Inconel 713 Turbine Nozzle

NCDMM Project No. 03-0011-10

Technical Report

PROBLEM / OBJECTIVE

Technical Directions Inc. (TDI) in Ortonville, Michigan, was commissioned to produce a small jet engine for the Loitering Attack Missile (LAM). This system is currently being reviewed by the Army at Redstone Arsenal for use in the NLOS-LS (Non-Line of Site Launch System) system. TDI in turn enlisted Extreme Precision Screw Products of Flint, Michigan, to machine key engine components. The high-temperature materials used in jet engines present machining challenges that include limited metal removal rates and frequent tool failure. For a turbine nozzle made of Inconel 713 nickel-base alloy, Extreme Precision sought ways to increase productivity in drilling and turning operations and also overcome problems encountered when using taps to thread small-diameter holes.

ACCOMPLISHMENTS / PAYOFF

NCDMM created a "proof-of-concept" simulation using Predator verification software supplied by software provider, COM 1 Information Technologies, an NCDMM alliance partner.

TDI supplied NCDMM with Inconel castings so the proof of concept machining could take place on the actual material used in the nozzle.

Process Improvement

After analyzing the machining operations, the NCDMM recommended replacing the cobalt drills used previously with physical vapor deposition (PVD) coated solid-carbide drills. PVD-coated carbide inserts were suggested for turning processes. The tools permitted higher cutting speeds (surface feet per minute/sfm) and feed rates (inches per revolution/ipr). NCDMM also suggested milling the threads with high-performance PVD-coated solid-carbide thread mills. Unlike taps, thread mills will not jam in the hole if breakage should occur. Thread milling eliminated the need to transfer a nozzle to an electric discharge machining (EDM) unit to burn out a jammed tap, a process that can take eight hours or longer. Eliminating the workhandling and time for that secondary operation lowered overall part cost. The thread mills also reduced threading time and boosted productivity.

Implementation and Technology Transfer

A limited supply of castings has delayed full implementation of the NCDMM recommendations, but results to date are highly positive. They include an increase in metal removal rate in turning from 0.006 cubic inches per minute (in^3/min) to .014 in^3/min. Cutting speed was increased 50 percent, from 100 sfm to 150 sfm. The high-performance solid carbide drills enabled machining parameters to be increased from 25 sfm at 0.002" ipr to 70 sfm and 0.0025" ipr. Overall, machining time for the turbine nozzle dropped from 51 minutes to 31 minutes.

Expected Benefits

In summary, full implementation will produce:

- A 40 percent average increase in turning and drilling productivity.
- Elimination of tap breakage and the need to rework nozzles on an EDM unit to remove broken taps.
- Reduction in threading time from 10 seconds to 5 seconds (50 percent).
- A better understanding of the benefits of thread milling and high performance tools in the machining of high temperature alloys.

At an estimated machine cost savings per turbine nozzle of $20.00, savings in machining time alone over the entire intended production run of 20,000 engines will amount to $400,000.

TIME LINE / MILESTONE

Start Date ..... October 03
End Date ..... April 04

PROJECT FUNDING

NCDMM funding ..... $< 5K

PARTICIPANTS

Extreme Precision Screw Products
Com 1 Information Technologies, Inc.
NCDMM
Kennametal Inc.

For additional information concerning this project, contact the NCDMM at www.ncdmm.org