The Relationship Between Peening Intensity and Metal Erosion Rate With Respect to Nozzle Angle

V.A. Ferrari,* M.M. Woelfel**

*Vacu-Blast Corporation, 501 Bragato, Belmont, California 94022, U.S.A.
**Potters Industries Inc., Hasbrouck Heights, New Jersey 07604, U.S.A.

ABSTRACT

Metal erosion is related to nozzle angle when peening with glass beads. Data is presented to show that metal erosion is greatest at or near 90° nozzle angles and that surface finish is largely independent of nozzle angle when peening pressure is held constant.

KEYWORDS

Shot peening, surface finish, metal erosion, glass beads.

OBJECTIVE

To demonstrate that the optimum nozzle angle for peening with glass beads is less than 90° and equal to or greater than 45°. This paper will extend this objective to show that rotating a jet engine blade while peening removes excessive blade material and is uneconomical with respect to overall production costs including process time.

EXPERIMENTAL DETAILS

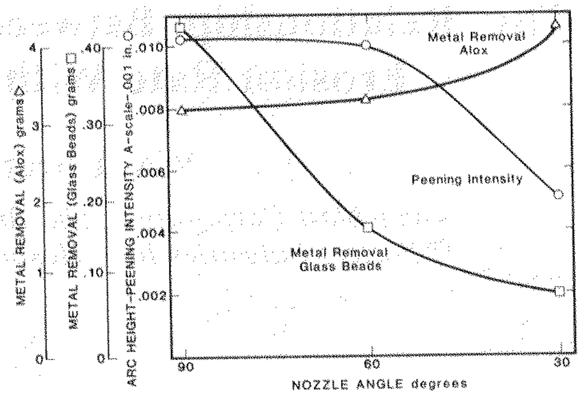
A series of tests designed to evaluate metal erosion rates on a rotating blade airfoil were run under the following conditions:

Media:	Potters Glass Beads GP-100 (300-425 micron)
Nozzle size and pressure:	6mm, pressure type system; 276 KPa
Nozzle distance and angles:	100mm; 90°, 60°, and 30°
Peening time/test:	6 minutes
Material:	6-4 Titanium

Each nozzle angle test was duplicated using Almen strips to record the reduction in peening intensity as the nozzle angle became smaller. Every test was started using a fresh charge of new beads. In addition, a similar series of erosion rate tests were run using #54 (600-180 micron), aluminum oxide abrasive. These latter tests were run solely to demonstrate the likely qualitative erosion effect that might be experienced if the bead charge was contaminated with a large percentage of broken particles.

DISCUSSION

The authors know that most jet engine blade manufacturers and overhaul facility operators require that the blades be rotated during peening. This process has become more historical than analytical. A rotating blade presents a constantly changing angle to the blast stream. Therefore, the effect of the shot stream is also constantly changing. Most technicians in the field of shot peening know of the relationship of nozzle angle to peening intensity but have not realized the costly results when peening a rotating blade.



A search of applicable literature confirmed the fact that specific nozzle angles produced better surface finish when peening intensity (not pressure) was held constant; or, improved peening performance or reduced metal removal rates, but we could not find any conclusions that pertained to a specific application. The authors are herein attempting to demonstrate to the industry that:

1. Nozzle angles should, where possible, be less than 80°:
   a) Metal erosion is highest at 90° and is undoubtedly due to deformation-induced fracture of the surface layers (Salik-80)
   b) Bead consumption and particle blinding is highest at 90° nozzle angle (Balcar-81)
   c) Tests showed very little variation in surface finishes as nozzle angles changed provided peening pressure remained constant.
2. Nozzle angles should, where possible, be greater than 45° because of the extreme fall-off of peening intensity at angles smaller than 45°.

Therefore, it would appear that the optimum nozzle angle should be somewhere between 45° and 75°. This optimum range is achieved only 33% of the total time the rotating blade is subjected to the peening media [4 quadrants x (75°-45°)]/360 x 100%. The balance of the time is spent excessively eroding blade material (17%) or underperforming (50%). This "underperformance" increases production time and is a tremendous waste of compressed air and beads.

The solution for medium and high pressure blades is simple in that the twist of these types of blades is negligible and therefore they can be held stationary (not rotating) and the nozzle group moved along the length of the air foil - or vice versa. However, the low pressure blades with their large area and large angular twist present another problem. Optimizing the peening process on these types of blades can be achieved by integrating the blade twist with the nozzle(s) motion so that the desired preset nozzle(s) angle is maintained along the entire surface of the blade. The two motions required to achieve this integration can be made to interact by using a scrap blade and cam follower with linkages. To prevent distortion of the blade, the peening nozzles must be equally divided on either face of the blade so that each face is peened simultaneously.

CONCLUSIONS

It is uneconomical and detrimental to peen jet engine blade air foils (and possibly roots) while the blade is rotating.

REFERENCES

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