48008

Information and data presented to the
Shotpeening Division of the SAE Iron &
Steel Technical Committee at its June
17, 1948 meeting.

The Importance of Uniformity in the Application of the Shotpeening Treatment

By

JOHN STRAUB

American Wheelabrator and Equipment Corp.

I have long been enthusiastic about the importance of uniformity of shot size in a peening operation, particularly from the standpoint of removing broken shot from a peening machine as quickly as possible.

Some of the results of our recent fatigue tests on shot peened specimens have indicated that wheatever ideas I may have had with respect to the importance of uniformity in a blast of shot were under emphasized.

One of the most striking fatigue test comparisons is that in which specimens were peened with and without a high percentage of broken shot in the peening machine. This series of tests was run for the purpose of simulating the conditions which existed in a production peening machine. The production machine involved contained approximately 86% broken shot in the working material.

The following fatigue tests were made on flat specimens of 9260 steel, 40-45 RC with a thickness of 1/4 in. and a width of 1 1/8 in. in the region of maximum stress. The tests were in simple bending, with a stress range of substantially zero to a maximum of 137,000 psi. The surface of the specimens was as-rolled on the side subjected to tension stress.

One group of 10 fatigue specimens was peened to a very scant coverage as measured on a quantitiative basis.

A second group of ten specimens was peened identically to the first group and was then peened under the same conditions with respect to wheel speed and conveyor speed, but with a blast which consisted of broken shot to the same size analysis as that found in the production machine. Since the working shot in the production machine consisted of one part whole shot and five parts broken shot, the fatigue specimens which had been peened with whole slots were then peened with five times as much broken shot.

The results of these tests are shown in Fig. 1, in which the fatigue life of each specimen is shown. The first group of specimens shown on the extreme left, represents non-peened specimens. The next group to the right represents those specimens peened with whole shot only, and the third group represents those specimens peened with whole and broken shot. Note that the fatigue life is practically unchanged by the addition of the blast with broken shot, despite the fact that the blast of broken shot had increased the arc height from .011 A-2 to .014 A-2 and had increased the coverage from only 30% to well over 100%.

This work was done after an extensive series of tests had indicated that under similar conditions, with respect to blast uniformity, the fatigue life increases with increasing arc height up to .014 A-2 or greater. It had also been shown, previous to these tests, that under the same conditions with respect to blast uniformity, increased coverage resulted in increased life up to 100%.

Another group of specimens was then peened with whole shot to an arc height of .014 A-2 and 98% coverage. Note that the arc height and coverage in the last mentioned group are the same as those obtained with the mixture of whole and broken shot. The results of this group are plotted in Fig. 1, at the extreme right. Note that in this case, the fatigue life is definitely greater than that of the group peened with whole and broken shot even though the arc height and coverage are the same.

Referring again to groups 2 and 3 in Fig. 1, it is apparent that the broken shot adds nothing to the fatigue life which was obtained with a relatively small quantity of whole shot.

For example, assume that the production peening machine containing five parts of broken shot and one part whole shot, is operated with a flow rate of 300 lb per min to the wheel. Now assume that the broken shot is removed from the machine and that the flow rate to the wheel is decreased so that the amount of whole shot flowing through the wheel is the same as it was with the mixture, all other conditions being the same. This would mean that the flow rate would be one-sixth of 300 lb per min or 50 lb per min.

Under these conditions, the parts passing through the machine would represent an ideal case for rejection because of the fact that the coverage is only 30% and the arc height is less than 80% of the specified requirements. But in actual fact, those parts are just as good as those which were peened with the mixture, in spite of the vast differences in coverage and arc height. It requires very little imagination to realize the difference in cost between flowing 50 lb per min of whole shot versus 300 lb per min of whole and broken shot through the wheel.

I believe that these results show rather conclusively that broken shot in a peening machine is of utterly no value relative to the whole shot, even though the cost of the operation with a large proportion of broken shot is decidedly higher.

This does not imply that grit or broken shot of itself cannot be used to increase fatigue life. Increased fatigue life can be obtained by blasting with grit or broken shot. It does imply, however, that the broken shot is totally ineffective relative to the full-sized shot by virtue of its reduced weight. In other words the effect of broken shot is definitely not additive to the effect of whole shot in its relation to increased fatigue life.

The data cited are believed sufficient to demonstrate the futility of expecting any additional increase in fatigue life from broken shot in relation to that obtained with full size shot. However, I have pointed out only what I have considered sufficient data to justify this conclusion. Actually we have considerably more data to support this conclusion, but in the interest of brevity, I have not included other test results.

Unfortunately, the influence of these factors on fatigue life and cost cannot be recognized without a comprehensive series of fatigue tests. It is a foregone conclusion that the end goal of shot peening is increased fatigue life at low cost. No matter how effective peening may be in increasing fatigue life, it will not be generally accepted unless the cost of the operation is sufficiently low that it will more than pay its own way.

I am more confident now than I ever was that peening can far more than pay its own way, provided the requirements of low cost are recognized. To my knowledge, the largest single factor controlling the ultimate costs of peening is uniformity of the intensity of the blast.

In the analysis of what constitutes the intensity of the blast, there are three major elements involved:

1 - Velocity of the shot. This does not represent a serious problem from the standpoint of uniformity. It is unlikely that in a peening operation the shot velocity, in a given blast, would be subject to much more than 10% variation.

2 - Hardness of the shot. Uniformity in this case is not a serious problem. If the shot is harder than the work, then any variation in shot hardness would have no more than a slight influence, if any, on the results; if the elastic limit is not exceeded in peening, it makes little difference how nearly the elastic limit is approached.

3 - Size and weight of the individual particle. Uniformity in this case, appears to be the greatest problem of the three. Actually, the present specifications for peening shot allow a variation in size of almost 20%. This does not include the allowance for oversized and undersized shot relative to the nominal size.

For equivalent fatigue life, peening with whole shot of uniform size is unquestionably more economical than peening with shot having a wide range of size. As mentioned, this is not always easy to demonstrate without comprehensive fatigue testing, but in cases where such tests can be made, the result is always the same.

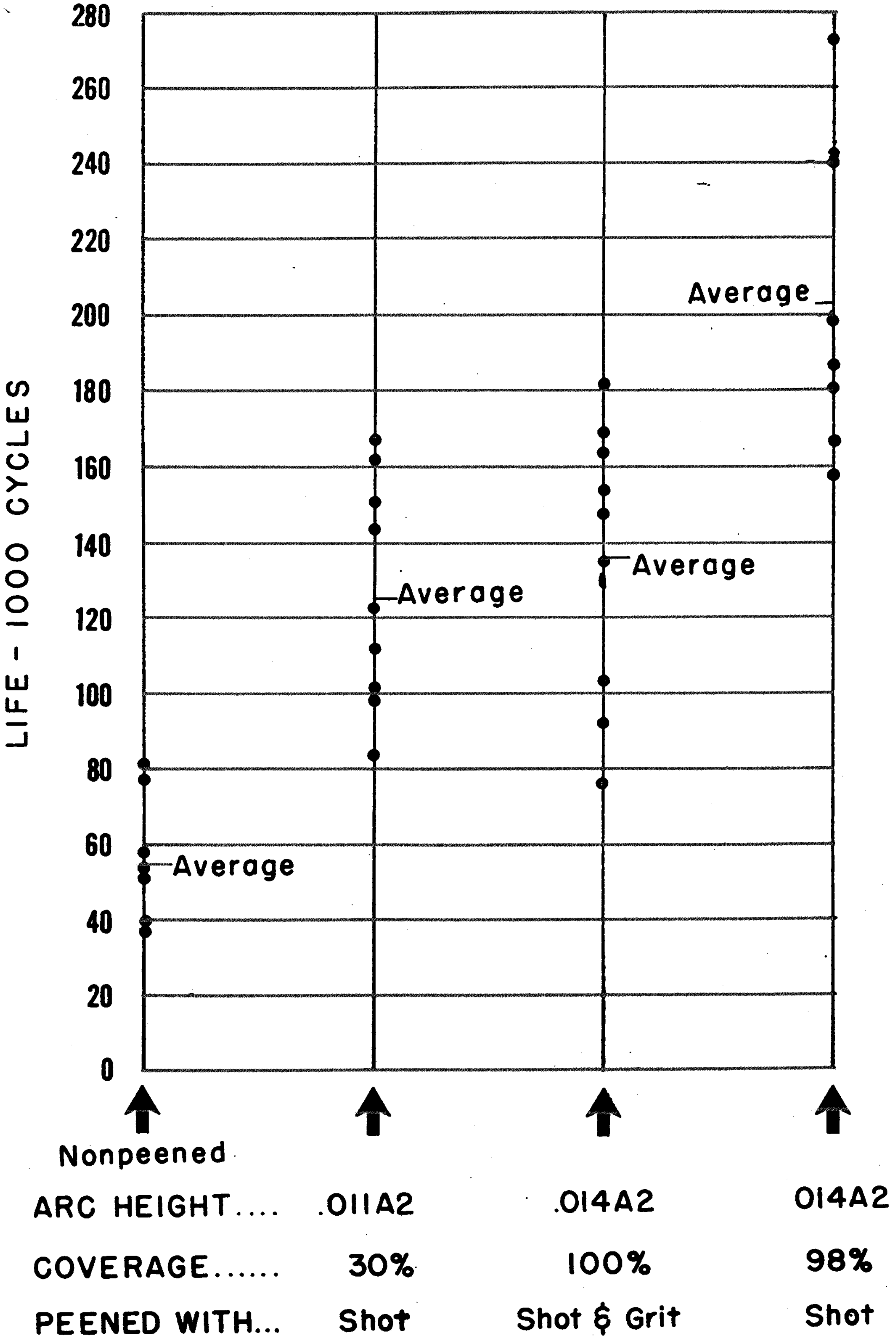
To stabilize a peening machine, (to obtain a high percentage of whole shot in continuous operation), it is necessary to remove the broken shot continuously. If, in replacing the broken shot, the new shot which is added has a wide range of size, then in removing broken shot, the smaller size of the new shot will be removed from the machine without actually having been used in the peening operation.

Approaching the problem from another standpoint, assume that a shot is broken in half. The weight of each broken particle will then be half of that of the original pellet. This half would be equivalent in weight to a whole pellet whose diameter is the cube root of .5, or approximately 80% of the diameter of the original pellet. Therefore, it follows that whole shot, whose diameter is less than 80% of that of the large pellets, would be equivalent to broken shot and, would be of no value relative to the larger size.

On this basis, it appears that for peening, the range of shot size should be as close as practical to a range of from 100% to 80%. It is interesting to note that this tolerance is quite close to the present SAE specifications for peening shot.

I do want to make myself clear that the above considerations are based on the assumption that the peening machine is to be operated in a stabilized condition. If this is not the case, then any attempt to restrict the shot size would be obviously to no avail. But as time goes on it becomes more and more apparent that broken shot in a peening machine will be tolerated less and less because of its uselessness relative to the whole shot. In all of the fatigue tests which we have run, as well as the results of other tests which have been reported in the literature, we have found no evidence of any conflict whatsoever that uniformity of the blast is of utmost importance.

Since uniformity of shot size appears to be such a vital factor in blast uniformity, I believe that every effort should be made to obtain peening shot with the minimum practicable variation in size.


LIFE - 1000 CYCLES
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Average
Average
Average
Average
Nonpeened
ARC HEIGHT.... .011A2 .014A2 014A2
COVERAGE...... 30% 100% 98%
PEENED WITH... Shot Shot & Grit Shot

STRAUB