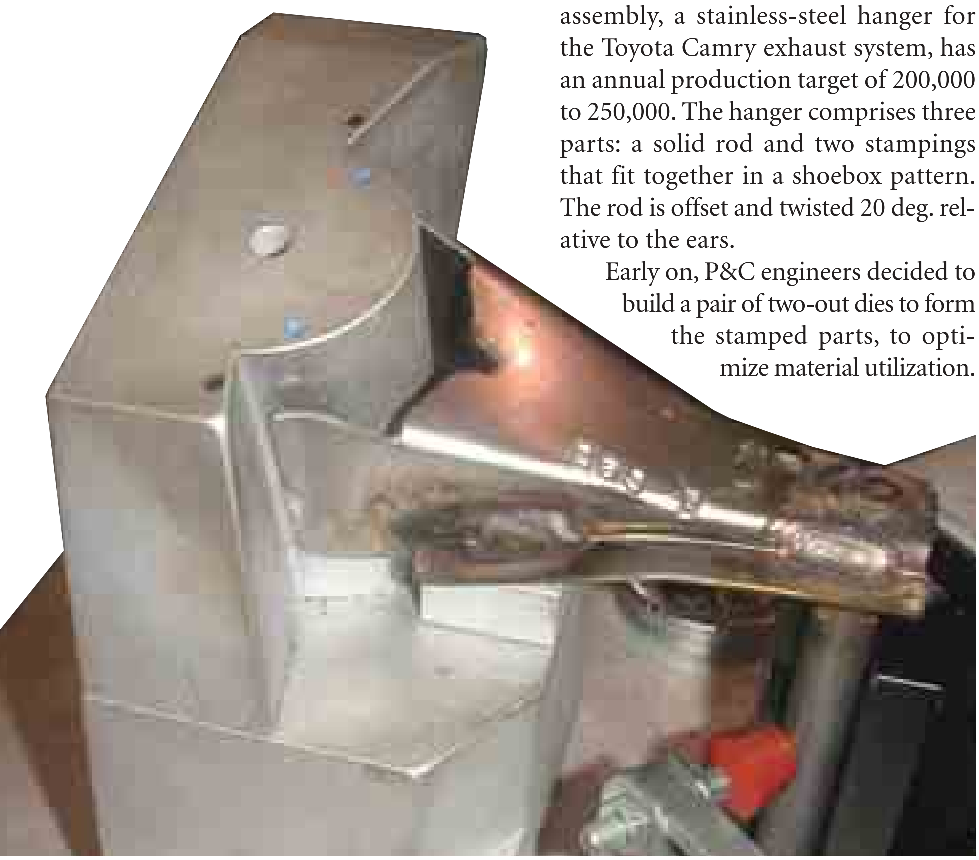
Die Development

Avoid Knee-Jerk Problem Solving

Metrology software helps a stamping shop's die detectives solve a unique automotive tooling problem, carving weeks from the troubleshooting schedule and saving thousands of dollars.

As Tier Two automotive supplier Pridgeon & Clay (P&C), Grand Rapids, MI, has evolved to handle an annual growth rate of 15 percent, the firm, a manufacturer of medium-sized stampings and assemblies, has seen a lot of new-part kickoffs. While the die-build and prove-out process for every part experiences bumps and hiccoughs, one recent subassembly created some interesting challenges and brought to the forefront some unique problem-solving tools and techniques. The subassembly, a stainless-steel hanger for the Toyota Camry exhaust system, has an annual production target of 200,000 to 250,000. The hanger comprises three parts: a solid rod and two stampings that fit together in a shoebox pattern. The rod is offset and twisted 20 deg. relative to the ears.

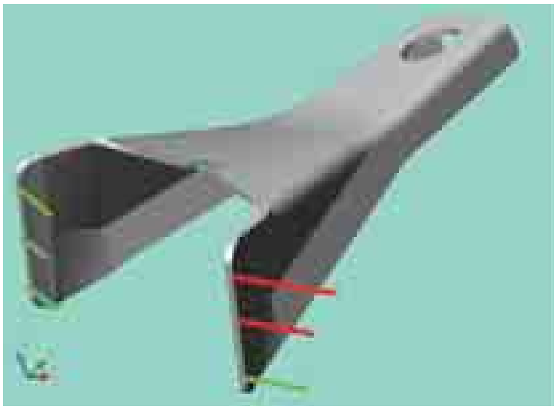


The hanger subassembly—a solid rod and two stampings—in the gauge. The rod is offset and twisted 20 deg. relative to the ears.

Early on, P&C engineers decided to build a pair of two-out dies to form the stamped parts, to optimize material utilization. However, the snug fit of the shoebox created problems for P&C and its die shop, Aggressive Tool and Die Inc., Coopersville, MI. The contract closed in December 2004, and one month later Aggressive went to work on the two dies. Concurrently, the P&C tooling engineer asked the customer, Arvin Sango, Inc., for permission to add a manufacturing hole to use as an interim datum to assess the level of process control for stamping and welding operations. Instead, Arvin Sango allowed a notch to be cut in the upper and lower shoebox pieces. While the notches did not affect the final assembly, they were used on the part gauges and weld fixture.

PPAP Done, All is Well, Right? Not so Fast

The manufacturing plans called for the dies to be built and then tested at P&C in Grand Rapids, then shipped off for production at the P&C facility in Franklin, IN. It took a bit of extra trial and error to move the part samples from the die shop run-offs to fit the gauges, but Aggressive had them ready by April 2005. All of the sample parts fit



This whisker diagram of the hanger subassembly indicates the direction and magnitude of dimensional deviation—red indicates out of tolerance, green, in tolerance.

the gauges within the specified tolerances. With Arvin Sango pushing for early delivery of a batch of parts for its setup runs, P&C completed its welding trials in Franklin, had the subassembly PPAP'd and trial parts sent off. At this point, everyone at the main plant in Grand Rapids thought that all was well. After all, the parts had passed the gauges and the subassembly had been successfully PPAP'd.

More than a month passed before an e-mail alerted Greg Dryer, the P&C tooling engineer in Grand Rapids, of a possible production problem. Ross Martin, P&C vice president of operations, was at the Franklin plant at the time, and learned of issues with the assembly during a production-review meeting. Martin immediately scheduled a hands-on run of the subassembly and saw that while some shoebox fits were just fine, most were too tight. Forcing parts onto the weld fixture and prying them off after welding might produce a few good subassemblies, but never would support production rates.

After some urgent discussion, P&C shipped the dies back to Aggressive and sent the weld fixture to its Grand Rapids facility. From the inconsistency of fit of the shoebox parts, it was clear that there must be a die problem; from the issues with the weld fixture, it was clear that changes would have to be made. Martin passed the task on to P&C measurement manager Bill Conway, who knew from years of experience that the knee-jerk reaction to a problem like this was to make five or six changes to the dies and try again. He also knew that this was exactly the wrong thing to do, and explained to Martin that he could not make any recommendations until he had performed a full analysis of at least a 30-part sample.

Metrology Tool Speeds Analysis

For the sample analysis, Conway's metrology team used CheckMate software from Origin Intl., Markham, Ontario, Canada. The CheckMate metrology application works with all types of dimensional metrology equipment. Conway assigned the detail work to Todd Carpenter, a senior metrologist on his staff, who prepared CMM programs to measure 30 parts pulled at random from a 700-part run, without needing a CMM holding fixture since CheckMate uses its SoftOrient system to free-state align the parts to the CAD program. From the automated CMM, measurements were loaded into the CheckMate Root-Cause Browser.

Carpenter started with the bottom half of the shoebox. This part has three datums: A–the flat surface, B–the hole for the rod, and C—the notch. Analysis showed that one sidewall was off on some parts by +0.2 mm and the other sidewall by -0.2 mm, while on other parts the pattern was reversed with the first sidewall off by -0.3 mm and the other by +0.3 mm. Normally, the response would be to grind one face of the die and weld the other. Carpenter checked with Dryer, the tooling engineer for the project, and found that the hole and the notch were both punched at the next-to-last die station–after all of the form and trim features had been finalized. They both knew from past successes in solving tooling problems that it is much cheaper and faster to move a punch than to change the form and trim steels. So, Carpenter used the what-if analysis capability of the CheckMate Root-Cause Browser to determine that the form and trim were precise and in control. The analysis also showed that if the punches for the datum holes were moved–by different amounts for the front and back sides of the two-out die–then these parts would meet specified tolerances.

Aggressive made the changes, bringing the parts into nominal within 0.1 mm. The cost of moving the datum punches: $300, with a three-day turnaround. To grind and weld would have taken at least three weeks and cost $600 to $10,000—and might have led to more changes.

Tool Tightening Up Next

Carpenter then started work on the top part, which proved a more difficult task. The ears, which for the customer were the most important aspect of the assembly, were, surprisingly, not part of the datum structure. Initial measurements of 50 parts showed the ears with a full millimeter of variation. The first change was to tighten up the tooling, to hold the piece more rigidly, at the datum punch station. This brought the variation down to 0.3 mm. For the next run of 50 parts, Carpenter used CheckMate to determine that the ears were properly oriented and the correct distance apart, but the notch datum was out of control. Once again, the form and trim were correct but the datum was wrong.

Fixing this issue was complex because of the twist in the part and because the notch punch did not strike normal to the plane of the sheetmetal. It took two more tooling iterations to adjust the notch punch correctly and bring it into control. Aggressive also had to readjust for a trim change that it had made during an earlier iteration. Ironically, this notch was added at P&C's request and was of no interest to the customer. Finally, one last change had to be made after the welding tests to compensate for one of the ears pulling inboard during welding.

A Customer Convinced

After making all of the necessary changes to the front and back of both two-out dies, P&C wound up with a process in control within very narrow limits—0.1 mm. Any final tweaks on the weld fixture were simple, and the part entered production.

All during this process, maintaining customer confidence while the experts resolved the problems remained a key concern. Again, CheckMate provided an assist. Dryer says, "With the diagrams, reports and tables from CheckMate at each step in the process, my work with the customer was easy. Its personnel could understand what was happening; see that our conclusions were backed up by good data; and see that we were on the way to a realistic solution. That's a far cry from the days of trying to convince a skeptical customer by waving your arms."

Software Affirms Tooling and Process Robustness

To successfully PPAP on time, every time, tooling must be robust and production processes in control and capable. This means that the GD&T analysis of all features—as-measured or best-fitted—pass and that all statistical analyses achieve at least their threshold values or better, typically Cp and Cpk > 1.67 (or Pp and Ppk in the case of a tool shop). P&C now uses CheckMate to ensure that tooling is robust prior to acceptance. It also uses the software, in many cases, to confirm that its production processes are in control and capable before giving a green light to full production.

Says Conway, "Gauges work fine for attributes, and seven parts passing the gauge can get you a successful PPAP. But to develop a production process that is in control and repeatable, we need a production run of at least 100 to 300 parts, with a sample of 30 to 50 parts, fully measured and analyzed—by that I mean run through a CMM and analyzed in CheckMate."

P&C also uses CheckMate to evaluate a variety of what-if scenarios without having to reset and remeasure parts. It can assess the impact of best fitting just the form, then form and trim together, and finally best fit for form, trim, all of the holes and slots including the datum features. Usually it can determine the best solution within hours and make changes the same day, not after weeks of trial and error. P&C then can communicate the corrective-action plan throughout its organization as well as to the tool shop and to the customer rep. Further, to simplify the required changes to tooling, CheckMate's results and corrective actions are presented in both car-body as well as die coordinates. **MF**

Article written from information supplied by Origin Intl. Inc., Markham, Ontario, Canada, 231/788-4176; www.origin.com.