Justin Combs | Marketing Manager | Lambda Technologies

Low Plasticity Burnishing Extends P-3 Orion's Life Span

THE P-3 ORION turboprop aircraft has been in active military service for almost 50 years. These planes were developed to operate in the harshest environments and are used for surveillance, combat, cargo and research duties. The P-3 has seen action in Vietnam, Iraq, Afghanistan and Somalia. With a new focus on cost savings, the U.S. military has begun extending the required service life of its airborne fleet. By developing new technologies and maintenance methods, they hope to increase the lifespan of critical planes, such as the P-3, by 20 years or more. Until viable replacements can be developed, each year that a model can see continuous service saves millions of tax dollars.

The P-3 is commonly used in marine environments where it is exposed to corrosion pitting and stress corrosion cracking (SCC) damage that can initiate fatigue failures. The aluminum propeller bore is vulnerable to corrosion, and any cracking can quickly propagate due to high-cycle fatigue during the basic operation of the aircraft. Safe operation requires a rigorous inspection and repair cycle. The previous maintenance practice called for heavy shot peening, followed by reaming to restore the bore finish and re-machining operations to return the proper bore geometry for replacement of a bushing in the tapered section. The P-3 propellers were originally designed for unlimited service life. However, the loss of material during machining required the propellers to be scrapped after just three maintenance cycles.

To offset costs and viably extend the life of the P-3, NAVAIR, the Navy's aviation branch, began looking at other alternatives to shot peening that would reduce the scrap rate of propellers. They chose Low Plasticity Burnishing (LPB®). Developed by Lambda Technologies in Cincinnati, LPB induces a very deep, stable layer of compressive residual stress in the surface of a component. This layer of protection makes the piece dramatically more resistant to damage and can exponentially increase its fatigue life. The process works by rolling a high-hardness ball across the surface of the work piece to create beneficial compression. The ball is supported by a constant volume flow of fluid, preventing any chance of dragging or damaging the component. It leaves a mirror-like surface finish that facilitates inspection and doesn't require additional machining. Parts can be treated during manufacturing or after they have been in service and no alteration of the component's material or design is required.

LPB processing is performed using basic CNC machines or robots, allowing for quick and easy integration into shop processes. Pacific Propeller International (PPI) in Kent, Washington is now performing maintenance on the P-3 propeller bore for NAVAIR using a robotic LPB system. Computer control also guarantees repeatability and process regulation. The closed-loop LPB pressure control system adjusts the burnishing force in real time with precision exceeding Six Sigma quality requirements. Each part is tracked by serial number and SPC information is immediately available to quality control teams. Given the added benefits, PPI was provided with a new way forward for protecting the P-3 from corrosion damage.

"We are very excited to be working with Lambda, and look forward to the future," says Mike Johnson, General Manager of PPI. "Innovative solutions offered by Lambda will help us provide new levels of service to our customers."

The smooth surface finish left by LPB allowed PPI to eliminate the reaming and machining steps. This eliminates the need to scrap the part after three maintenance cycles and indefinitely extends its service life. At $35,000 per propeller, millions can be saved in cost avoidance after just a few years of implementation.

The new LPB method didn't just replace the shot peening process. The compressive layer was deeper and more uniform with LPB. In aluminum applications, like the P-3 propeller bore, Lambda is able to design a protective compressive layer that is deeper than the deepest corrosion pits. Because the material is held in compression to a depth greater than any pits can reach, crack propagation from pits is eliminated. The fatigue life of the propeller bore is dramatically extended as the process also mitigates cracking from stress corrosion cracking and high-cycle fatigue. The speed of processing was

also greatly increased, helping to ensure that the aircraft is available when needed. Performing the operation on just one machine also lowered the equipment footprint on the shop floor.

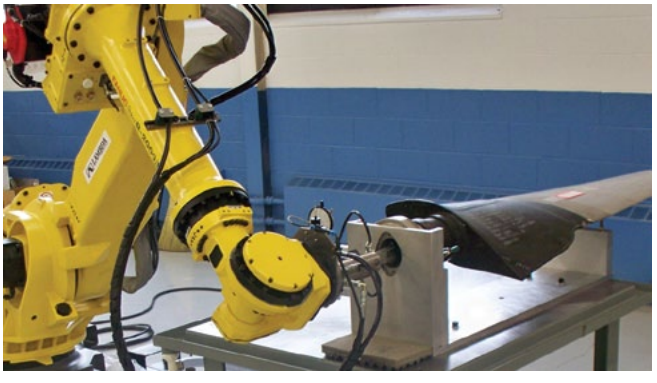
Lambda and NAVAIR took a novel approach to replacing shot peening with LPB by deciding to process the bore robotically. Complete turnkey robotic systems were developed by Lambda and installed at the PPI facility, along with two others at Cherry Point Marine Depot and Warner Robbins Air Force Base. These three systems currently service the entire P-3 fleet. The CNC programmable 6-axis robots combine control and flexibility in ways that more traditional setups can't match.

"The main benefits of robotic processing are control and repeatability. This system is completely closed-loop controlled. That allows us to verify absolutely that we've achieved what we set out to do, and using CNC robots allows us to do it exactly the same way every time," says John Cassidy, Project Quality Engineer at Lambda.

The P-3 propeller bore can be problematic to process. A six-axis robot fitted with Lambda's tooling is easily adapted to difficult or odd geometries, and the inside of a propeller bore posed no problem. Robotic systems are also not limited to one application. With a simple CNC code and tool change, they can very quickly be treating a component with an entirely different design.

The systems Lambda installed are a true "push-button" technology. The common interface makes the process easy to use and doesn't require extensive training on exotic machinery. Operators only need to load the part to be processed and start the procedure. There are no environmental or safety hazards, and LPB offers the logistical advantage that part need not be moved to a remote facility or different section of the processing plant. In some maintenance situations, LPB processing can even be performed in-situ, without removing the piece from service. LPB treatment is usually done in a matter of minutes, and systems can be developed to process multiple parts without the need for operator intervention.

The P-3 is not going away. Thanks to a determination to find new answers to old problems, this versatile and robust aircraft will continue to serve as long as it is needed. However, the benefit is not limited to just military aircraft, and PPI plans to expand its operation to offer LPB treatment to more of its customers.



Robotic Processing of the P-3 Propeller Bore