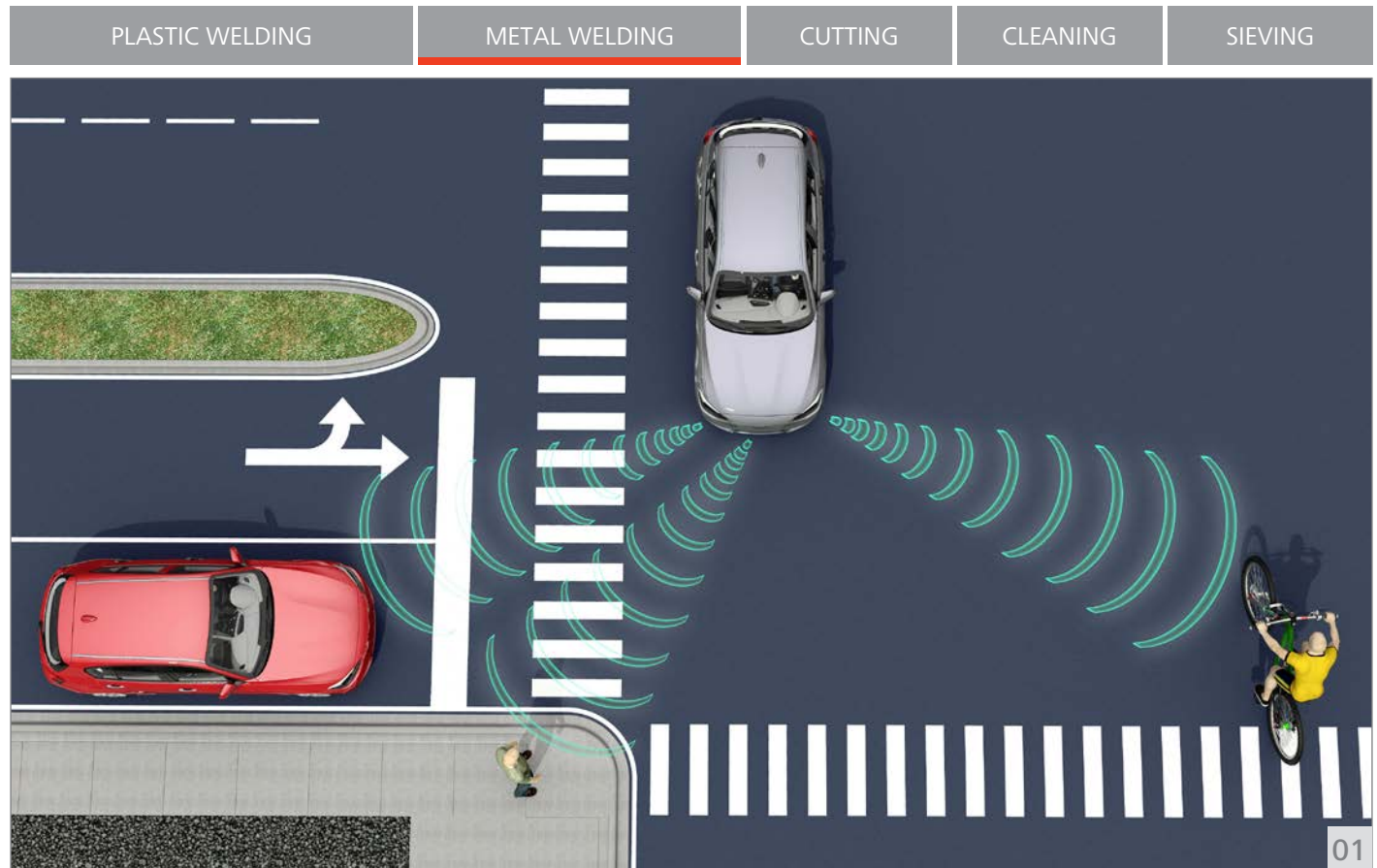


Reliable bonding technology for autonomous driving

Ultrasonic welding for fast processes with full control



Bronschhofen (CH), 10/2020

Autonomous driving - For a long time, it has seemed like science fiction. Now it is increasingly becoming a reality. In the next 10 years, driving as we know it will undergo greater changes than in the last 30 years. More and more sensors and camera systems are finding their way into modern motor vehicles. However, they all work only if they are reliably connected to the control and regulation units. As a result, the cable set becomes a key component. Ultrasonic welding is a practical procedure for connecting individual strands to each other or to a terminal. It guarantees fast process times, offers extensive possibilities for process control and the systems can be designed to prevent expensive rejects in advance.

At the end of development, the autonomous vehicle will make the human driver superfluous. Experts have divided the path to this goal into five successive levels of autonomy: assisted, semi-automated, highly automated, fully automated, and fully autonomous driving. With each passing level, more and more responsibility is taken away from the individual until all vehicle occupants ultimately become passengers and no driver's license is needed. Levels one and two are now offered as standard by all car brands. Stages three and four are in the test phase, series production is partly in preparation and the initial tests are underway for stage five.



01 Sensors and camera systems will enable autonomous driving in the future

02 Ultrasonically welded cables in various material combinations (Cu-Cu, Cu-Al, Al-Al)

Safety has top priority

Safety and reliability have the highest priority. Any danger to vehicle occupants and other road users must be safely prevented. In order to achieve the necessary safety level, manufacturers therefore rely on two approaches, similar to those used in aircraft technology: reliable technology and redundancy.

The corresponding procedure is defined in ISO 26262. The implementation of the standard is intended to ensure the functional safety of the electrical and electronic systems and components in the motor vehicle. Car manufacturers therefore also demand statements on the reliability of the technology and production of the cable set, because the best sensors and cameras are of no use if they are not reliably connected to the control and regulation units.

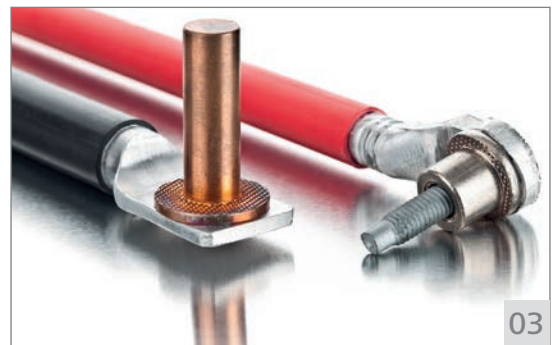
Ultrasonic metal welding

If individual strands are to be connected to each other or to a terminal, ultrasonic welding is considered proven and reliable. The purely metallic connection is not subject to aging or fatigue and, according to many OEMs and cable assemblers, no spontaneous failures are known to date. The firm bond also ensures very low contact resistances. Both the same and different materials can be joined together, e.g. copper and aluminum (figures 2 and 3). Additional consumables such as sleeves, solders or fluxes are not necessary, because the metals are welded together directly. In addition, there are short process times and low thermal stress on the joining partners. The material properties do not change and adjacent materials, e.g. insulation, remain intact. In addition, continuous process control can be easily implemented. Defective parts are detected and rejected. Depending on the level of automation of the system, bad parts can be disposed of immediately and subsequent errors can be prevented.

Best practices for reliable ultrasonic welded joints

Despite process control and error detection, the correct procedure should be followed when designing the joints and preparing for production. On the one hand, the industry standards USCAR38 (Fig. 4. stranded wire terminal connections) and USCAR45 (Fig. 2. stranded wire/stranded wire connections) of the SAE international (Society of Automotive Engineers) form the basis. Many automotive suppliers and cable assemblers also have their own regulations and guidelines that must be taken into account.

The connection point must be designed to withstand the mechanical, thermal and electrical loads during vehicle operation for the life of the vehicle. For example, the number of strands to be joined together plays a role, because insertion becomes difficult above a certain number. Incorrectly inserted strands are recognized by the process control as poor welding, but in order to avoid this rejection, a maximum number of eight wires has proven to be a good solution in practice. The smallest conductor cross-section should be at least 7% of the total cross-section; for dimensions below 5mm² it is 9%, so that missing strands are reliably detected. The largest cross-section should be a maximum of three times as large as the smallest one. A special case in strand welding, which, in principle, can be avoided by correct insertion or anti side-splice accessories, but which should nevertheless be prevented already at the design stage, is the symmetrical splice setup. If two or four conductors with the same cross-section are welded next to each other instead of overlapping, a vertical split splice may occur. This can be easily prevented by an asymmetrical node design.



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- 03 Copper pin and threaded nickel-plated copper pin welded onto an aluminum conductor rail
- 04 High voltage cable with nickel-plated copper terminals
- 05 High current contacts

Material selection, logistics and packaging

The choice of material greatly affects the welding quality. Copper with at least 99.9% purity (Cu-ETP, Cu-OFE) as well as aluminum with at least 99.5% purity (1050A, 1350A, 1370A, each with material condition H112, respectively O or F) are most suitable. Contamination with lead or coatings with tin have a negative effect. The same applies to larger quantities of extraction oils and additives on and between the individual wires. If aluminum cables are welded onto copper terminals, a 3 to 6 µm-thick chemical nickel plating of the terminals ensures that the connections are of high strength. Generally, the points to be connected must be as free of oil, grease, protective agents and dirt as possible. This has a direct relationship with properly storing the materials. High temperatures and long storage periods cause increased oxidation, an accumulation of the drawing oils present in all lines at the lowest point and plasticizer deposits on the stranded wires. All these effects have a negative influence on the welding quality and cause preventable rejects. With the TLF0100, ZVEI (German Electrical and Electronic Manufacturers' Association) offers a technical guide with application notes for automotive cables. Among other things, the cable manufacturers involved recommend maximum storage for up to six months at temperatures between +15 and +35°C in a dry place, protected from the weather and without direct sunlight and UV exposure. Needless to say, cables and joints must be protected from damage during storage and transport.

The production of cable sets is a semi-automatic process. Trained personnel load and unload the welding systems and start the process. Some terminals are also fed automatically, e.g. with MAK high-current contacts (Fig. 5). Clean work is required for materials preparation and the whole process. Contamination of the joining partners must be prevented, e.g. by wearing gloves. The prepared cables should only be partially stripped. The insulation is only completely removed just before it is inserted into the welding area. Application tests are also common at the beginning of a new production lot, as well as random tests at regular intervals thereafter. Changes in the supply chain can also result in modified material properties and should also be checked in the application. A user and rights management system ensures that only trained personnel can make changes to the production parameters.

Reproducibility and documentation

To ensure a stable process, the joining partners must be inserted in a reproducible manner. There are appropriate masks and stops for this purpose. Needless to say, the systems must be well-maintained. Only original spare parts are used and technical aids such as wire cutters and insertion aids are not manipulated or switched off. Modern welding systems enable item and age testing of the joining partners to be processed. They log all welding data and can save it on a network drive. Complete order processing is also possible via integration into a higher-level MES system like the 4Wire CAO from DiIT.

If users take all these points into account as early as during the design phase, it will enable optimizations that will subsequently prevent rejects and problems in the production of the cable set. Telsonic's application engineers will be happy to advise you with this matter. The ultrasound specialist already has over 40 years of experience in this field. They offer tailor-made solutions specifically for metal welding and support users from the design phase to integration, ensuring that the solution in question is perfect for the application.

by Christian Huber, Product Manager, TELSONIC AG (Switzerland), and Ellen-Christine Reiff, Stutensee editorial office



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