A NDT SYSTEM WORKING AT MANUFACTURING ENVIRONMENT

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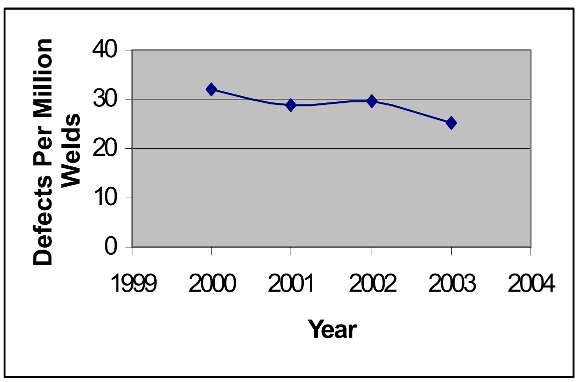
Abstract: An ultrasonic test of A scan has been used for spot weld inspection. In order to use the technology at manufacturing environment to test resistance spot welds successfully, a system has been developed.

Introduction: DaimlerChrysler Sterling Stamping Plant has been using ultrasonic A Scan tests to audit resistance spot welds since 1997. It not only reduces a lot of scraps made by traditional destructive tests, but improves welding quality.

An ultrasonic test of A scan is not a new technology. However in order to use it at manufacturing environment to test resistance spot welds, a system has been developed.

Three elements of the system are discussed. Calibration of welds reduces the sensitivity of operators. Intensive training and practices improve the test accuracy. Development of sampling strategy increases the confidence level of NDT.

Results: There are two numbers that have been monitored since NDT program started although NDT is only one of key contributors. Figure 1 was number of defect welds per million welds made. Figure 2 was savings in dollar, which was calculated by the estimated expenses without NDT subtract actual spending with NDT program.



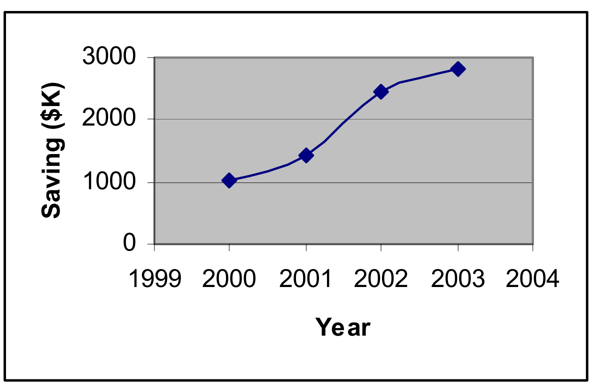


Figure 1. Quality index Figure 2. Estimated saving

Calibration of resistance spot welds: There are million welds made at a manufacturing plant. Destructive test is a traditional way to check the quality of the welds. Because of limitation of the destructive test, A scan Non Destructive Test (NDT) has become more popular in sheet metal welding. In mass production environment, a proper calibration of A scan is a major factor to reduce the sensitivity of operators. The calibration consists of three parts, master coupons of welds, selection of probes, Alpha series and all parameter's settings of USD15, ultrasonic flaw detector.

A master coupon in Figure 3 has been made with satisfaction welds that are with penetration of more than 20% of the thickness of an original sheet and nugget size, $4\sqrt{t}$. Here t is metal thickness. 15 MHz or higher frequency probes are selected. The probe sizes are selected based on nugget sizes. Because of higher frequency of probes, therefore Near Zone N is longer as (1), in which sounds are concentrated; wavelength λ is short as (2), which is more sensitive to sheet metal; beam spread γ is smaller as (3), which loses less energy.

$$N = \frac{D^2 F}{4C} \qquad (1)$$

Where D – diameter of a sound beam, F – sound frequency, C – material velocity.

$$\lambda = C / F \qquad (2)$$

Where C – material velocity, F – sound frequency.

$$Sin\gamma = \frac{1.22C}{DF} \qquad (3)$$

Parameters in USD15 are set as followed. Ranges are set per metal thickness. Pulser is set as 33 Ω damping that is a good compromise between resolution and sensitivity, the power intensity 220 pF with auto low mode of PRF (Pulser Repetition Frequency), which delivers clear peaks on CRT for manual operation.

A good weld shall be satisified those conditions as followed. The distance of two peaks closes thickness of two sheet metal welded together. Peak signals show high attenuation because material grain growth in the welding zone intensifys scattering of sounds. High signal attenuation repensets the accepatable penetration of a weld. The secondary echos represent that a weld nugget is undersized. Figure 4, 5 and 6 represent an acceptable weld, a weld with less penetration, a weld with undersized nugget respectively.

The calibration makes a complicated NDT process simple and feasible, especially at a mass production environment.

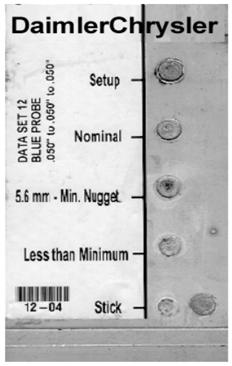


Figure 3 - Calibration Coupon

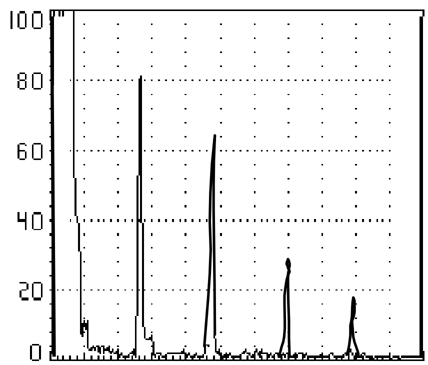


Figure 4 - Acceptable weld

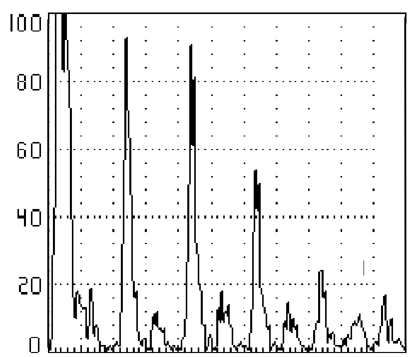


Figure 5 - Less Penetration

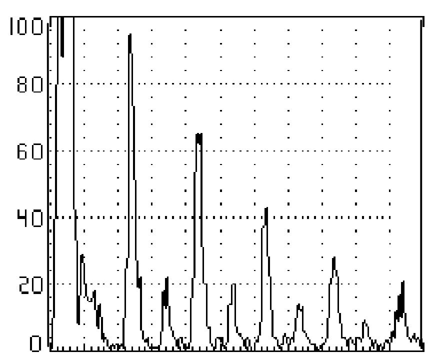


Figure 6 - Undersized weld

Training and Practice: Inspectors are certified by NDT program before using NDT for quality inspection. The certification includes two parts. One part is training in class, in which there are a class of sixteen hours of Resistance Spot Weld Inspection and a class of forty hours of NDT. Another is hand-on training that requires the practice in thirty minutes everyday for thirty days. Inspectors have to achieve at least 95% of accuracy, verified by destructive tests in order to be certified as NDT inspectors and re-certified by testing 50 welds every month.
To improve inspector's skill continuously, daily practice is more beneficial to inspectors. The inspection procedure requires to do NDT on the first sample, then destructive test on it to establish correlation between two tests. Inspector's confidence has been built up along their practice. The accuracy of NDT has been improved as figure 7, in which was based on the average of accuracy of 48 inspectors.

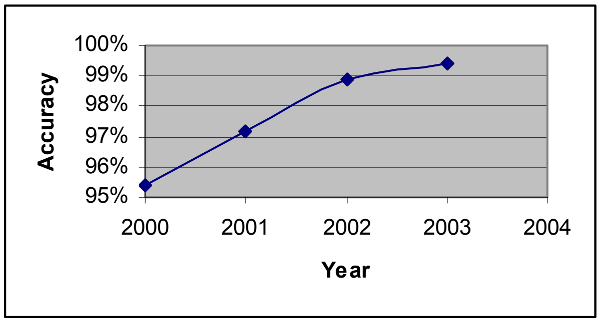


Figure 7 – Practices improved accuracy of NDT

Sampling Strategy : Samping plans are based on process capability, lot size, complexity of products and diffeculty of reprocess.
When a mean of samples is used to pridict a mean of population, the error can be represented as (4).

$$\varepsilon \cong \frac{3\sigma}{\sqrt{n}} \qquad (4)$$

Hence ε - prediction error, n – sample size, $\sigma = \sqrt{\dfrac{\sum (X_i - \overline{X})^2}{n-1}}$ - variation of samples, coefficient 3 – for 99.7% confidence, then

$$n \cong \left(\frac{3\sigma}{\varepsilon}\right)^2 \qquad (5)$$

Usually, the measurement error shall be less than 10% of process tolerance T. Process capability $C_p = T/6\sigma$, therefore

$$n \cong \frac{25}{C_p^2} \qquad (6)$$

(6) can be used to estimate sample size based on process capabilities.

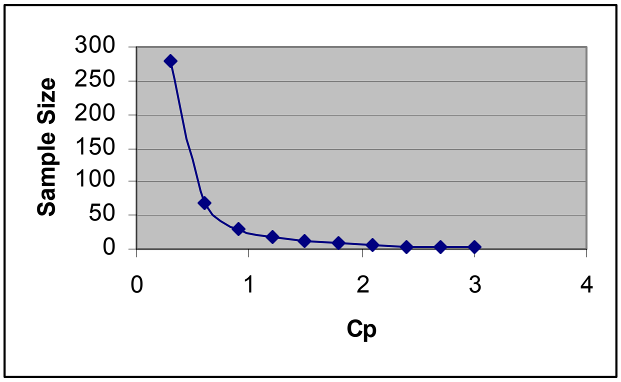


Figure 8. Sample sizes based on process capabilities

The sampling plan includes that one sample is inspected by a destructive test after NDT correlation study for eight hour production shift, parts during the period of a defect discovered shall be verified and a pry test shall be done at least while an uncertain NDT signal occurs.

Conclusions: In mass production environment, the system established has reduced the sensitivity of inspectors, improved the accuracy and reliability of inspection on A scan of NDT. However a new method or technology shall be developed to overcome the shortcomings of A scan, especially uncertainty of identifying a weld with lacking penetration.

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