ROLE OF SHOT PEENING PROCESSES IN HELICOPTER COMPONENT QUALIFICATION AND REPAIR

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Purpose:

Determine the effects of varying key shot peening process parameters on the resultant peening intensity for intensities and shot media sizes for materials typically used in U.S. Army Aircraft components.

Objective:

To increase the understanding of the variations of the shot peening process and their subsequent effect on peening intensity and relate the peening intensity to fatigue strength. However, this paper is strictly limited to the peening intensity investigation.

Technical Approach:

The most commonly specified shot media sizes and peening intensities for the materials commonly used in Army Aviation dynamic components were determined and are shown in Table 1 below:

Shot Media Size	Associated Intensity	Nominal Intensity Requirement	Associated Material(s)
S70	5 to 11N	8N ± 0.5N*	Ti 6Al-4V
S110	8 to 12A	10A ± 0.5A	4340 and 9310 steel
S170	8 to 12A	10A ± 0.5A	Ti 6Al-4V
S230	10 to 12A	11A ± 0.5A	7075-T73

* Source could only achieve an intensity of 9.5N for this material/media size combination.

Table 1, Materials and Associated Shot Media Sizes and Intensities

A commercial shot peening source was then contracted to develop peening processes to shot peen with cast steel shot at the **nominal** intensities for each of the four shot sizes associated with the materials shown in Table 1 in accordance with AMS-S-13165. Once the nominal or baseline peening processes were developed for each of the shot size/intensity combinations, the same commercial source then varied 4 different peening parameters individually, ideally in two positive or negative increments estimated to have an effect on the baseline intensity value. Equipment limitations occasionally limited the extent certain parameters could be varied. The peening parameters investigated were: air pressure, nozzle angle, nozzle distance and media flow rate. Three Almen strips were then peened at the “2T” time interval from the applicable nominal/baseline peening saturation curves to determine the resultant average for each independently varied process parameter. The 2T time interval was chosen in order to assure that each test condition/point would still result in a minimum of 100% coverage of the Almen strips. Once the effect of varying all of the particular parameters was determined, the parameters were then combined to determine the “worst case” high and low peening Almen intensities for each baseline peening process. Standard steel Almen strips were used in the study, each strip was measured prior to peening, and only strips measuring

Technical Approach: (continued)

0.0000" or 0.0001" (0.0 to 0.1 A or N scale) were used throughout the entire study. All strips were also examined after peening to assure that a minimum of 100% coverage was achieved.

Procedure:

Fixtures and tooling were developed to peen the Almen strips identically to the subsequent test specimens for the coupons made from the materials specified in Table 1. Figure 1 shows a schematic and tooling used for the peening process used throughout the study and Table 2 gives additional detail regarding the fixed peening parameters.

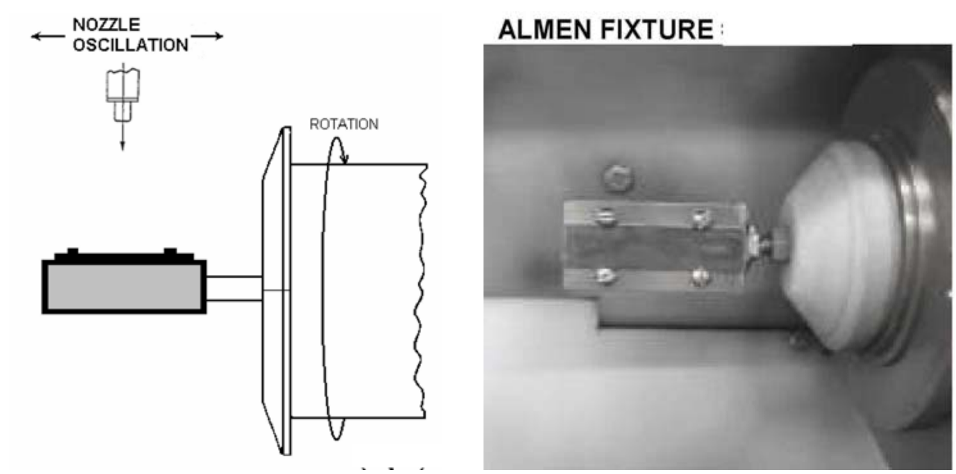

Figure 1, Peening Schematic and Associated Tooling

MACHINE SETUP AND PROCESS PARAMETERS – O.D. OPERATION			
AIR PRESSURE / PSI:	SEE CHART	NUMBER OF NOZZLES:	1
ROLLER SPEED (RPM):	N/A	NOZZLE DIAMETER (IN):	3/8
SPINDLE SPEED (RPM):	55-60	AIR JET DIAMETER (IN):	SEE CHART
OSCILLATION SPEED (IN/MIN):	20-25	NOZZLE TO PART DISTANCE (IN):	SEE CHART
LENGTH OF STROKE (IN):	3.5 – 4.5	NOZZLE ANGLES (DEG):	SEE CHART
PEENING TIME:	2 MINUTES = T2	NUMBER OF PARTS PER RUN:	1
ADDITIONAL INFORMATION:	NOTE: ALL ALMEN STRIPS MUST BE CHECKED WITH 10X FOR MINIMUM 100% COVERAGE.		

Table 2, Other Peening Parameters

Results:

Intensity results for each separately varied process parameter are presented graphically in Figures 2 through 5 for for each material/shot media size combination. For the **S70** shot size**, "N" scale/type Almen strips** were used, all other media sizes used "A" scale/type Almen strips.

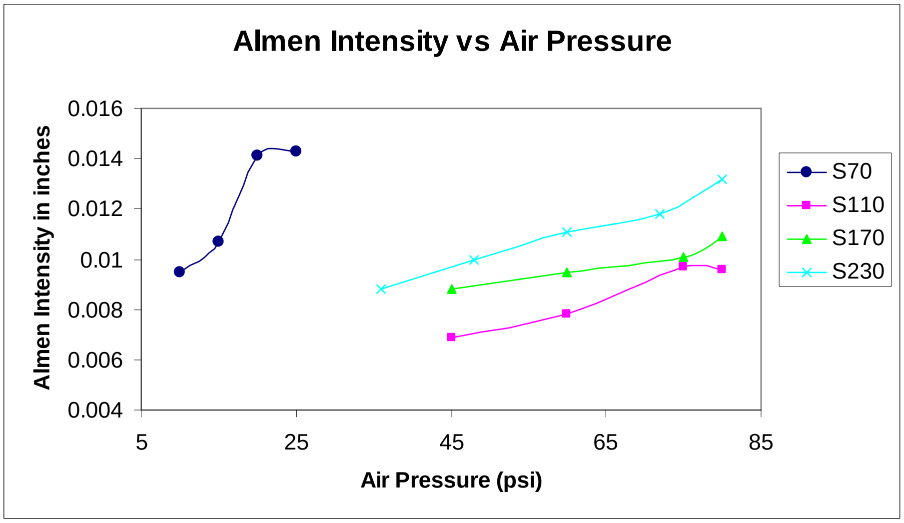

Figure 2, Graph of Almen Intensity Versus Air Pressure

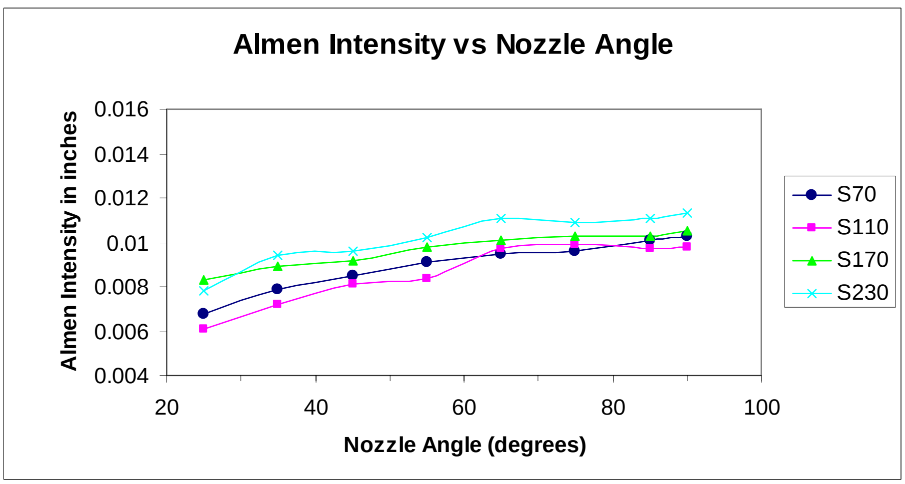

Figure 3, Graph of Almen Intensity Versus Nozzle Angle

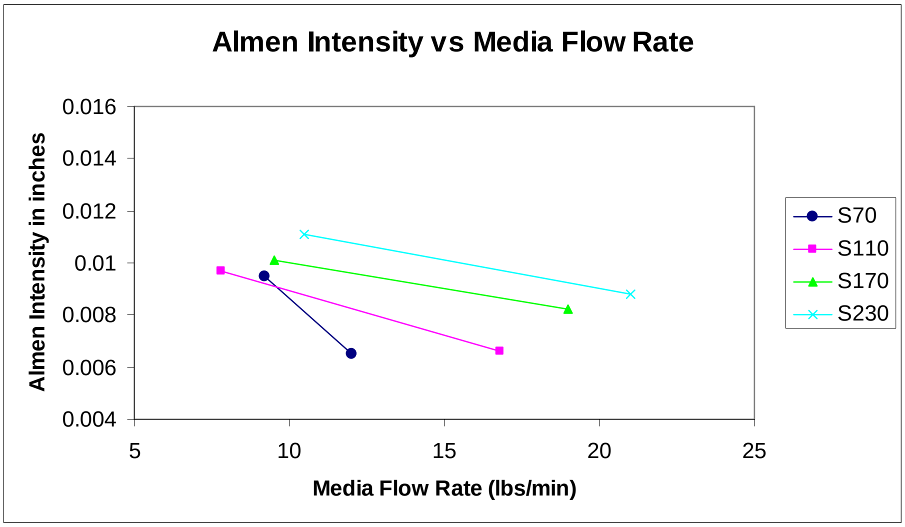

Figure 4, Graph of Almen Intensity Versus Media Flow Rate

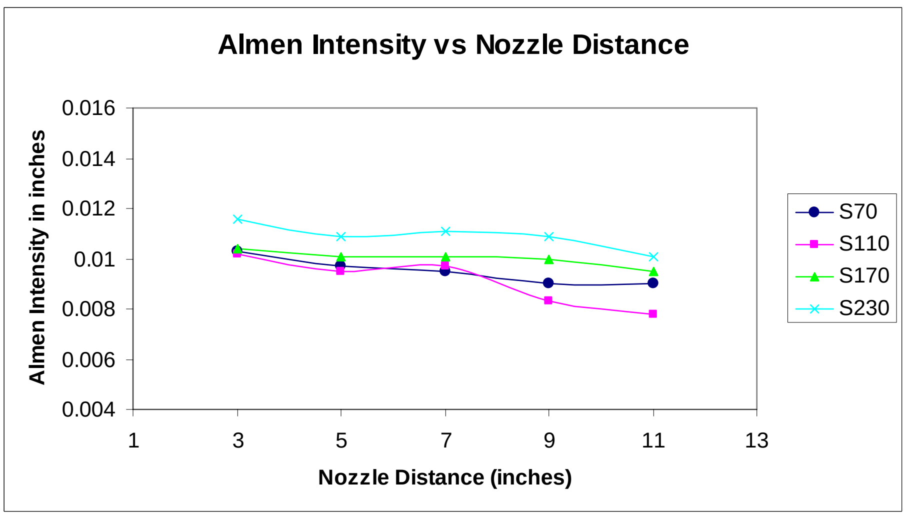

Figure 5, Graph of Almen Intensity Versus Nozzle Distance

Table 3 below details the worst case strip intensity results achieved for the combined parameters:

Material/Shot Size	Worst Case Intensity Low	Worst Case Intensity High
Ti 6Al-4V (S70)	0.0057"	0.0159"
4340/9310 (S110)	0.0042"	0.0101"
Ti 6Al-4V (S170)	0.0072"	0.0115"
7075-T73 (S230)	0.0063"	0.0143"

Table 3, Worst Case Intensities Using Combined Process Parameters

Discussion:

Air pressure exhibited nearly linear behavior regarding intensity until the maximum intensity for a particular media size was achieved. The linear behavior observed in this study compared favorably with other data also showing linear behavior for air pressure versus intensity [1].

Changes in nozzle/impingement angles have a pronounced effect at low angles and very little effect at angles greater than 65º. This data did not correspond well with published data [2] which showed a greater decrease in all intensities down to the 25° angle evaluated in this study. It is possible that the difference resulted from how the Almen strips were peened, they were rotated in this study, and apparently held in a fixed position in the other study.

Summary:

The peening intensities specified for the follow-on peening intensity/fatigue study are given below. Again, this paper does not detail or discuss the results from the fatigue study. These intensities are based primarily on the results presented above. When a drawing specified peening intensity value exceeded that of an intensity measurement achieved during the process parameter study, the drawing specified value was used to determine the High 1 and High 2 intensities.

7075-T73 Aluminum:
Low 1 = 4A,   Low 2 =10A
High 1 =12A, High 2 = 14A

4340 and 9310 Steel:
Low 1 = 4A,   Low 2 = 8A
High 1 = 12A, High 2 = 14A (values based on drawing requirement)

Ti 6Al-4V(1):
Low 1 = 3N*, Low 2 = 5N (*non standard air jet used to achieve this intensity)
High 1 = 11N, High 2 = 14N

Ti 6Al-4V(2):
Low 1 = 4A,   Low 2 = 8A
High 1 = 11.5A, High 2 = 14A (values based on drawing requirement)

Conclusions:

Changes to air pressure and nozzle angle had the greatest effect on intensity. Air pressure exhibited nearly linear behavior regarding intensity until the maximum intensity for a particular media size was achieved.

Changes in nozzle/impingement angles have a pronounced effect at low angles and very little effect at angles greater than 65º. At low angles, this effect is almost parabolic, implying the lower the angle, the greater the effect.

Intensity and media flow rates are inversely proportional. Due to limited data, the effect could not be characterized further.

Nozzle distance has a limited effect on intensity, the effect is inversely proportional.

References:

1. J. Champaigne, 1993, Shot Peening Process Variables, The Shot Peener, Volume 7 Issue 3, Page 17.

2. Dr. D. Kirk, 2005, Effects of Varying Shot Impact Angle, The Shot Peener, Summer 2005, Page 28.