Ricochet Peening

We recently received an email from an engineer with an aerospace manufacturer, suggesting more information on ricochet peening in The Shot Peener magazine. "There are many scenarios that require ricochet peening in industry," he wrote.

We shared the following research paper with him, and we agree. Ricochet peening is very common but little research has been done on intensity verification on ricochet-peened surfaces. It would be a great topic for the upcoming Twelfth International Conference on Shot Peening (September, 2014 in Goslar, Germany).

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Abstract
Ricochet peening may be used in cases where it is impossible to obtain complete visual coverage by direct impact. AMS-S-13165 refers to this as reflected shot stream. This study illustrates the influence on the shot stream reflected angle and impact intensity as a function of material hardness.

Keywords
Ricochet Peening, Reflected Shot Stream, Impact Angle, Ricochet Angle, Peening Coverage

Introduction
Ricochet peening, also called reflected shot peening, is a convenient method of providing coverage when the surface to be peened is obstructed. This can be especially useful when the area to be peened is fatigue critical and elaborate methods are either unavailable or cost prohibitive. Figure 1 illustrates a typical application for ricochet peening.

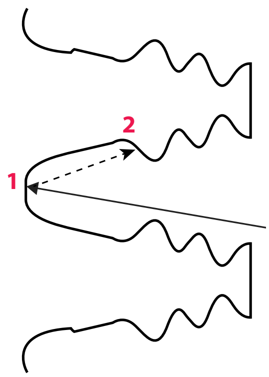

Figure 1. Peening of dovetail slot: 1) First impact 2) Second impact

Method
A direct pressure peening system with MagnaValve shot flow control shown in Figure 2 was used to perform these experiments using size S-110 cast steel shot. A right angle fixture of tool steel was constructed to represent the first and second impacts (see Figure 3). The nozzle was aimed such that the first impact was on the ricochet plate and the impact of the reflected shot was on the target plate. The first task was to evaluate the incident and reflected angles of the shot stream on the ricochet plate.


Figure 2. Peening Cabinet

The surface of the ricochet plate was painted and examined after a brief exposure to the shot stream thus revealing the reflected angle of the shot stream. See Figure 4. If the ricochet plate provided an "ideal" inelastic collision, then the 45° incident angle would result in a 45° reflected angle. However, energy losses at the first impact site reduce the reflected angle as shown in Figure 5 (see page 16).

The second task was to evaluate the intensity of the second impact after the shot stream was reflected from the ricochet plate. The arc height response of an Almen strip placed on the ricochet plate was used as a reference for intensity comparisons (Figure 6). The authors recognize that this is not an accurate evaluation of intensity since full saturation curves were not generated but it was deemed to be sufficient to illustrate a general comparison of intensity levels. The first strike intensity was set at 0.4 mm arc height.

Almen strip arc heights for the second impact were then recorded for each of the three cases of first impact on tool steel, aluminum and mild steel.

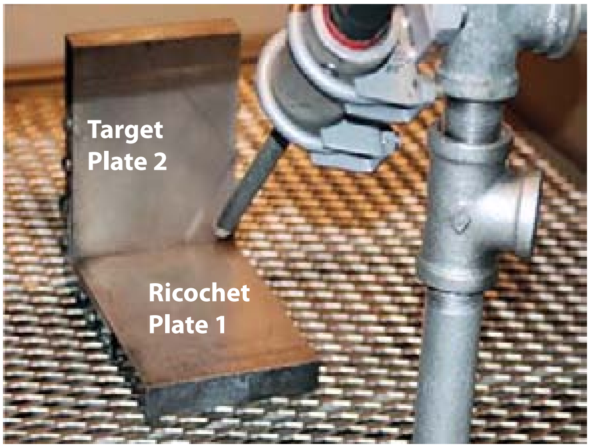

Figure 3. Nozzle aimed at Ricochet Plate (1)


Figure 4. Tool steel, aluminum and mild steel ricochet surfaces.

Results

The higher hardness material produced a larger reflected angle for the shot stream (Figure 8) and also a higher intensity for the second impact (Figure 9).

Table 1. Experimental Data

Impact Material	Hardness BHN	Impact Angle	Impact Arc Height	Ricochet Angle	Ricochet Arc Height	Incident Angle
Tool Steel	650	45	0.38 mm	33	0.43 mm	57
Mild Steel	110	45	0.38 mm	24	0.38 mm	66
Al 6061	86	45	0.38 mm	22	0.32 mm	68

Discussion

The numerical results are shown only for illustration and should not be applied directly to other applications. Complete saturation curves should be developed to ascertain the actual intensities achieved on each peened surface.

Conclusions and Implications

Ricochet peening, impacts with reflected shot, may be an effective method to provide coverage in certain applications, such as dovetail slots in aircraft turbine engines or other materials. The shot stream reflected angle is affected by the material hardness.

The test results show that the softest material, the Aluminum, absorbed more energy at the point of reflection and delivered a higher angle of incident (68°). There is a reduction in arc height measured at the incident site (0.32 mm) than at the reflection site (0.38 mm) despite the higher impact angle of 68°. This is due to the loss of energy during the reflection collision. The test on the Mild Steel showed no difference in measured arc height between the point of reflection and the point of incident. Although the incident angle (66°) was greater than the reflection angle (45°), energy was again lost in the reflection collision. The Tool Steel, the hardest material, had the least amount of energy absorbed at the reflection site and delivered the lowest angle of incident (57°). However, the measured arc height at the incident site (0.43 mm) was greater than the measured arc height at the point of reflection (0.38 mm). The natural conclusion would be that the intensity projected by the reflected shot stream might actually be higher than the intensity at the impact surface.

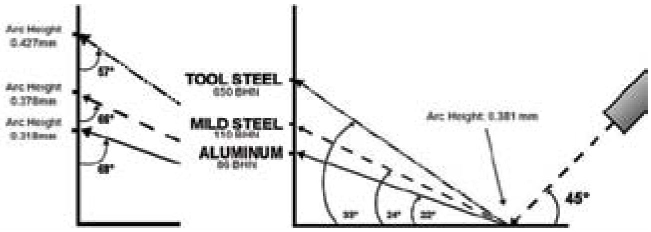

Figure 5. Angle of incidence and reflection for three hardness targets.

Figure 6. Technique to establish arc height of 0.38 mm at 45° impact.

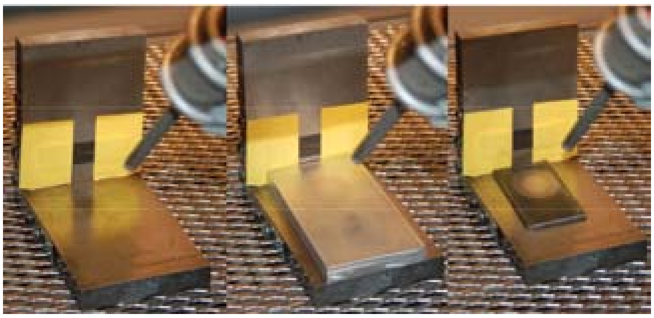

Figure 7. Almen strips used to measure second impact intensity after first impact on tool steel, aluminum and mild steel.

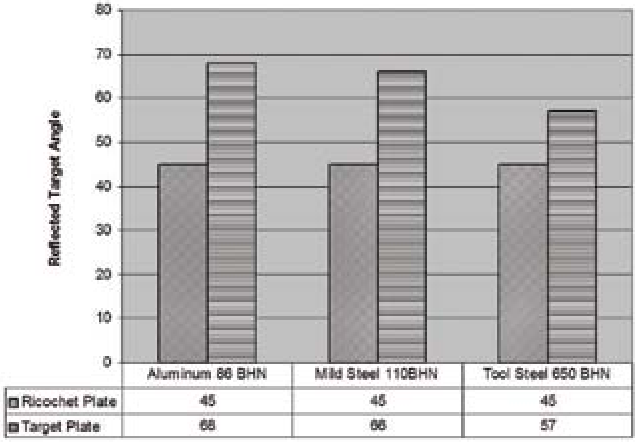

*Figure 8. **Ricochet reflection angles**. Shot stream reflected angle after first impact (1) at 45°*

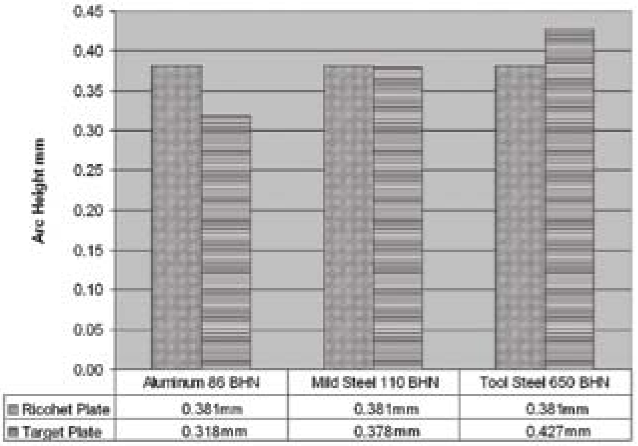

*Figure 9. **Ricochet impact intensity**. Intensity of second impact (2) with first impact set at 0.381 mm.*