Automated Shot Peening

At the Munich, Germany, site of MTU Aero Engines (MTU), a production shot-peening machine was commissioned March 2000. It is used to peen aircraft engine parts with steel shot to compact their surfaces in a fully automated cycle. Surface compaction combats cracking induced by scratches and other causes and enhances the part's tolerance of stresses. This doubles and occasionally triples the life of parts. The items selected for shot peening generally are rotating, highly-stressed turbine and compressor parts. The shot-peening machine had been received in November the year before and then expeditiously installed, set up, calibrated and acceptance tested, after it had demonstrated its capabilities by processing test specimens at its manufacturer's, USF Schlick, Greven facility.

The shot peening process

The machine accommodates workpieces up to 800 mm in height and 1250 mm in diameter. These are centrally positioned and clamped in place on a rotary table which can be pivoted in and out of the peening chamber to facilitate the work. "We had wanted that turntable," said Stefan Schmid, who heads the peening and painting section at MTU's surface heat treatment and chemistry center. The machine's manufacturer then went ahead and implemented it. With the turntable, and the workpiece on it, returned to the peening chamber and the process started, noise levels remain below 75 dB (older machines make noises around 85 dB and operators there need ear protectors).

A pair of manipulators, one overhead and one at the rear wall, position the air jet nozzles horizontally and vertically. The nozzles additionally rotate and pivot, enabling the shot to reach the entire surface of these geometrically complex workpieces. Using two small 200 to 2000 g shot-a-minute nozzles, also slots and holes can be peened. Four other nozzles direct up to 8 kg shot a minute to the workpiece.

Computer-controlled shot peening

The CNC feature permits complete automation of the peening process. The computer stores programs for each of about 20 different workpieces. The operators are programming the peening processes themselves; once the program is running, they have time to attend to other tasks. The machine needs 6 operators to man three shifts a day, according to Schmid. These operators are qualified to work two or three different machines. A shot peening operation takes 10 minutes to 3 hours, depending on the type of work. Each workpiece is continuously peened all around. The machine handles up to 30 pieces a day.

The new machine uses three different types of shot, i.e. wire shot (CCW14) and cast shot (S110/S230) of diameters ranging from 0.3 to 0.8 mm. Changing the type of shot takes half an hour. Compare this with 5 hours to do the job on the older machines. Schmid figures that MTU saves more than 50 % of the work hours and about 40 % of machine time needed on conventional machines.

Reclamation of peening shot

The machine reclaims four different peening media separately. The used shot is extracted from the peening chamber through suction channels. A helical separator segregates spherical shot from out-of-round or fragmented shot, where the faster spherical shot rolls off in the outer region of the spiral and the slower out-of-round shot remains inside. A strainer sorts standard size shot from over- and undersizes before it is reused. Additional, the shot in use is routinely classified for size distribution and shape. "Reclaimed shot actually works better than virgin shot," explains Schmid, who estimates his section uses about 100 kg shot a month.

Continuous monitoring

The shot peening process is fully computer-controlled and completely documented. Depending on customers' instructions, the test records will be retained for durations of up to 20 years. To immediately respond to variations in peening intensity, as many as 120 so-called Almen test strips may be peened for a single production job (even if it only comprises of five or so parts). The machine operators do their own inspecting of the parts they peened.

"The process is often underrated," according to Schmid. "The strength of the parts depends on it 100%." The last time parts are thoroughly inspected is after shot peening; the operators are mavens in the field.

The peening and painting section operates another six shot peening machines for surface compaction. More than three quarters of the jobs processed there are coming in from the engine manufacturing and overhaul activities.

Modernize manufacturing processes, eliminate bottlenecks

The practice of shot peening engine parts to compact their rim layers has been in use for about 20 years. That about is the age, too, of MTU's oldest shot peening machines. For peening parts with geometries like those of the parts manufactured at MTU, there are no alternative processes available for production use; laser beam or ultrasonic compaction might be used to complement shot peening. At present, 90 % of the parts shot peened at MTU are for commercial engines; the military fraction will grow when the engine to power Eurofighter goes into production. It was not least because of anticipated Eurofighter uses that MTU bought the new machine.

MTU's capacities in the peening sector were running low. Also, the older machines required a tremendous fixturing effort. What Schmid wants is make the shot peening process more flexible, pinning his hopes on CNC techniques and machines offering minimal setup times. He dreams of integrating shot peening into production lines, which of course would require harmonization with other suppliers to the line, such as pretreatment or crack inspection. MTU's selection of USF Schlick for the job was to test a new machine supplier. "You seek new suppliers when you start reorganizing, not for the last machine you're going to buy," Schmid said. The peening section has just begun to restructure, and USF Schlick was able to provide the short delivery MTU needed. Plans are to add additional, comparable shot peening machines. The first of them is just ordered.