

Development of single-sided spot welding opens up new possibilities in rail vehicle manufacturing



Tobias Broda, until the end of last year the head of the technical division of pressure welding at the SLV Halle, at the test facility: Together with Nimak, he developed a single-sided spot welding system with thermal expansion-based process control. (Photo: SLV Halle GmbH)

“From now on, this innovation allows construction methods that were inconceivable earlier,” stresses Tobias Broda, who until the end of last year was head of the technical division of pressure welding in the R&D Department of the Welding Training and Research Institute (SLV) Halle (<https://www.slv-halle.de/en/>) in Halle/Germany. He adds: “It is precisely in the joining technology used in rail vehicle manufacturing where the new process equals a technological breakthrough.” He talks about a joint development with Nimak GmbH (<https://www.nimak.de/en/>) in Wissen/Germany, according to the company’s own statement one of the world’s leading providers in the area of resistance welding technology and Germany’s largest manufacturer of robot and hand-held welding guns.

In cooperation with Nimak, Broda succeeded in developing a single-sided spot welding system with thermal expansion-based control. The idea for this project supported by the Central Innovation Program for Middle-Sized Businesses (ZIM) of the German Federal Ministry for Economic Affairs and Energy is based on the “magneticDRIVE” technology likewise developed by Nimak. In this technology, the use of a microprocessor-controlled electromagnet allows to control for the first time not only

the intensity of the current, but also the force and its course during pressure welding. This allows the implementation of a very precise and gentle force buildup as well as individual force profiles, which in turn allow extremely short joining processes within 10 to 20 ms. “Thanks to the instantaneous control of the ‘magneticDRIVE’ the programmed target force is ensured,” adds Kay Nagel, Head of Sales at Nimak.

It is precisely in sectors for which light construction concepts play an important role where the new development in single-sided spot welding offers entirely new possibilities. This is, for example, also the case in rail vehicle manufacturing – the core competence of SLV Halle – where profile constructions and, in the future, tubular structures can lead to considerable weight savings. The conventional double-sided resistance spot welding used to date is increasingly reaching its limits here, as the joints cannot be reached owing to the construction geometry. Basically, resistance welding is very interesting in lightweight construction because it is still the most economical joining technology and allows fast joining processes. In this respect, it was important to develop a solution that also satisfied the demanding requirements of working with aluminium while ensuring high reproducible quality.

Single-sided spot welding with thermal expansion-based control

Contrary to conventional double-sided spot welding, in which the two electrodes can no longer fit closely opposite one another in the upper and lower sheet metal in single-sided joining, Nimak has developed an entirely new double welding gun. This was also about mastering the special challenge of spot welding aluminium. Because aluminium conducts electric current particularly well, it is difficult here to guide the current flow through the upper and then also through the lower sheet metal or the framework structure and back once again. In order to create high-quality connections here, it is necessary to work with especially matched welding force programs. That is exactly where Nimak has now succeeded with the new double welding gun, which differs from conventional

double welding gun installations by using two “magneticDRIVE” force and repositioning systems with integrated force control instead of the conventional pneumatic ones of the electromotive units.

At the same time, the “magneticDRIVE” system has a path measuring system or sensor technology that allows measuring the expansion of the spot during welding. Tobias Broda investigated the extent of this thermal expansion in the joint project to derive a manipulated variable from it for the welding process. The objective of his work was to develop a reliable correlation between expansion and shrinkage as well as the diameter of the spot. “We allowed the results of this analysis to flow into the programming of the thermal expansion control,” explains Kay Nagel. “Based on this, the optimal current, time and force profiles for each case are used during the course of the welding process.” The magnet’s path or current signal is also used in this respect to influence the spot size by adapting the force.

Thus, “magneticDRIVE” is now used in two ways: First when measuring the heat-related spot expansion, something that had not previously been considered, and secondly during the expansion of the spot, when the electrode then



The newly developed double welding gun by Nimak with two electrodes that simultaneously press on the sheet metal from one side also allows the joining of places accessible from only one side. (Photo: Nimak GmbH)

instantaneously repositions. This force control results in an even better welding result. Depending on the material strength of the aluminium, welding can be done with a current significantly lower than 50 kA, thereby facilitating the use of smaller welding transformers and inverters, which leads in turn to a substantially lighter welding system and promotes the use of industrial robots.

Quality requirements for rail vehicle manufacturing are fully met

“The objective of single-sided spot welding with thermal expansion-based control is to achieve an optimal spot size that should also have as few imperfections as possible,” summarises Kay Nagel. “Thanks to the possibility of being able to measure exactly how strongly the spot expands and how deeply the electrode will later sink into the sheet metal, we can precisely say whether the welding process meets the requirements.”

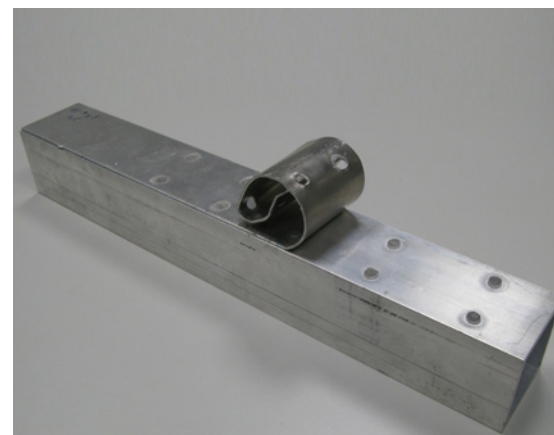
Tobias Broda, the previous head of the SLV technical division, has confirmed that this has been demonstrated for rail vehicle manufacturing. According to the standard DIN EN 15085, the new welding technology meets the stipulated requirements for rail vehicle manufacturing, in Germany especially for the German Railways (Deutsche Bahn). The quality requirements have been met because the minimum diameter of the spot and its required stress have been



View of the production of Waggonbau Niesky: Profile constructions and tubular structures are playing an increasingly important role in rail vehicle manufacturing as well. Here, single-sided spot welding opens up new possibilities. (Photo: André Schulze)

achieved. Process stability has also been demonstrated as part of a procedure qualification test according to DIN EN ISO 15614 Part 12 through visual inspection, shear strength tests and macrosections done on a sample compound.

“The new Nimak welding method is therefore ready to be marketed,” states Broda. Even if it will often take considerable time for a new technology to be applied in practice and rail vehicle manufacturing will generally act rather reluctantly in doing so, Broda is optimistic: “With a recent exchange of experiences and further education for the welding supervisors in rail vehicle manufacturing at the SLV Halle, the development is positive and has been adopted with interest.” (According to press information from Nimak)



The quality of the single-sided spot welding is proven by the peel test: Its strength is higher than the basic strengths of the raw material. Furthermore the determined spot diameter of the joining is excelling the basic requirements of rail vehicle manufacturing. (Photo: SLV Halle GmbH)