Borescope inspection critical to vital manufacturing processes

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Four processes—metal machining, welding, casting and EDM—are key manufacturing processes for a host of industries: aerospace, medical equipment, automotive, heavy equipment, power generation and more. The evolution of these four processes has brought ever-increasing technological sophistication to the plant floor and to quality assurance. Borescopes, based on sophisticated and technologically advanced optical systems, are frequently manufacturers' first choice in inspecting mission-critical parts or components.

Borescopes play specific roles in visual inspection, roles dictated by the quality issues inherent in each manufacturing process, outlined below. A general rule applies, however. Rigid borescopes offer better resolution, brighter images and greater durability (and cost less) than flexible borescopes. When the option exists, rigid scopes are the better choice.

- EDM is frequently used for parts that have asymetrical geometries or small details that don't lend themselves to normal machining--fuel injector nozzles and hydraulic sleeves for instance. Visual inspectors of EDM'd parts or components are typically looking at the roughness of a surface--how well the material has been "melted" away by the electron beam. In these situations, rigid scopes are usually the tool of choice.
- Hydraulic systems, Aircraft systems, power-generation and chemical-processing systems, and pharmaceutical processing equipment all contain welds and welded tubes. Inspectors of welds usually look for weld continuity or strength at a heat-effected zone (HEZ). Most stainless steel tubing, like hypodermic needles, is made through the welded and drawn process, where the welded seam needs to be inspected for smoothness and integrity.
- Engine blocks, exhaust manifolds and turbochargers are often cast aluminum parts for automotive and some aviation applications. Voids and sand are the primary issues in casting visual inspection. In pressure die-casting, for example, air often mixes with the metal. As the metal solidifies, bubbles of air become trapped in the casting. Subsequent machining can open up any resulting voids and lead to surface irregularities or leaks. Castings often feature complex shapes that can require flexible borescopes for inspection.
- Machined parts such as brake manifolds or fuel injector bodies and nozzles, manifolds, valves, sleeves, cylinders and spools in hydraulic systems. Metal machining problems can include burrs, surface finish irregularities, contaminants and other defects.

In many instances, products and their component parts are made with more than one manufacturing process. Take turbine engines, the foundation of the power-generation industry. Turbine blades are complex castings; the igniter and fuel nozzles—part of the burner can—are machined parts; the burner can itself is a welded system. The following applications demonstrate that parts and assembled products both are candidates for borescopic inspection.

- A designer and manufacturer of engines, including turbo-shaft engines for helicopters, had a backlog of 3000 helicopter fuel control units needing inspection. Each unit required hours to disassemble and reassemble. By using rigid borescopes to inspect the units without disassembly, the firm quickly eliminated the backlog. It now uses the scopes for routine

inspection every 800 hours. The result is increased helicopter safety and reliability at a lower cost.

- A defense contractor uses both rigid and flexible borescopes to inspect hypergolic rocket engines. Inspectors look at mixing nozzles that mix fuel and look for pitting and scarring inside the missile thrust chamber. Another defense contractor uses both rigid and flexible scopes to detect foreign objects, contamination burrs and other irregularities in castings and machined parts and components like small detail castings, attach holes and more.
- Machinists that design and manufacture precision-machined automotive parts use rigid borescopes to check for burrs and imperfections in hard-to-see interiors of automotive-transmission turbine shafts. The scopes can see deep inside a part where a problem like an incomplete drill hole could cause catastrophic transmission failure. Scopes also help the plant's manufacturing engineers optimize the setup process, reducing errors and scrapped parts. They can now check parts as they come off the line to verify all the specifications. Catching problems early in the process cuts costs in time, labor and materials.
- A manufacturer that makes fitting for aircraft hydraulic systems had to reorganize its manufacturing processes after its largest customer refused to buy fittings with minor imperfections on internal surfaces. The company became a lean manufacturing plant with each work group responsible for its own quality control. Rigid borescopes deliver the needed clear, sharp views of interior surfaces and are sturdy enough for a machine-shop environment. Machinists also use the scopes to adjust their processes to further reduce flaws and keep the work on schedule. By putting the scopes into machinists' hands the company kept its customer happy and reduced de-burring man-hours while processing the same volume of parts as before.

A common theme among these applications often is fluid flow. Fuel, hydraulic fluid, water, oil, medication—the parts through which any of these vital fluids flow must be free of burrs and/or contaminants that can clog and limit the flow. The parts also must not have cracks through which fluid could leak.

The benefits of using borescopic inspection in the welding, casting, EDM and metal machining processes are numerous:

- Unlike destructive testing, borescopic inspection doesn't require tearing down and damaging an expensive part. Destructive testing in the aerospace industry can be particularly problematic because of the low volumes and high costs of parts.
- More and more manufacturers are instituting 100 percent inspection policies. The strict quality control is necessary because, in almost every instance, the parts are mission critical, and manufacturers want assurance that not one defective part will pass out of their facility.
- There is no substitute for the human eye and brain working together. The combination allows whoever's doing the inspection to identify and evaluate issues that other, more high-tech inspection processes like x-ray, machine vision, and eddy current simply can't. Inspectors can identify quality issues that are hard to pick up even on video. They can see color, texture and other qualities of a part or surface that aren't apparent with other inspection systems.
- As borescopes become more affordable, it is more reasonable for manufacturers to use them on the plant floor. The advantage here is time: They don't have to stop a production line to inspect a part in the quality lab, nor do they have to return to the floor to stop the line if they detect a problem. Manufacturing engineers or machine operators can test items right off the line, allowing for faster decisions on how to correct any

problems uncovered. Using x-rays to inspect the head of a car engine could take as much as 16 hours; borescopic inspection, just seconds.

- Testing techniques like x-rays and eddy current require trained personnel to operate the equipment and interpret the data. Borescopic inspection is easy to learn and requires minimal training. What inspectors see through a scope is usually easily recognizable, requiring no interpretation or guesswork.