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Q: We are considering changing our steel source for several of the parts we produce; however, one of the new materials is not approved by the automotive original equipment manufacturer (OEM). What approval process are they talking about? The proposed replacement appears to be the same as our existing one.

A: The process of joining two materials together is something that never really crosses your mind when you purchase a motor vehicle. In fact, it is almost something that is assumed since your driving of the final product is proof that it can be done. However, as with many things, a little digging reveals there can be much more to this process than meets the eye. In fact, the idea behind trying to determine how weldable a material is begins to make real good sense once you understand what it entails and its potential impact on the assembly of the final product. In actuality, the determination of a material's weldability is really a subset of a much broader characterization process the automotive OEM employs to ensure the material in question is suitable for the intended application. In other words, material characterization is really a methodology used to classify or describe a material that is based on an objective analysis of measurable characteristics.

While this discussion focuses on weldability, with the engagement of the right personnel, it could just as easily be a conversation about determining corrosion resistance, formability, or any of a dozen or more other manufacturing traits that need to be accounted for and addressed in order to successfully assemble the final product.

An analogy for the process of material characterization is that of a building inspector. Building inspectors work behind the scenes and their existence never really crosses your mind. But once you understand they are looking at the structure before the drywall goes up to ensure that all of the other supporting elements of the building (electrical, plumbing, ventilation, etc.) are in place and functional, you begin to understand why their role is so important from the point of view of protecting the eventual final customer. The welding characterization process works in much the same way as it affords the automotive OEM an opportunity to verify if the material is truly capable of being processed in its manufacturing environment, thus protecting you, their customer, and helping to ensure that they have made, and you are purchasing, a quality product.

Characterization Methodology

The predominate method utilized by all of the automotive OEMs for welding characterization is resistance spot welding (RSW). For completeness, gas metal arc welding (GMAW) and laser beam welding (LBW) are now also being considered or utilized for OEM characterization. Additionally, and as one would expect, each OEM typically wants the weldability characterization performed in a manner that is consistent with its processes and standards. As a result, the weldability characterization process is often performed on specific types of equipment so as to replicate the unique manufacturing environment in which the material will be used. A partial list of these unique manufacturing elements could include the following:

• **Electrode Caps.** The list of requirements in this area alone can be quite extensive and runs the gambit from taper types (male, female), taper standards (RWMA, ISO), body diameters, contact face geometry (RWMA A-nose, ISO-5821 Type-B, etc.), and last, but not least, the actual material (RWMA Class-1 or RWMA Class-2, in all their variations).

• **Weld Control.** The requirements in this area can cover the make of the control (manufacturer), the type of current [alternating current vs. midfrequency direct current (AC vs. MFDC)], and/or the methodology of using the control (automatic voltage compensation or constant current). As an aside, our experience has shown there can be some slight variation in weldability when utilizing different AC controls, but not so with the MFDC units.

• **Transformer.** Once the weld control has been determined, the selection of the transformer is really driven by the welding machine. However, care must be exercised in the selection as the lack of weldability variation seen in MFDC weld controls can reappear by the selection of the wrong MFDC power supply. This is especially true when performing aluminum characterizations.

• **Electrode Cooling.** Both the water temperature and flow rate may be specified for a particular characterization. While both are critical elements to be monitored and controlled, our experience has shown the actual physical condition and arrangement of the cooling system (water tube placement, size, integrity, etc.) are far more important than the actual temperature or flow rate.

An important point to keep in mind is that no one characterization evaluation can cover all possibilities. In fact, despite the performance of a thorough weldability characterization, it may be difficult to predict the necessary weld setup parameters for production operations. The reason for this is that each test is a singular condition among many possibilities and cannot account for the potential litany of material combinations, root opening or fitup concerns, general condition of the tooling, or other production variables. However, if the weldability characterization is conducted in a consistent manner, the process will allow for the determination of significant material traits that, when compared to other similar materials, can reveal where deviation from the norm has occurred and permit the OEM

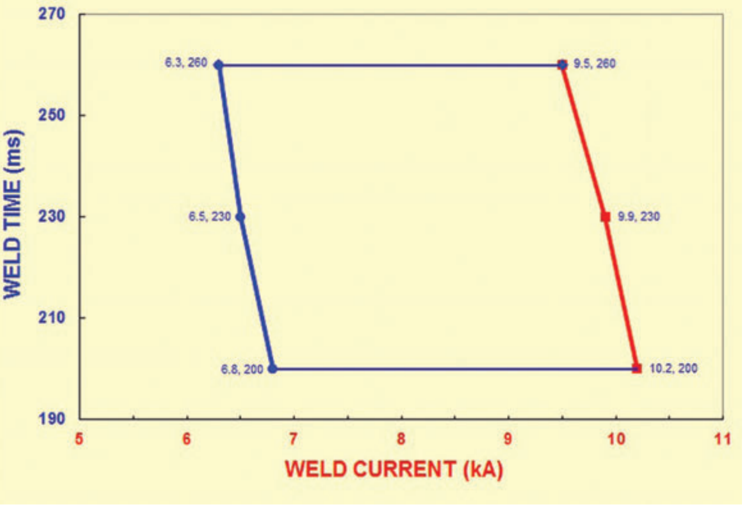

Fig. 1 — A resistance spot weld lobe.

to screen for potential issues. An excellent source for more detailed information about RSW material weldability characterization testing of sheet metal is AWS D8.9 (Ref. 1).

Characterization Elements

Once it has been determined how the material will be welded, the next step is to select the necessary characterization elements that are to be evaluated. The desired elements to be evaluated may vary based on the material gauge, coating, and substrate strength. A partial list of these unique characterization elements could include the following:

• **Weld Range/Lobe.** A weld lobe is a means of graphically expressing the numerous combinations of weld current and weld time that produce satisfactory welds for a specific set of conditions (weld force, electrode cap configuration, metal stack-up, etc.) (see Fig. 1 and the March 2012 RWMA Q&A for more details on weld lobes).

• **Fracture Mode.** This is the appearance of the weld after a destructive separation or peel test. (See the May 2010 RWMA Q&A for more details on fracture modes.)

• **Weld Strength.** This may be determined by either a quasi-static or dynamic test, with the latter being either a fatigue or impact test. The mechanical samples constructed for these evaluations typically test the weld in two directions, either full shear (0 deg) or normal to the weld (90 deg).

• **Hold Time Sensitivity.** This characterization element is related to a change in the weld's cooling rate and is really a man-made phenomenon related to processing. The changeover from multifixture, cascade-fire gun stations to almost complete robot welding has reduced the likelihood for this to occur. Consequently, some OEM tests no longer evaluate hold time sensitivity performance.

• **Electrode Endurance.** This element really focuses on the coating of the material and its wear effect on the electrode. As weld processing has changed, so has this evaluation. Almost entirely gone are the days of open-ended characterization tests that might go for 10,000 (or more) welds, replaced instead by more manageable, but still meaningful, sprints of just 500–1000 welds.

• **Current Sensitivity.** The advent of MFDC has brought to the fore the fact that some materials weld better with one current type than the other. While the vast majority of materials do not exhibit a preference, this is still an important evaluation element as the selection of current type is one area where the large OEMs and the smaller Tier 2 and 3 suppliers are most likely to approach welding from divergent points of view.

An important point to consider is that the descriptions of the above-mentioned elements do not contain one word regarding acceptability criteria. This was done on purpose as each OEM evaluates the material's performance of each element against its particular needs, and it would be impossible to try and provide more than the most generic of guidance in this area.

Final Thoughts

It is hoped these descriptions have served to illustrate the challenges facing both the steel and automotive OEM organizations as they strive to produce a quality product in a very competitive environment. At the least it should help illustrate there is a great deal that does occur behind the scenes as a product moves from concept to design and that one of the biggest challenges is the selection of the right material for the application. Just as consumers have a choice with regard as to what they consider important in a vehicle (passenger and/or cargo room vs. performance), the product designer must decide which of the above elements has more credence for their application.◆

Acknowledgment

The author would like to thank Eric Pakalnins for his invaluable perspective on resistance weldability material characterization.

References

1. AWS D8.9:2012, *Test Methods for Evaluating the Resistance Spot Welding Behavior of Automotive Sheet Steel Materials.* Doral, Fla.: American Welding Society.

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