Spot welding is used heavily in the automotive manufacturing sector.

What is a spot weld?
Spot welding is a technique used in industrial applications to quickly weld thin metal sheets together very quickly, often through the use of automated systems. The metal sheets are pressed together with two copper-alloy electrodes which hold the sheets together with tension. Current is then applied through the electrodes to melt the metal sheets and fuse them together at that spot, by creating a small area of fused metal known as the nugget. Spot welding is ubiquitous in the automotive manufacturing sector, where it’s used to construct car bodies and frames; a car contains an average of 5,000 welds! (1)

Spot welding has a number of key benefits that have seen its widespread adoption across many different industrial sectors. One of its main strengths is that it’s very fast compared to other methods of welding, with most joints taking 200-600ms (2) to achieve maximum strength. Another key benefit of spot welding is that it requires very little operator skill to perform properly, making it a great candidate for employment with automatic welding robots. In contrast with other common types of welding such as MIG & TIG, spot welding does not require many consumables to continue operation, merely a source of power and the occasional replacement electrode.
What kind of defects can be present within spot welds?

As with all welding techniques if aspects of the process are incorrectly controlled defects can occur in the finished piece and make it unsuitable for service. There are a number of factors that need to be controlled to make a suitable spot weld such as the clamping force, current amount, electrode condition & geometry and the welding time, and others. Typically, the tolerances involved in these variables mean that a difference of 10-20% in an important factor is likely to degrade weld quality below suitable levels. (3)

For example, if the clamping force is too great, it’s possible to excessively indent the metal during the welding process, impacting the integrity of the part. However, if the clamping force is too weak, not enough contact will be made between the micro-surfaces of the two sheets which, counter-intuitively, leads to much greater heat generation and an unsuitable weld.

How are spot welds tested for quality?

There are a number of different ways to test a spot weld for quality. The oldest used technique is a destructive one, known as the peel test. A peel test involves, as the name would imply, peeling or prying the welded pieces apart physically until the weld breaks and then inspecting the inside. The way the metal breaks apart, whether the pieces split or break, can determine the quality of the join. This can be useful to sample test batches for quality when no other method is available, but it is a time-consuming process that generates waste and sacrifices good welds.

An alternative and often preferable method is to use ultrasonic testing (UT) equipment. With UT, ultrasonic pulses are sent into the piece and the returning echo profile is assessed to infer material qualities. These come in different configurations, from large, fully-automated robotic systems to handheld single-spot devices used by operators on the factory floor.

The basic principle of operation for spot weld UT is for a small, high frequency delay-line transducer to be placed on the weld after it has cooled to attempt to measure multiple back wall echoes from the top of the first piece to the bottom of the second piece. This can be achieved with a standard delay-line transducer, but there are also specialist units with water-filled membranes to avoid issues with surface geometry.
What do common spot weld faults look like with ultrasonic testing?

**Good Weld:**

Ultrasonic Pulse travels from probe to back-wall of piece, back to probe.

Distance between echoes is the thickness of the conjoined piece.

Slight attenuation of echo amplitude due to heat-related changes to metal.

**Burnt Weld:**

Much greater attenuation of signal than with good weld.

High temperature has altered the grain structure of the weld metal, causing it to become much coarser.

Lots of oxidation visible.

Caused by excessive current, lack of clamping force, extended weld time, etc.

**Lack of Fusion:**

Ultrasonic pulse cannot reach bottom sheet as it has not fused to the top sheet.

Distance between echo peaks is the thickness of a single sheet.

Can be caused by insufficient heat, current or welding time.

**Stick Weld:**

Caused when pieces stick together but do not fully fuse. Initially looks like a sound weld.

More subtle presentation than other defects; marked by an increase in echo amplitude.

Lack of fused area reduces attenuation from altered grain structure, resulting in less measured attenuation as compared to a good weld.

Testing spot welds with Elcometer NDT

For this application, we recommend our FD700DL+ flaw detector combined with a 15 MHz, 1/4” acrylic delay-line transducer. The FD700DL+ is our compact weld inspection gauge featuring
60/120Hz full colour LED screen, adjustable voltage pulser and full data logging suite. Its small size, tuneable pulser and excellent display visibility make it the perfect choice for rapid on-line spot weld inspections.

For more information about our product range, application guides and more please visit elcometerndt.com or follow us on LinkedIn.

References
