Take full advantage of the benefits derived from lean manufacturing by engineering quality at the front end of the process—in the die—rather than at the back end, where scrap and rework can eat you alive.

In-Die Inspection

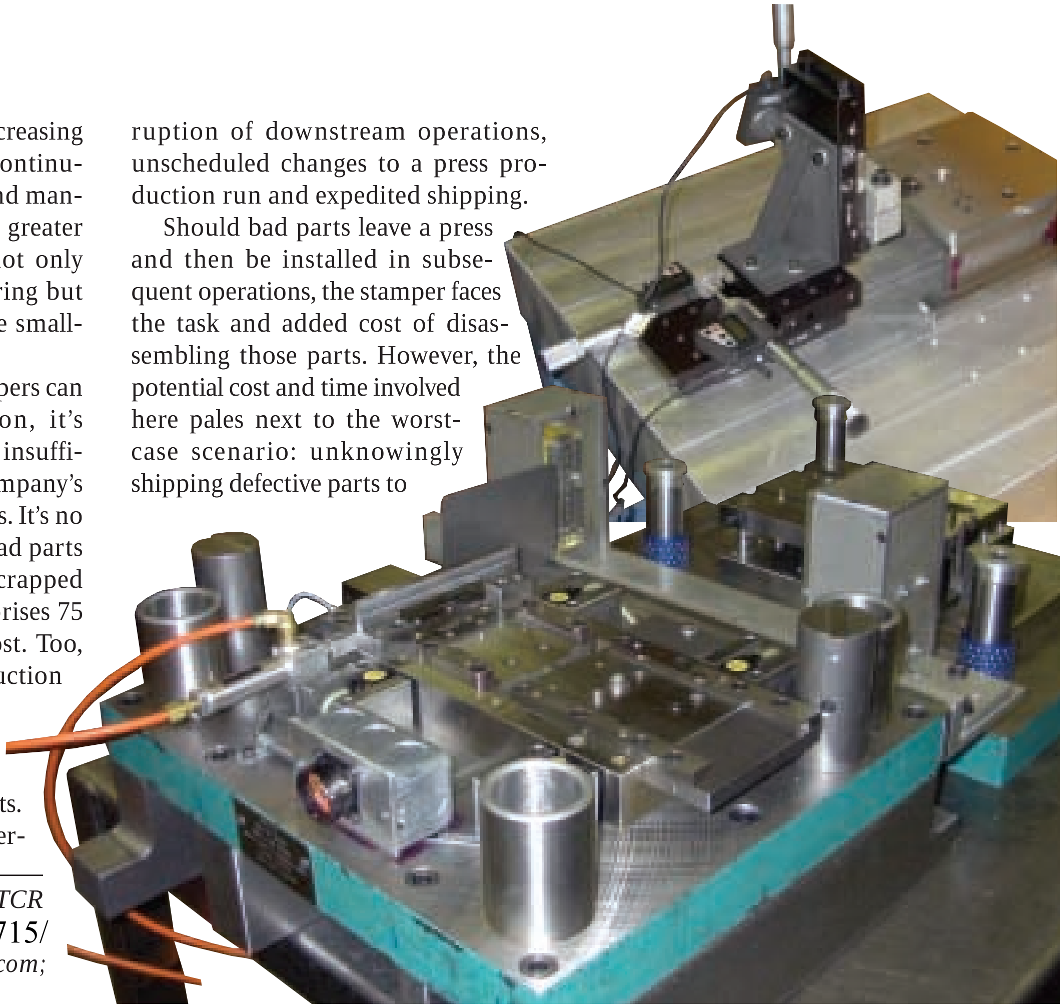
A Practical Approach to Complement Lean Manufacturing

BY TODD WENZEL

As stampers face steadily increasing competition, the need to continually improve part quality and manufacturing efficiency takes on greater emphasis. In-die inspection not only complements lean manufacturing but assists with efficient, profitable small-batch production.

Before examining how stampers can incorporate in-die inspection, it's important to understand how insufficient inspection can affect a company's overall manufacturing processes. It's no secret that the production of bad parts can carry a heavy pricetag. Scrapped raw material alone often comprises 75 percent or more of a part's cost. Too, costs associated with the production of bad parts can increase significantly when additional labor is needed to carry out tasks such as sorting out defective parts. Other costs may result from interruption of downstream operations, unscheduled changes to a press production run and expedited shipping.

Should bad parts leave a press and then be installed in subsequent operations, the stamper faces the task and added cost of disassembling those parts. However, the potential cost and time involved here pales next to the worst-case scenario: unknowingly shipping defective parts to



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the customer and putting your company's future business at risk.

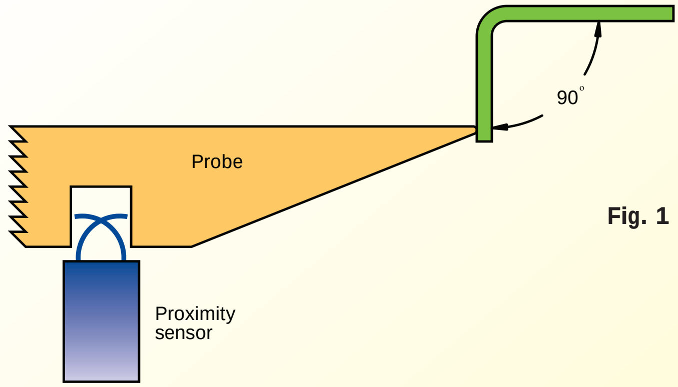

Fig. 1

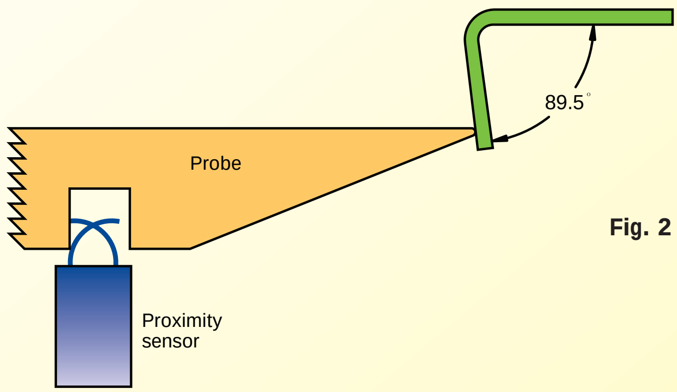

Fig. 2

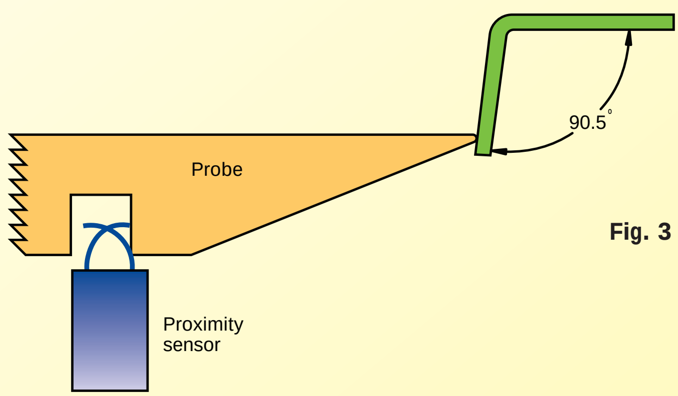

Fig. 3

Detect Bad Parts Immediately

The further a defective part travels through the manufacturing process, the more expensive it becomes for the stamper. In-die inspection helps stampers detect bad parts immediately, allowing them to minimize costs associated with production of defective parts.

Typically, though, when stampers hear the term "in-die inspection" a number of things come to mind. Many feel that implementing such a practice is extremely costly, requires electronics expertise that their company's personnel lack or requires the purchase of expensive analog process-monitoring equipment for presses.

Surprisingly, for most applications, in-die inspection represents a modest investment, especially when compared to the cost of producing scrap. Some simple checks can cost as little as $1000 for a given die. Also, most in-die inspection doesn't require a tremendous amount of electronic knowledge. In fact, the most technically challenging skills needed typically reside within the repertoire of any good toolmaker.

Finally, a surprising number of inspections can be performed with conventional digital die-protection equipment. Many stampers already use digital systems to prevent tooling damage, and in many instances could harness their existing equipment for the additional benefit of part inspection. A short list of what can be checked includes:

- The presence or absence of a feature;
- Critical hole sizes;
- Force measurement of critical die processes;
- Critical hole locations;
- Radius inspections;
- Form angles;
- Material-thickness measurements;
- Threads after tapping;
- Presence of taps;
- Distance between two features; and
- Form heights.

Analog vs. Digital

Having identified a basic checklist, it's important to establish a simple definition of digital and analog output sensors. Digital sensors have a common characteristic that makes them "digital." Here, we'll focus on a proximity sensor, the most typical application in stamping jobs. We'll ignore sensors that monitor temperature, pressure, etc.

The common characteristic of digital sensors is their ability to indicate if there is an object close enough to be detected—a simple yes or no indication. Because output is limited to just these two possibilities, they are called digital sensors. Conversely, analog-output sensors have the added ability to provide a measurement that indicates how far an object is from the sensor.

With these differences in mind, it becomes easier for the stamper to evaluate the type of sensor and the kind of inspection a particular job requires. Using the example of an angle formed to within a specified tolerance, the following discussion outlines the inspection steps using a digital sensor. The example's hypothetical part: a 1-in.-tall formed piece with a required angle of 90 deg., ±0.5 deg.

If the stamper requires only a Go/No Go check to see if the part meets dimensional tolerances, he can rely on an inexpensive digital sensor tied into a standard die-protection unit. To accomplish this, the toolmaker must construct a simple spring-return metal probe driven into contact with the formed part by the closing action of the die. He machines a notch in the probe, its width matching the width of the selected sensor's operating field and the allowable tolerance matching the range of motion the probe will move in the form angle. The probe will move between either extreme of the good part range of 90 deg. ±0.5 deg. The sensor mounts so that its sensing field falls precisely in the middle of the notch in the probe when checking a 90-deg. part.

At the bottom of the stroke, the controller will check the sensor to ensure that it detects the presence of the probe within its sensing field. If not, the part meets specification (Fig. 1). If the form angle is too small (Fig. 2) or too large (Fig. 3) the sensor detects the probe material, indicating an angle outside tolerance—a defective part.

This simple inspection allows the stamper to stop the press immediately, before producing additional defective parts. On a more sophisticated control system, the press can continue to run while automatically ejecting all defective parts.

When to use Analog

Self-adjusting tooling offers one example where using analog output sensors better suits the job. Rather than ejecting bad parts, self-adjusting tooling helps eliminate production of defective parts in the first place.

Using the previous hypothetical part example, we take actual position measurements of the spring-loaded probe. As the form angle changes, a servomotor adjusts the form station while the press runs. The adjustment brings the part back to the 90-deg. angle before it opens or closes far enough to become defective.

This type of closed-loop system, while more difficult than simple inspection and not too common, does find use in pressrooms. If the toolmaker has to install these types of precise sensor applications, whether analog or digital, he needs some specific test equipment that precisely maps the sensing field of a variety of sensors. These precise maps help the toolmaker identify which sensors to select before building the tool. He can then design the tool to accommodate selected sensors. As an alternative, the toolmaker can opt for the labor-intensive process of trial and error that requires testing each sensor on the die itself, after it has been built.

Test equipment includes such items as a three-axis positioning device; sensor interface panel to power sensors in the toolroom and indicate the sensor’s state; and a multimeter. A test bench for such work usually requires an investment of less than $10,000.

To ensure that the press stops when the sensor signals an out-of-tolerance condition, the press control must monitor the tooling sensors—commonly referred to as die protection. But in this type of application, it is really process monitoring, not just helping to avoid die crashes.

Simple digital die protection can be purchased for less than $10,000 per press from a variety of aftermarket control manufacturers. More sophisticated controls can be purchased from these same manufacturers with ever-increasing capabilities for high-end part inspection, process control and monitoring, and stamping-system automation. **MF**