upon inspection, Mr. Woodard finds that it has warped unacceptably. Maybe this problem can be solved with a tooling modification or a change in the welding sequence. But maybe it can't. Does it need to have a gusset added for greater support? Do some of the pieces need to be made out of thicker material?

And true to Toro's strategic objective, the product/production issue is identified well before any production tooling is ever built. The ability to achieve this objective is not just about technology, 8 though. To be sure, modular fixturing, ~ good inspection data and the electronic exchange of information are great tools. But the heart of the issue is getting the right people to focus on the right problems at the right time. And then, quite simply, they can work it out.

That last part is what's hardest for a lot of companies--the teamwork. And maybe it would be at Toro too, were it lot for a lot of open minds. "We couldn't do this without the support of the product development team in Minneapolis and the production team across the street," says Mr. Schack. That realization, among all the parties, is the most precious prototyping asset of all.

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