# Effects of Peening on Fatigue Life of Wrought 5454 Aluminum Automotive Road Wheels

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ABSTRACT

This paper describes the application of peening to wrought aluminum automotive road wheels. Peening parameter development considerations including optimum intensity and peening media size are discussed. Standard SAE fatigue tests for automotive road wheels are applied. It is concluded that peening enhances fatigue life of wrought aluminum automotive road wheels. It was found that optimization of this enhancement requires compressive stresses imparted within a narrow tolerance.

KEY WORDS

Primary Failure Mode
Peening Impact Angle
Peening Media Fracture Rate
Saturation

Typical stressed components in today's automobiles are repeatedly analyzed to ensure minimum weight at the desired load carrying capability. Automotive road wheels are no exception.

Die cast aluminum wheels are the most widely used alternative to the standard two-piece formed steel wheel, howbeit, at a substantially greater cost. As an alternative to this, Kelsey Hayes Company recently embarked on a test program to determine the feasibility of wrought aluminum wheels. These wheels are of similar construction to standard steel wheels, having a formed rim welded to a spun center or "spider" section. Calculations suggested a weight savings of 9.0 pounds over a standard wheel of similar size. The sum of the approximately 10 pounds that can be removed from suspension components for every pound removed from a wheel, proves significant weight savings on an automobile with little or no aggregate increase in cost.

In developmental testing utilizing standard SAE Dynamic Cornering Fatigue tests for automotive wheels (SAE J-328A), unpeened wheels made of the selected material, 5454, showed a scatter range for failure from 230,000 to

396,000 cycles. At this point a shot peening program was initiated to increase fatigue life.

The authors and other engineering staff from Kelsey Hayes Company met to discuss the problem. Airtech Precision Shot Peening, Inc. of Livonia,Michigan was assigned the tasks of selecting peening parameters for optimum fatigue life and performing the shot peening operation. Since no destructive test data was available for peened 5454 in .375 inch section, it was decided that establishing a fatigue life versus intensity curve would be necessary before examining other peening variables. The peening intensity range to be examined was selected through a study of past research data developed by Airtech on similar materials and by industry and U.S. Military specifications. MIL #3 glass bead was selected due to its ability to achieve all of the intensities tested without incurring unduly high fracture rates caused by the high media velocities implicit with smaller bead at these intensity levels.

## TEST PARAMETERS

All glass bead was screen tested to verify sizing and vibro tested for concentricity. Cast steel shot was discarded as an option for test procedures due to ferrous contamination. Utilizing a multi-nozzle, suction type peening machine with automated turntable, nozzle motion and blast cycle time, Airtech established intensity curves for each of three intensity levels (6A, 8A, 10A). To ensure full saturation without the possible negative effects of multiples of 100% saturation in aluminum, a calculated 125% of full saturation time was utilized for peening cycle time (1). Since the primary failure mode was in the outward facing surface of the spider section of the unpeened wheels (Fig. 1) with no failures occuring in the rim section during destructive testing, spiders were peened prior to assembly. Peened spiders were subsequently heliarc welded to wrought 5454 rims using hand held welding equipment. The area of primary failure was calculated to be sufficiently distant from areas affected by the heliarc welding operation to preclude stress relieving of the compressive layer induced by peening from material temperature increase. Spiders and representative test specimens were centered and fastened to the peening machine turntable. In order to accurately represent the part shape, Almen specimens were attached to a spider machined to accept standard test strips. Almen strip readings were taken before and after peening test components of each intensity range. Nozzles were distributed across the part so as to have overlapping blast patterns and were fixed in place at as close to $90^{0}$ as possible to rule out the effect of impact angle variables (Fig. 2). (2) Nozzle placement remained unchanged throughout all processing to minimize the effect of broken peening media in the peening machine; the charge of glass bead was changed after peening each specimen. A total of three specimens were peened at each of the intensity levels. All quantifiable variables including impact angle for each nozzle, nozzle-to-part distances,nozzle and airjet sizes, air pressure for each nozzle, turntable speed, and cycle time were recorded.

Fatigue testing was performed by Kelsey Hayes Company on a machine designed and manufactured by Kelsey Hayes Company. Testing was conducted on this machine in reverse bending mode at 1180 foot pounds.

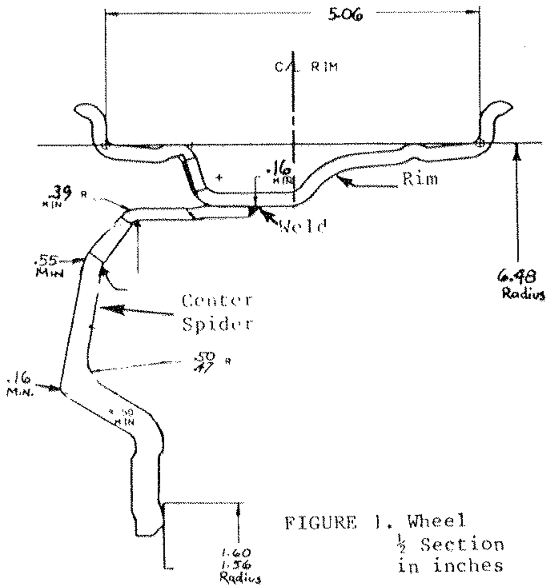


FIGURE 1. Wheel ½ Section in inches

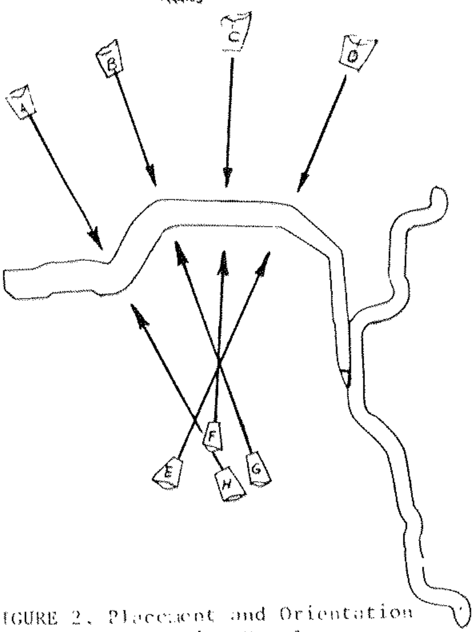


FIGURE 2. Placement and Orientation of Peening Nozzles

## RESULTS

Results of fatigue test data are shown in Fig. 3 and Fig. 4. Mean fatigue life for the 6A test specimens was 377.7% above the mean for unpeened; low fatigue life 429.6% above low fatigue life for unpeened; and high fatigue life 341.3% above high fatigue life for unpeened. Mean fatigue life for 8A test specimens was 470.0% above the mean for unpeened; low fatigue life 519.9% above low fatigue life for unpeened; and high fatigue life 448.5% above high fatigue life for unpeened. The difference in mean fatigue life for 10A was not statistically significantly different from unpeened. The low fatigue life was not statistically significantly different than the mean of the unpeened specimens. NOTE: One specimen in the 6A range failed in the weld between the rim and spider. As this is not a typical failure mode in test wheels welded by automated procedure and subsequently fatigue tested to SAE J-328A, the failure was attributed to the variables induced by hand welding and discounted for our purposes.

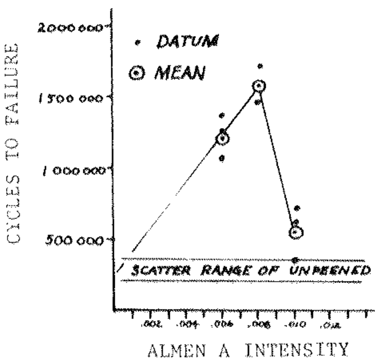


FIGURE 3. 5454 Fatigue Test Results

| Specimen Condition | Mean Fat Life | Standard Deviation |
|---|---|---|
| Unpeened | 276,156 | 4,427 |
| 6A | 1,319,246 | 93,172 |
| 8A | 1,574,220 | 162,448 |
| 10A | 568,436 | 178,851 |

FIGURE 4. Mean and Standard Deviation Values for Test Groups

## CONCLUSION

When specifying production intensity ranges extrapolated from developmental testing it is common, where only one intensity variable has been examined, to add $\pm$ 1 or even 2 Almen to the test parameter if testing resulted in substantial life increases. If this had been the case with the wheels tested where testing was only at 8A and put into production with an allowable intensity range of 8-10A, widely varying field results would have occured. It is clear that when specifying shot peening intensities for production, either empirical field data, destructive test results, or other means of fatigue life prediction are necessary to obtain optimum fatigue life results.

## FOOTNOTES

(1) N. Person, Metal Progress, July, 1981, Affect of Shot Peening Variables on Fatigue of Aluminum Forgings.

(2) Meguid and Duxbury, A Practical Approach to Forming and Strengthening of Metallic Components Using Impact Treatment; Pergamon, 1981.