Is 100% Coverage Necessary?

100% coverage: Is it necessary for all shot peening applications? Or is the work needed to achieve it, in some instances, a waste of time and media? Or worse yet, does it compromise one of the very benefits we hope to achieve through shot peening—the thermal stability of the compressive layer?

Paul Prevey and John Cammett's work at Lambda Research, a private institute that offers research services to a broad base of industrial, government and academic clients, tested the premise that 100% coverage should be the goal and submitted their results in a paper, "The Effect of Shot Peening Coverage on Residual Stress, Cold Work and Fatigue in a Ni-Cr-Mo Low Alloy Steel". (Introduction to paper is reprinted below.)

Mr. Prevey's previous research on thermal relaxation prompted his interest in testing the need for 100% coverage[1]. In his earlier work, he explored different methods of surface enhancement that produce minimal cold work. Low cold work was shown to provide the most thermally stable compression. The benefits of surface enhancement are lost if the compressive layer relaxes at the operating temperature of the component.

Mr. Prevey's results—surface enhancement methods that offer the most retention of compression at operating temperatures and therefore give substantial fatigue life improvement— prompted Mr. Prevey and Dr. Cammett to explore lower coverage rates in shot peening. Testing was done on 4340 steel, 38 HRC, peened to 0.22mm A (0.009 in. A) intensity, then fatigue tested in tension-tension loading (R=0.1).

The unexpected and exciting discovery from this investigation was that a coverage level of as little as 20% (0.2T where 1T = 100%) provided a compressive layer and fatigue performance equivalent to 100% coverage under conditions employed in their study.

Dr. John Cammett presented the paper at the Eighth International Conference on Shot Peening where it was very well-received. According to Paul

The Effect of Shot Peening Coverage on Residual Stress, Cold Work and Fatigue in a Ni-Cr-Mo Low Alloy Steel

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1. Introduction

The underlying motivation for this work was to test the conventional wisdom that 100% coverage by shot peening is required to achieve full benefit in terms of compressive residual stress magnitude and depth as well as fatigue strength. Fatigue performance of many shot peened alloys is widely reported to increase with coverage up to 100%, by many investigators and even in shot peening manuals.[1] The fatigue strength of some alloys is reported to be reduced by excessive coverage[2] Aerospace[3,4], automotive[5], and military[6] shot peening specifications require at least 100% coverage. Intemal shot peening procedures of aerospace manufacturers may require 125% to 200% coverage. Most of the published fatigue data supporting the 100% minimum coverage recommendation was developed in fully reversed axial loading[2,7] or bending[8,9] with a stress ratio, R= S_{min}/S_{max}, of-1.

The residual stress field arising from an individual shot impact is much greater in extent than the physical size of the impact crater and the resulting surrounding ridge of raised material[10]. Hence, at least some degree of undimpled surface area, less than 100% coverage, should be tolerable in terms of residual stress and fatigue strength achieved by peening. Accordingly, residual stress-depth distributions were determined for specimens peened to various coverage levels. Fatigue performance was tested at R>O, so that the shot peened surface was loaded only in tension. Additionally, cold work-depth distributions and the effects of thermal relaxation on both residual stresses and cold work were determined.

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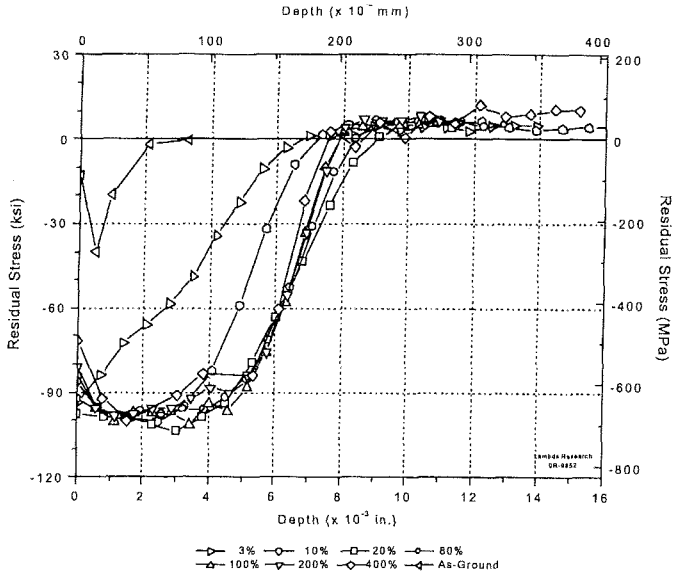
The complete paper is available at www.shotpeener.com.

Prevey, "Many people weren't prepared for our findings. We ran our test in a positive R-ratio since many practical applications of shot peening, such as automotive leaf springs and turbine blades, involve service loading at positive R-ratios. Most other testing by other investigators has been done at fully reversed bending (R=-1) which involves compressive loading."

Mr. Prevey's and Dr. Cammett's work will have a significant impact on shot peened products where tension-tension loading occurs, and/or where improved thermal stability of the compressive layer will be a benefit such as in automotive leaf springs, compressor and turbine blades and disks. Specifications that require 100 - 200% coverage should be addressed for potential modification. Mr. Prevey believes that shot peening equipment with CNC software and media flow controls will drive the need to change the specs as will military applications. Reductions in peening times will have an obvious economic benefit in reduced production time and media consumption.

Lambda Research is now testing lower coverage rates on other alloys such as IN718 where



This graph depicts the residual stress-depth distributions for various coverage levels. Note that it has virtually identical residual stress profiles measured for the different coverages. (Coverage is defined as ratio of time to produce 100% surface impacts.)

they are finding the same results. If you have questions or if you are interested in learning more about this research, email Paul Prevey at pprevey@lambda-research.com and Dr. John Cammett at cammettjt@navair.navy.mil.

[1] The Effect of Cold Work on the Thermal Stability of Residual Compression in Surface Enhanced IN718