JOINing of copper to aluminium by ElectroMagnetic fields

Results in Brief

Dirt-cheap but strong-as-steel light metal joints

EU-funded scientists unveiled an innovative method of joining dissimilar metals, exploiting the excellent alloying properties of copper. This will highly benefit industries requiring the use of light, strong materials to manufacture efficient and durable components.
Balancing weight and strength has always been a challenge in the design of safer, higher-performance, cheaper and more environmentally friendly products for the manufacturing sector. Research results and successful industrial case studies have shown that reduced weight and improved performance can only be met if material properties and geometry are ideally adapted to the requirements, the load profile, and the function of the product.

Producing the desired shapes calls for innovative manufacturing strategies especially for materials that are difficult to handle. Joining metal alloys by electromagnetic pulse welding is a promising innovative technology that can meet this demand. “The process can be used for welding similar and dissimilar material combinations, including multiple ones that are difficult to join using conventional welding processes,” notes Verena Psyk, coordinator of the EU-funded project JOIN-EM.

Just as the name suggests, electromagnetic pulse welding uses electromagnetic forces for joining work pieces. The joint is formed without heat, depending more on the impact of the joining parts. The process needs no fluxes or shielding gases and produces no harmful smoke, fumes or slag. This reduces the overall negative impact on the environment. “Although this joining technique resembles more popular ones like explosive welding or cladding techniques, it is significantly less safety-critical. Thus, it can be more easily implemented in the industry,” adds Psyk.

Working principle

Electromagnetic pulse welding involves the use of a so-called pulse generator that mainly consists of a capacitor bank. When the required energy amount is stored in the capacitors, it is instantaneously released into a coil. The discharge current induces a strong transient magnetic field. The pulsed magnetic field generated induces an opposite current in the work piece.

The interaction between the two currents and the magnetic field generate Lorentz forces that accelerate the work piece to very high velocities during a very short period of time. After overcoming the initial gap in between, the work piece impacts with the target work piece at a very high velocity. The quality of this collision depends on the impact velocity and the collision angle. If these collision parameters are within a process window, then a welded joint is generated, which frequently features a wavy interface.

Optimising use of a finite resource
Due to its excellent thermal and electrical conductivity, copper spans a wide range of applications, especially heating and cooling equipment and electrical devices. However, it is a heavy metal and its intense application contradicts modern lightweight approaches. Given its rising demand and the current level of known reserves, copper will become more expensive and difficult to obtain, creating an additional cost issue for manufacturers.

JOIN-EM aimed to decrease the consumption of copper by partially substituting it with aluminium. “Our new joining solution helps implement improved lightweight designs of copper-aluminium hybrid parts with further cost reduction and better performance. Joining operations will be performed faster and more efficiently, resulting in longer-lifetime and higher-quality joints. Put together, all these will decrease energy consumption and greenhouse gas emissions – an increasingly significant requirement for several industries,” explains Verena.

Project partners demonstrated the success of their new joining process in three full demonstrators – a refrigerant circuit, a flat condenser and a pouch cell. They are also now exploring the possibility of applying their process to other multi-material joints including copper-steel and aluminium-steel alloys.

Keywords
JOIN-EM, joining, joint, copper, aluminium, electromagnetic pulse welding, dissimilar metal
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