

# ShopWatch

## Hand Fabrication Still Cuts It

For many small manufacturers, the high cost of tool setup keeps them from offering cost-effective short-run production and new product development. But short runs can offer small manufacturers the ability to be competitive in today's business environment.

For example, Precision Metal Components (PMC) (Grover Beach, CA) specializes in close-tolerance, hand-fabrication work, and is known for deep-drawn, precision metal enclosures. PMC has produced parts for the telecommunications, electronics circuitry, and automotive industries, and has hand-crafted metal components for Trident and Stinger missiles and satellites and microwave communications equipment.

One manufacturer that has been using PMC's hand-fabrication services for the past ten years is LR Baggs Co. (Nipomo, CA). The firm manufactures electronic pickups and pre-amp equalizers for guitars and violins. Since most of their parts are small and very precise, and needed only in small quantities, LR Baggs found that hand fabrication work was perfect for their enclosures. "PMC helped us with the design and manufacture of enclosures for pre-amp equalizers, a variety of pickups, and, recently, with a double-barrel microphone and mixing devices," says Debbie Fletch, production manager at LR Baggs. "The double-barrel tube they make for us contains amplification electronics and attaches to a plug-in jack. We started with just a rough concept and they helped us design it and created several prototypes so we could see if it was a workable idea."

Recently, PMC produced pre-amp equalizer boxes for LR Baggs that required many intricate machining

procedures. Circuit-board controls had to be fed through slots in the piece. When completed, the top and bottom pieces fit together perfectly, allowing the controls to feed through precisely.

Not only is hand fabrication a cost-effective alternative to expensive pre-production tooling, but it gives companies requiring specialized shapes, bends, or notches the



ability to manufacture cases or other enclosures economically and quickly. In addition, hand fabrication provides the means to produce prototypes and prequalify components for first-article approval. PMC's work is produced to very tight specifications since their military work must meet and/or exceed MIL-I-45208-A specifications.

"If a client tells me it needs to produce only 500 pieces of a particular part, and they don't want to pay \$4000 in engineering fees for tooling, I tell them not to worry. Our hand fabrication department can build the parts without creating tooling, and do it very economically," explains Tricia Brehm, PMC's general manager. "We can also do it in less time than it takes to tool and produce it on a punch press. It usually takes three to four weeks to complete most parts, depending on the quantities required."

An added bonus with hand fabrication is the ability to produce prototypes a client can use to test a design or to show clients. The fabrication company can work with a customer's supplied stock and blueprints to make odd shapes, step bends, or angles that would be hard to duplicate with assembly-line production. The fabricator shears blanks to size, folds the sides on a hand press brake, and sends them to the assembly department where they are either hand brazed or sent through an atmospheric brazing furnace. They can be hand soldered with silver solder, also. Finishing processes, such as powder coating, painting, and plating, are outsourced.

"We specialize in handling things that are unique and out-of-the-ordinary," Brehm says. "A client may want a container or enclosure to fit into an odd-shaped area, or they may need a stepped bend or notched corners to fit a particular area. We can do all of these things, and to very high military specifications."

Using equipment calibrated to National Bureau of Standards requirements, PMC's products must pass stringent quality control checks at every stage of production. In-line checks assure product specifications and construction to within  $\pm 0.002$  (0.05 mm) tolerances.

All product test results are tracked on computerized statistical process control (SPC) charts, allowing for quick reference to any quality assurance function within the manufacturing process. This provides the low parts-rejection rates that give PMC a reputation for producing high-tech, close-tolerance components for military and commercial applications. For more information on PMC's hand fabrication capabilities, Circle 180.

Weld signature irregularities were directly correlated with weld bead porosity in this process. In one test weld, a small contamination spot was placed in the center of the seam. Figure 6 shows the resulting weld.

The defective weld's signature (Figure 7) shows welding process instabilities as soon as the arc passes into the weld seam contamination, as it did in the fitup tests. Figure 8 is a zoomed-in view of the defective weld's contamination region that can be compared with the zoomed-in region of the defect-free weld (Figure 2) and, as in the fitup tests, reveals instantaneous arc instabilities resulting from weld pool perturbations.

Each test showed that the system's real-time monitoring approach captures process instabilities that are, in turn, tied to the gross porosity from water-based contamination.

### Analyzing the Analysis

It is important to note that in all the contamination cases, it was weld process variation that reflected porosity problems, not the average value of either voltage or current.

Each weld signature also indicates the process' average voltage and current, shown as the dashed red/white and black/white curves, respectively, superimposed on the real time signatures. When defect-free and defective weld averages are compared, there was little variation. Monitoring approaches that rely on low fidelity or averaged voltage and current data are insensitive to this type of process defect.

Similar results have been observed in other transfer modes including CV/GMAW globular transfer, CV/GMAW spray transfer, pulsed GMAW, and FCAW. However, the ability to detect porosity problems is tied to the underlying process' stability. In this example, the underlying process is a well-stabilized, short-circuit transfer mode. Process deviations due to contamination tend to stand out quickly and reliably from the regular process. System limits and margins can be reliably set to distinguish between the two. In other cases where the underlying process, or part repeatability, is more variable, instabilities from contami-

nation can be swamped and become undetectable. Other applications were examined in which even gross porosity was not reliably detected because of inherent variations in the welding process and the already unstable weld pool dynamics.

Fine porosity problems are, typically, undetectable. Porosity of this type bubbles to the surface after the weld pool has passed. Therefore, the arc itself, as well as the weld pool, is not disturbed and there is little or no effect on weld signature.

Oil-based contamination has been more difficult to detect in specific cases. At times, oil-based contamination seems to ionize or burn off and be less of a contaminating factor than water-based contamination.

In general, porosity issues are difficult to reliably detect. Each application should be rigorously examined to determine to what extent the monitoring system can identify process irregularities which are related to porosity.

For more information about this system, **Circle 371** on the reader service card.