The Role of Robotics in Computerized Shot Peening

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ABSTRACT

The use of computer-controlled robotic shot peening has increased substantially in recent years. This is particularly true in the area of improving the performance of highly stressed parts. Jet engine manufacturers are relying increasingly on robotic peening for life enhancement of critical components. The current trend in the design of high-performance fuel-efficient gas turbine engines is to incorporate improved, lighter materials for increasingly stringent operating conditions. To meet the performance requirements now demanded of these materials, almost all gas turbine engines rely heavily on proper shot peening technology to greatly enhance the fatigue life of the engine components. In many cases, the complex shape and precise peening requirements of these components virtually eliminate conventional peening methods. Automotive companies are continuing to appreciate the benefits computer-controlled shot peening offers for their highly stressed drive train components.

This growth in the use of computer-controlled robotic shot peening has been made possible because automation has allowed us to take the process from the laboratory to the factory floor. This paper will discuss the following key areas where significant improvements have been achieved:

1. Closed-loop control of the robot manipulation.
   - Quality predictability and improvement.
   - Cost savings in machine up-time, flexibility, and production rates.
2. Closed-loop control of all peening process parameters.
   - Part program down-loading from a host computer as well as using a bar code reader at the machine for part program entry.
   - Data logging for statistical process control.

KEYWORDS

Closed-Loop Control  Efficiency
Repeatability  Predictability
Flexibility  Statistical Process Control
CLOSED-LOOP ROBOT MANIPULATION

The use of computer controlled robots has allowed manufacturers to meet the ever increasing demands required of the shot peening process. Prior to the advent of robots, or multi-axes blast gun manipulators, the peening process was dependant on "hard" automation, usually with only one axis of gun movement at a time. This often resulted in either over-peening some areas of a part to assure full coverage in other areas, or under-peening of difficult to reach areas. At best, the peening specifications of many critical components have been compromised because conventional peening methods could not provide an even, consistent compressive stress layer over the entire part.

Also, since there is high reliance on operator "feel" in the setting and adjustment of the peening nozzles of a conventional system, much of the total production time of a complex part is spent in set-up rather than actual peening. Aside from the quality control problem of no two operators setting the nozzles exactly the same, many companies were forced to purchase several peening machines to process the same parts, due to the fact that "up-time" was so low. To accommodate all of the different impingement angles necessary to assure complete coverage, conventional peening systems require at least one nozzle per angle, often resulting in a very cumbersome, inflexible, and complex cluster of nozzles.

Robotic manipulation of the peening nozzle has allowed manufacturers to treat the peening process much like that of any other CNC controlled process, with absolutely predictable cycle times, peening results and cost-per-part data. With typical repeatability of +/-0.002" on linear axes and +/-0.5 degree on the rotational axes, a robot can follow the outside contour of a large part with a single nozzle in one program, and position a small, precision peening lance into difficult to reach holes and slots with another program.

Peening programs can be developed off-line with computer aided design and down-loaded to the robotic peening system. However, since most programmers and operators prefer to write a program by viewing the actual nozzle-to-part relationship, these programs are usually developed by positioning the robot through its desired path with a hand held teach pendant. A remote teach pendant allows the programmer to input data such as nozzle-to-part distance, impingement angle and travel speed directly into the robot controller and test the program from inside the peening cabinet. After the program is developed, it can be kept in the memory of the controller, read from punch tape or floppy disc or down-loaded to the robot controller through a DNC link with a host computer.

Program selection can also be accomplished through manual part number entry or be fed into the controller via a bar code scanner.

ROBOT SELECTION

Although there are many commercially available articulating arm and gantry style robots, few, if any, are properly suited for the demanding and unforgiving peening process. Due to the harsh environment in which the robot must survive, durability and reliability should be the main criteria in choosing a robot or multi-axes manipulator. All moving parts, both inside as well as outside of the peening cabinet, should be well protected and shielded from the abrasive atmosphere inherent to peening and blasting.
Along with being durable and reliable, a suitable robot for peening should be highly accurate, very repeatable and easy to program. It should also have a work envelope and freedom of movement sufficient to travel over the entire part(s) for which it is designed, particularly in the case of many jet engine components, where peening of both outside diameters and inside diameters of large, round parts is required. Conversely, since in most cases the part is either rotated in front of, or traveled past the peening nozzles, a high speed blast gun travel is seldom required. Typically, linear speeds of 150" per minute and rotational speeds of 720 degrees per minute are more than sufficient.

**CLOSED-LOOP PROCESS CONTROL**

Not only have robots provided a far superior method for blast gun manipulation than conventional automation, they have been instrumental in enhancing the entire peening process. With the precision and repeatability that a quality robot offers, manufacturers of critical components can be assured of proper coverage, saturation and intensity required in the peening specification.

Through the use of encoders on all the axes servo drives, closed-loop feedback on a real-time basis is constantly monitored by the robot controller. Continuous closed-loop monitoring and control of the media feed rate, compressed air pressure and air flow also contribute to provide a dependable peening system that can be left unattended cycle after cycle. Should one of the monitored critical systems fail, the program is immediately halted, eliminating any potential damage to the part being peened. Once the situation is rectified, the peening program resumes, assuring that the part is completely peened to specification.

All the critical parameters can be recorded on computer so that a documented history of each and every part can be kept on file. With this integration capability, robotic peening lends itself nicely to a singular machine application, or part of a multi-technology flexible manufacturing cell.

**CONCLUSION**

With an increasing effort in the aerospace and automotive industries to develop life enhanced products, more demanding and exacting peening requirements are emerging. Robotic shot peening equipment is an important and essential step in preparing for future process needs.