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Customized Comparison Tools for Peening Coverage

Using Peened Material Samples to Ease Coverage Inspections

EVERY OPERATOR, process developer and quality manager in the shot peening industry knows about the challenges in inspecting and rating the Coverage on peened parts. The achievement of full or 100% Coverage is very essential though to determine the corresponding peening time. Knowing the peening time saves energy and wear, avoids over-peening and is the basis to comply with peening instructions that require specific multiples of 100% Coverage.

Finding a reliable peening time for full Coverage usually requires a Coverage development using several sequential time-based steps producing lower Coverage rates. Estimating Coverage at lower degrees is often difficult and leads to discussions between operators, process developers and quality managers.

In order to address this challenge, SAE J2277 provides patterns for comparing the inspected surface with a graded series of computer-generated pictures. These pictures are an appreciated tool for the inspector but do not claim to reflect reality. The inspection for Coverage on a real part surface after a peening process can be very challenging due to several reasons.

An overview of the difficulties that prevent an easy Coverage assessment can be divided into four categories.

Part condition and accessibility

Since shot peening is usually performed after surface machining, characteristic surface profiles from turning, milling, etc., can make Coverage inspection quite difficult. If a surface is rough, dents will be hard to distinguish from the original surface texture. Even surface colour and brightness will influence the rating results.

There are areas on a part that are hard to access with the standard tools of visual inspection. Areas like the inner side of a boring or undercuts don't give the required access for inspection equipment.

Illumination and magnification

The lighting and magnification tools used for Coverage inspection do have an impact since they can change the visual impression of the surface. Light source direction, movement and brightness, surface reflections and size of the inspected area can change the visual impression the dents have on the inspector's view. Therefore, it is important to keep illumination and magnification consistent throughout a Coverage development.

Depth and size of individual dents

Inspecting Coverage that has been created at low Intensities or on hard surfaces is difficult since the individual dents cannot be detected easily. It is particularly hard determining the Coverage of parts that have been treated by ultrasonic peening since dents are extremely flat.

Dent size is also dependent on shot size, leading to very small dents with small peening media. The varying dent sizes of cast steel shot also cause different-sized dents that make it harder to rate the Coverage on a part.

Inspectors

Two different, equally experienced inspectors assessing the same surface will usually end up with different results in Coverage rates, sometimes of more than 20%. This shows that, even though theoretically the Coverage is well-defined, Coverage determination comes with a subjectivity that is unwanted in the process. Even the same inspector may determine a different Coverage for the same surface on two different days.

To address the problems, there are several well-established methods. Instead of only one inspector, multiple persons can help improve the determined values. This is however cost and time intensive and not always possible. The same goes for time-consuming Coverage developments.

THE BENEFITS OF COVERAGE SAMPLES

Instead of spending a lot of time on every individual Coverage determination, the use of customized Coverage comparison samples helps to reduce the time and personnel effort that has to be put in every part.

The specimens for the Coverage Samples are manufactured from the same material and in the same pre-processed state as the components to be peened. A reproducible peening process is then applied, the media and Intensity of which

correspond to the real process. Using a specialized shot peening machine that can easily change the peening time by changing the number of passes or velocity, it can create several steps of Coverage in the range of 10 and 100%.

When later on the inspector compares the samples with the peened part, he or she will find a similar visual impression on both surfaces. The recognition of the Coverage state will then be a lot closer to its correct value.

The key to create reliable Coverage samples is that the rate of each sample needs to be determined as precisely as possible. As automized systems are still under development and themselves need to be trained by humans, there is the need for a procedure that ensures a high quality in Coverage determination, addressing most of the aforementioned problems. The idea is to use the experience of a number of inspectors in the Coverage development of samples and to combine this with the means of statistical mathematics.

Statistical Coverage development

Though the individual dents cannot be foreseen in a chaotic media impact like in shot peening, the increase rate is predictable by a statistic formula from SAE J2277, connecting the degree of Coverage with the time needed to achieve it.

$$C_n = 1-(1-C_1)^n$$

C_n percent Coverage (decimal) after n cycles,

C_1 percent Coverage (decimal) after 1 cycle,

^{n} number of cycles (number of passes, number of rotations, or uniformly chosen increments of time)

By converting the formula defined in SAE J2277 to

$$C_1=1-\sqrt[n]{(1-C_n)}$$

and inserting the values determined by an inspector, each inspection results in a C_1-value. Collecting C_1-values for every Coverage step and operator and building the average value over all of them leaves you with an averaged C_1-value.

This principle allows the use of all ratings of all inspectors for each step in the Coverage development of a sample which overcomes the main problem presented above—that low Coverages are hard to determine correctly.

Coverage development with multiple inspectors

Instead of relying on an automized system, the use of pictures, or on one inspector alone, we can apply the principle of "swarm intelligence" by the use of the averaged C_1-value.

These can be experienced operators, process developers or quality inspectors within the company. They should give their personal ratings for several steps with a growing number of passes or peening time on the samples. Even if the "swarm" may be small the average rating of Coverage should be closer to reality and more reliable than single ratings from each individual. Even inspections by the same person on several different days are possible to increase statistical data and improve accuracy. Values that are too far from the averaged value can be cut from the calculated result to further improve the Coverage values.

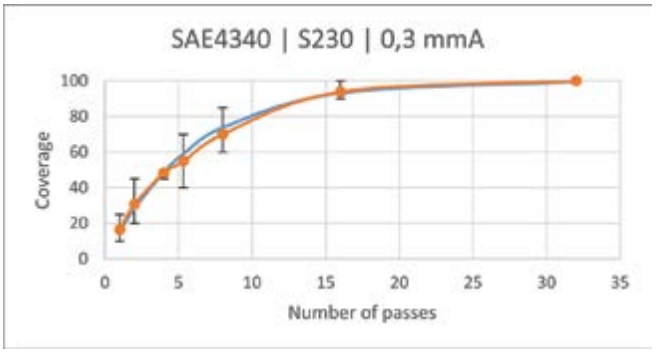


Figure 1: Coverage over number of passes

Using the formula from SAE J2247, a curve can be created from the averaged C_1-value as shown in Figure 1. The blue curve is the averaged data from five inspectors, each of these providing three Coverage inspections on seven different Coverage levels. As expected, the accuracy of the determinations around 50% has the highest deviation and differs the most from the idealized Coverage curve showing the usefulness of this method.

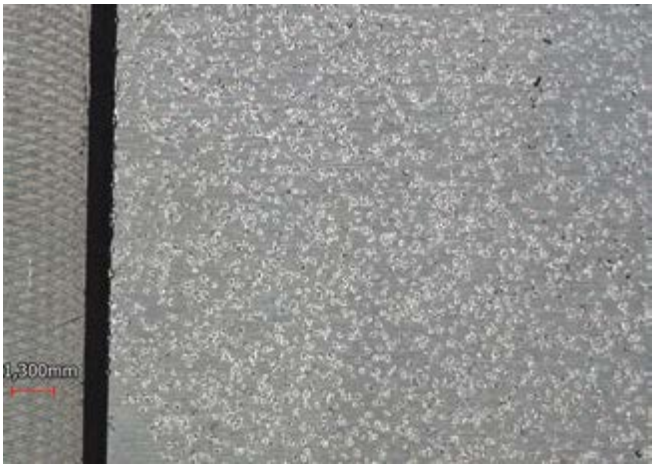
CUSTOMIZED COVERAGE SAMPLES

While the procedure above can be used to improve Coverage determination in every shot peening facility, the creation of Coverage samples comes with problems on its own. Peening standardized Coverage samples requires a different nozzle movement compared to the production process and a machine that is versatile enough to make the changes necessary. Additionally, the creation of Coverage samples requires machine and operator time that is often not available.

sentenso is offering custom-peened Coverage samples that are peened in our specialized peening machine featuring a range of sensors to ensure process stability over every Coverage step created. Our team of experienced Level 2 and Level 3 shot peening operators determines the Coverage on preproduction samples. These values are then used to create the actual Coverage samples that are created with the calculated number of passes from the curve created.

The Coverage samples should have a handy format similar to Almen Strips so the Coverage is basically uniform over the width and length. The samples are stored in a foam-lined case in which they are sorted according to material, peening media, shot peening Intensity and degree of Coverage in order to determine the respective degree of Coverage on the component in direct comparison side by side. The case can easily be carried to the inspection site. In order to provide the same condition of the peened samples and to avoid changes by corrosion, the sample surface can either be protected by a layer of PTFE or with a special protective coating depending on the sample material.

Coverage samples are supplied in a convenient foam-lined case



Coverage 17-4PH 0,31 mmA ASH 230 35%

In addition to everyday Coverage determination, the Coverage samples can be used for internal training of new process engineers and operators. This significantly reduces the time required to familiarize the staff with the Coverage determination and enhances its quality. Experienced inspectors can also use the samples for regular self-training and -monitoring.

For more information on sentenso's custom-peened Coverage samples, please contact info@sentenso.de, visit *www.sentenso.com*, or scan the QR code.