Combined Methods Aid Inspectors in

Determining

Shot Peening Coverage

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THE Straub and Surface Replica Methods together provide a means by which shot peening coverage can be accurately measured and easily controlled on production runs.

The Straub Method is highly accurate, although it is time consuming and requires the use of a microscope and planimeter to trace indentations. The Surface Replica Method, while one of comparison, is an excellent means of control, especially when used in conjunction with coverage standards.

A third method, Valentine's Method, has been evolved for determining coverage on parts with complex surfaces, but this method can give misleading results, comparative tests of the three methods indicate.

By applying both the Straub and Surface Replica Methods to the same shot peened area, one can determine the percent coverage and the appearance of the surface replica corresponding to that percent coverage. If there's a percentage range allowed on the coverage, say 100% to 85%, surface replicas corresponding to these figures can be made up and distributed to inspectors for use in checking production parts.

In Fig. 1 are reproduced photographs of surface replica films of various degrees of coverage used as standards to aid in the inspection for peening quality of Buick chassis coil springs.

The Straub Method involves the accurate measurement of percent coverage on a polished Almen "A" strip from its magnified image on the screen of a metallurgical microscope. The image of the peened strip at 50 magnification is traced and measured with a planimeter. For accurate determination of coverage this method is the only one yet developed. It has its limitation, however, because of the fact that its application is confined to a test strip rather than to the actual peened part itself. Quite frequently the design of a part to be peened may be such that a peened strip, however carefully positioned, will not represent the peening conditions on the part itself.

The Straub Method does, of course, provide an excellent means of determining the exact peening conditions existent in a machine.

In the Surface Replica Method, after a part has been shot peened, a transparent replica of the surface is made. First solvent is applied to the area where coverage is to be measured. Next transparent film is placed over the solvent and pressed down with thumb pressure for approximately one minute. Then the film is quickly peeled from the surface. Final step is to mount the film in a holder and project it onto a screen for viewing.

It has the advantage of reproducing the condition of the peened surface on a film which may be projected on a screen for inspection. This replica need not be confined to that of a flat surface but is adaptable also to irregular contours. In viewing its projection on a screen, an experienced eye can estimate with good accuracy not only the percent coverage but the magnified condition of the peened surface as well. The method has the added advantages of being fast, flexible, and portable—thereby lending itself to easy application at the site of any peening operation.

The third method, Valentine's Method, is used particularly for studying parts of varying cross-section of contour. In this method, a duplicate of the piece being studied is made from low-carbon steel of a specified carbon range, subjected while in the soft condition to the proposed peening cycle, and then annealed to produce a recrystallization and grain growth. The piece may then be cross-sec-
tioned in any plane and studied under the microscope. The extent of peening will be shown by the degree of grain growth in the various parts of the piece and will be in proportion to the intensity of the peening blast to which the area was subjected.

(The Straub, Surface Replica, and Valentine Methods are described in the SAE Shot Peening Manual.)

The three methods were compared in tests involv-
Flow in. diameter. The various Almen "A" strips, electropolished Standard Almen "A" strips, and normalized SAE strips were mounted on a table fixture as illustrated. The test parts were blasted chilled iron shot, SAE 170 cast steel shot, and G 50 grit. Peening was carried out on Standard Almen "A" strips, electropolished Standard Almen "A" strips, and normalized SAE 1008 "A" strips. The strips were mounted on a table fixture as illustrated in Fig. 3.

Shot Peening Coverage Is . . .

... the percent of the surface struck by shot during the peening operation. That is 100% coverage would indicate that the surface, when examined after peening, would consist of overlapping shot impressions with none of the original surface remaining. And 90% coverage would indicate that 10% of the area had not been struck with shot.

Coverage in itself, does not necessarily indicate the fatigue life to be expected. This is because the primary aim in shot peening is not simply the battering of the surface, but is the induction of compressive stresses in a surface layer. The compressive stress extends beyond the shot impression into the unpeened areas surrounding it and penetrates the surface to some depth. For some parts it is possible to produce a very satisfactory fatigue life at considerably less than 100% coverage.

In general, however, to insure the best peening results and to minimize inspection problems, peening equipment should be designed to insure 100% coverage.

When the part is released for production it is frequently necessary to purchase equipment for the peening operation. To achieve the same results as were obtained on the test parts, it is necessary to secure equipment which will produce the same intensity and coverage as were present during the experimental peening.

The procedure used in peening with each type of shot and for each orifice size was as follows:

1. The test strips were fastened to the table fixture, the cabinet closed, and the machine started. When the wheel reached full speed, the strips were blasted for exactly 30 sec. Then they were removed and identified. With each type of shot, coverage was varied by using the %, %, %, and % in. orifices. With the CW 54 cut wire, a 1 in. orifice was used also. Shot flow was measured by weighing the amount which flowed through the spout in 1 min. A sample for screen analysis was obtained from the spout at the same time.

2. With a table speed of 40 rpm it can be assumed that all three test strips were peened equally. The Standard Almen "A" strip was used for arc height measurement, the electropolished "A" strip for...
measuring coverage by the Straub and Surface Replica Methods, and the SAE 1008 strip for determining depth of cold work due to peening according to the Valentine Method.

After peening, the SAE 1008 strips were annealed at 1300 F for 1/2 hr for grain coarsening, cross-sectioned, mounted in Bakelite, and examined. Photomacrographs at 50 magnifications were made of each peened electropolished "A" strip. From these the percent coverage was measured with a planimeter as prescribed by the Straub coverage method. Surface replica impressions were also made of each of the polished Straub strips.

Photomicrographs of the low-carbon strips, like those in Figs. 4, 5, and 6, showed that the depth of cold work as evidenced by grain growth becomes progressively greater with increasing coverage. However, no appreciable depth increase was noted beyond 75% or 80% coverage. It must be remembered that the depth of grain growth does not necessarily indicate the true depth of cold work. Rather, it outlines that area which has been critically stressed to within a range which, upon heating, will produce grain growth.

Therefore, it is reasonable to assume that when peening low-carbon steel, the cold work effect actually extends to a depth greater than that indicated by grain coarsening. Similarly, excessively cold worked or overpeened metal, as seen in Fig. 7, shows the presence of fine grains at the surface with underlying large grains. In this case the degree of cold work at the surface has exceeded the critical amount necessary to produce grain coarsening.

When arbitrarily used as a means of determining peening coverage, the Valentine low-carbon duplicate method could be misleading. With a few exceptions, the photomicrographs of the Valentine strips indicate continuous cold working of the surface metal, and that complete coverage was present. The corresponding Straub photomicrographs in many cases, however, show only partial coverage. The natural assumption, based on Valentine's Method, is that the cold-worked areas surrounding the shot indentations overlap, giving the impression of complete coverage when it does not actually exist.

To illustrate the cold-work effect of one shot par-

Fig. 4—Coverage in this test run measured 27.6% by the Straub Method. Cross-sectional photomicrograph shows depth of cold work in nitric-etched SAE 1008 test strip for Valentine Method test at 50 magnification. Photomacrograph is of corresponding electropolished and peened Almen "A" test strip for coverage determination according to the Straub Method, also at 50 magnification. Test conditions were: 0.054-in. cut wire shot, 1/8-in. orifice size, 30 sec exposure, 5.2 lb per min shot flow, 8.0 A-2 arc height.

Fig. 5—Coverage in this test run measured 72.7% by the Straub Method. Cross-sectional photomicrograph taken for Valentine Method determination. Photomacrograph taken for Straub Method determination. Test conditions were: 0.054-in. cut wire shot, 1/8-in. orifice size, 30 sec exposure, 13.4 lb per min shot flow, 13.0 A-2 arc height.
Fig. 6—Coverage in this test run measured 99.9\% by the Straub Method. Cross-sectional photomicrograph taken for Valentine Method determination. Photomacrograph taken for Straub Method determination. Test conditions were: 0.054-in. cut wire shot, ¾-in. orifice size, 30 sec exposure, 45.8 lb per min shot flow, 23.0 A-2 arc height.

Fig. 7—Cross-sectional photomicrograph of overpeened strip shows fine grains at surface and underlying large grains. Degree of cold working surface has exceeded critical amount producing grain coarsening and heating. Photomacrograph shows corresponding Almen “A” test strip peened in same test run. Test conditions were: 0.054-in. cut wire shot, 1-in. orifice size, 30 sec exposure, 104 lb per min shot flow, 300 A-2 arc height.

ticle, a Rockwell “B” hardness impression was made on a low-carbon Almen strip. The strip was annealed at 1300 F for ½ hr and sectioned through the indentation. From the accompanying photomicrograph, Fig. 8, it is seen that the stressed area surrounding the impression is very widespread and would overlap with that of another impression 1/32 in. or more away.