Application of Rotary Peening in Aircraft Maintenance

Douglas E. Earl
Technical Service Engineer,
3M Company, 3M Center, 251-A3-05, St. Paul, Minnesota 55144

ABSTRACT

Shot peening with the 3M Roto Peen method provides the ability to obtain the benefits of conventional shot peening techniques, but with a more-compact and more-easily used system than those usually associated with this process. The portability and simplicity of this system have led to its wide use in both aircraft maintenance and manufacturing areas. The 3M Roto Peen system consists of tungsten-carbide shot adhered to a rotating flap. The motion of the flap propels the shot into the workpiece producing beneficial surface compressive stresses. The 3M Roto Peen system can be used by adapting powered tools that are generally available in most manufacturing and maintenance settings.

KEYWORDS

Shot Peening
Hand Tools
Portable Power Tools
Aircraft Maintenance
Rotary Peening

THE 3M TC-330 SYSTEM

The 3M shot peening system was designed to provide the beneficial effects of traditional shot peening techniques in a convenient and portable form. As such, it has seen wide use in applications where the need for portability, restricted access, or production limitations made other systems not feasible. The 3M Roto Peen system consists of tungsten-carbide shot adhered to a flap of synthetic fabric (figure 1). The flap is placed in a mandrel, made specifically for this use, and the mandrel is then placed in the collet of a powered, rotating tool. When the rotating flap is brought to contact the work piece, the attached tungsten-carbide shot strikes the surface. Distance from the work piece is controlled so that the shot strikes the surface in a nearly-vertical direction.
Fig. 1 Roto Peen flap and mandrel

The mechanism of the 3M Roto Peen system is the same as that of traditional shot peening methods, in that shot is caused to strike a work surface and produce surface compressive stresses. As such, traditional methods of controlling and monitoring peening intensity can be used. With the 3M Roto Peen system, peening intensity is controlled by governing the speed of the tool that is used to convey the rotating flap to the work surface. An estimate of the correct tool speed is obtained by referring to charts in literature that can be obtained with the product [1]. As with other peening methods, peening intensity is measured indirectly by the Almen strip technique.

System Calibration and Operation

The first step in a peening operation must be to obtain a recommendation for the desired intensity that the operation is to achieve. In most cases, this information will be supplied by the manufacturer of the part being serviced and often appears on service drawings of the particular piece.

After the desired intensity has been chosen, it is necessary to select conditions that will allow this intensity to be achieved. With the 3M Roto Peen system this amounts to selection of the correct rpm for the peening tool. This information has been developed for the full line of 3M peening products, and is available in published form [1].

Verification of peening intensity (and adjustment if necessary) is accomplished by peening Almen Strips. The operation is similar to that used in shot blasting, but with a modification to the Almen Strip Holder, and an important adjustment in the
interpretation of the results. In the 3M Almen Strip Holder the screws used to secure the Almen Strip have been replaced by magnets (figure 2). This was necessary because it was found that the screws in the standard holder led to premature wear of the 3M Roto Peen Flaps. The magnets in the 3M holder are free-floating (over small distances), and so do not restrain the Almen Strip as much as do the screws in the standard holder. As a consequence, an Almen Strip held with the 3M holder will develop more curvature than will a strip held in the standard holder for the same intensity of shot blast. For this reason, it is necessary to convert from standard intensity to 3M intensity when the 3M Almen Strip Holder is used. Figure 3 shows the relationship between the two types of holders. As an example, a standard intensity of Almen 8 will require a 3M intensity measurement of 10. This information is also available in chart form [1].

![3M Almen Strip Holder](image)

Figure 2 3M Almen Strip Holder

Once the correct tool speed has been selected and verified the Roto Peen system may be used to peen the workpiece. This is done by bringing the rotating flap into contact with the workpiece with enough interference to cause the shot to strike the surface in a nearly-vertical direction. The tool is then maneuvered in a continuous and uniform motion to uniformly peen the desired area. The time to achieve complete coverage is approximately one minute per square inch of surface for each flap used. Complete coverage is verified by inspecting for saturation.
COMPARISON WITH OTHER SHOT PEENING TECHNIQUES

Much research has been done to compare the action of the 3M Roto Peen system with the results produced by traditional shot blasting techniques. The most straightforward comparison is to compare the pattern produced on the workpiece by the Roto Peen system with the pattern developed by other shot blasting techniques (figure 4). When this is done, it is found that it is difficult to distinguish between the surfaces of parts peened with the Roto Peen system and parts peened by other techniques. Most important, the pattern produced by the Roto Peen System consists of uniform and circular depressions. There is no evidence of elongated depressions that might result from the shot striking the part surface at an oblique angle.

Fig. 4 Surface Profile Produced by 3M Roto Peen
Compressive stresses along depth profiles have been measured for samples peened with the Roto Peen System through X-ray diffraction techniques. In this analysis a sample of 4340 steel (hardness of Rc 51) was peened to an intensity of 12 Almen A by both the Roto Peen System and by air blast peening. Depth profiles showed equivalent compressive stresses at similar depths for both techniques (figure 5).

![Diagram showing residual stress vs depth]

**Figure 5** Depth Profiles of Compressive Stresses

Functional comparison between Roto Peening and free shot peening was done through the use of an R. R. Moore Fatigue Test. This test compared the cycles to failure for rotating-beam test samples that had been through one of three different treatments—free shot peening, roto peening, and an unpeened control. These results showed comparable improvement in fatigue life for both methods of peening (figure 6).
Fig. 6  R. R. Moore Fatigue Test

Summary

The 3M Roto Peen System is an easily-used method to peen small or difficult-to-reach areas. It is readily adaptable to equipment that is available in most work areas, and can produce results equivalent to those achieved by conventional techniques.