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PRZEGLĄD SPAWALNICTWA Welding TECHNOLOGY REVIEW

Evaluation of spot welding joints by ultrasonic method

Abstract

The basic connection used in the construction of vehicle bodies is the spot welded connection. On average, there are about 6,000 such connections on the car body. Despite the fact that this type connections have been used at the of vehicle manufacturing stage for many years, it is necessary to control the quality of spot welds in order to achieve high quality, stiffness and durability of the whole car body. There are two groups of methods for assessing the quality of spot welds, which include destructive and non-destructive methods, in particular ultrasonic methods. The article presents selected results of ultrasonic inspection of spot welds of vehicle body and verification-using destructive tests. Ultrasound transducer with a water delay line and a frequency of 20 MHz were used. The number of return echoes from the connection area and the RWS parameter were determined. Metallographic examinations of connection area were also made and shear force for connections of different quality (change in welding current intensity) was determined.

Keywords:
ultrasonic testing;
automotive vehicles;
car body;
spot welded joint

Introduction

Resistance spot welded joints are currently most commonly used to connect vehicle body elements. In addition to these joints, adhesive, brazed and laser welded joints are also used. On one car body, on average, there may be approx. 6000 spot welded joints, which are designed to ensure adequate stiffness and durability of the body during its operation. The quality of spot welds is determined by the parameters of the welding process [1,2]. Nevertheless, at the stage of car body production, vehicle manufacturers require the use of a control to confirm the quality of the joints made.

Testing of spot welded joints is carried out using both destructive and non-destructive methods. In the case of the first of the aforementioned groups of methods, the merging of the joint and the assessment of its structure and defects under the microscope dominate, but dereferencing and breaking of the joint is also used. The second group of methods – non-destructive – is dominated by the ultrasonic method [4÷6], which allows to evaluate the connection without interfering with its structure. In welded joint tests, the systems for assessing the welded connection in real time can also be used, which check the quality of each joint on a regular basis during production [7,8]. These systems are based on neural networks and are based on measuring the electrical parameters of the welding process. In recent years, there have also been devices that allow to visualize the diameter of the weld nugget [9]. They are based on the ultrasonic method, but allow, unlike a standard flaw detector, to visualize the joint.

The main purpose of the tests was the ultrasonic and destructive evaluation of spot welded joints that were made for various parameters of the welding process.

Conduct of the study

The tests were carried out in the non-destructive testing laboratory of the Poznan University of Technology. Samples of 0.8 and 1.2 mm thick steel sheets were used, electrogalvanized on both sides, which are used at the stage of manufacturing modern car bodies. The welded joints were made using a manual welder, and the electrodes had a diameter of 16 mm and a front of 4.5 mm. Constant electrode pressure was applied during the welding process, which was 2.5 kN. The welding process time was 0.28 s, and the process itself consisted of two impulses. The samples were made at different welding currents (5.0, 5.9, 6.9, 7.9 kA), and the view of one of them is shown in Figure 1.

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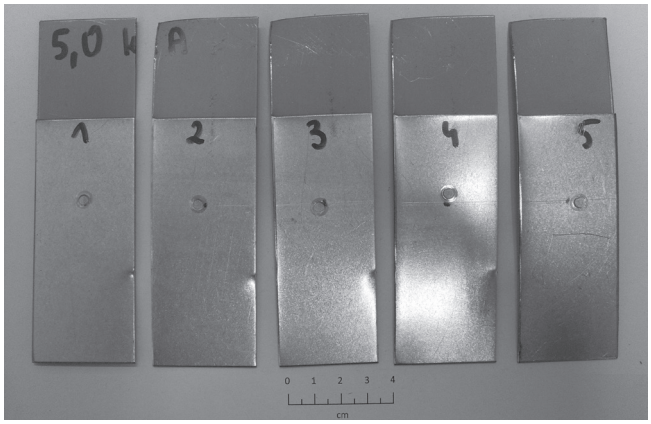

Fig. 1. View of the spot welded connections

The prepared samples were subjected to ultrasonic testing using a modern ultrasonic flaw detector and a transducer with water delay line. Each sample was subjected to ultrasonic testing seven times, which was determined on the basis of the coefficient of variation after 30 measurements on one weld. During the measurements, the number of return echoes, the number of intermediate echoes and the RWS parameter were saved, i.e. the thickness of plates after the joint was made. An exemplary view of the flaw detector screen and the view after the macroscopic observations during the implementation of basic research are shown in Figure 2 (good quality joint), Figure 3 (joint with too small diameter of the weld nugget), Figure 4 (joint with existing defects in the weld nugget).

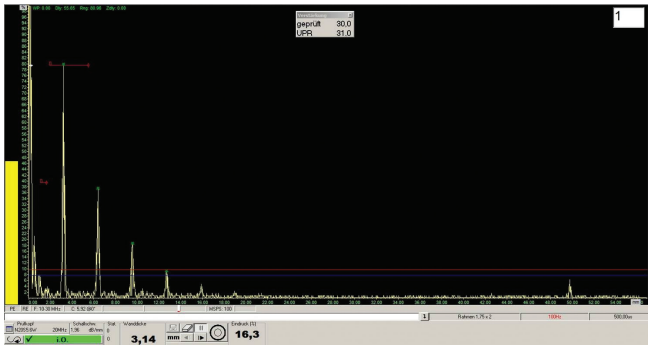

Fig. 2. The view of ultrasonic flaw detector screen for the high quality spot welded connections

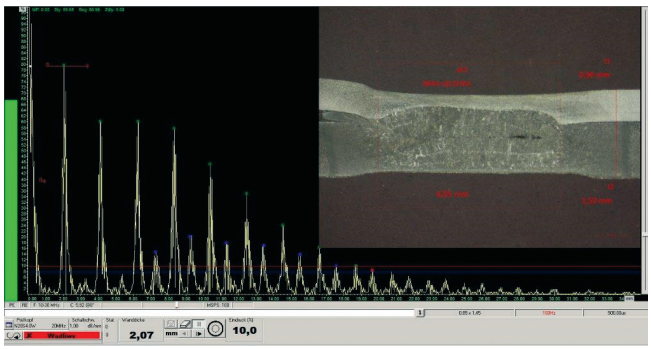

Fig. 3. The view of the ultrasonic flaw detector screen and metallographic section from too small nugget

The results of ultrasonic measurements were verified on the basis of mechanical tests – shearing tests carried out on a universal testing machine. After the samples were torn apart, each weld was subjected to measurement of the diameter of the weld nugget in two perpendicular directions, and the average value was taken as the final result. An exemplary result during the measuring of the weld nugget is shown in Figure 5.

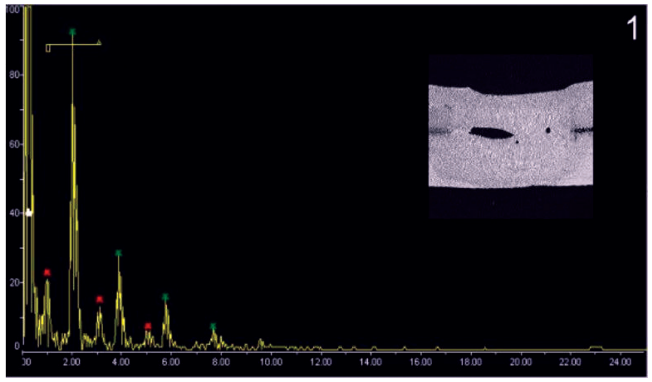

Fig. 4. The view of the flaw detector screen and the metallographic section of the weld nugget with defects

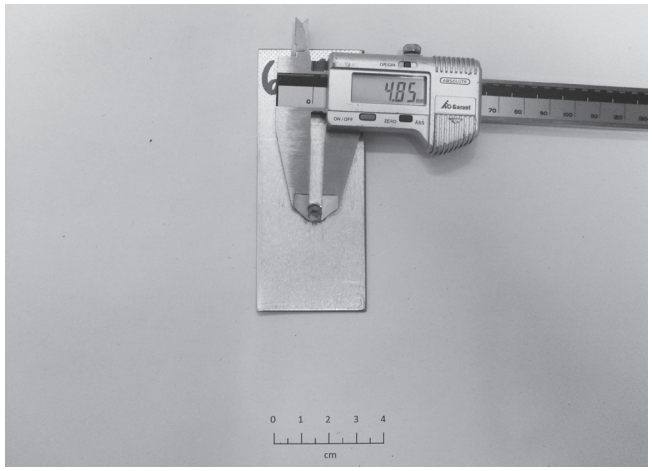

Fig. 5. Measurement of the weld core diameter

Research results

The results of ultrasonic and mechanical tests (shearing tests) are summarized in Table I. A total of 28 welded joints were tested (7 for each welding current) and seven ultrasonic measurements were made at each of the spot welded joints.

Analyzing the summarized test results in Table I, it should be stated that the minimum diameter of the weld nugget, for the car body sheets used, should be 3.6 mm, and the minimum shear force is 2.3 kN. On the basis of the obtained results, it can be stated that with the increase of the welding current the diameter of the weld nugget also increases. In the case of a welding current of 5.0 kA, the lack of fusion of the car body sheets was obtained for all of the joints, which was connected with the lack of the weld nugget. Low quality of these connections have not only been confirmed by ultrasonic testing, but also by a shearing test and the lowest obtained average shear force for all tested samples. In addition, for the 5.0 kA current, the minimum diameter of the weld nugget could not be determined because the joint penetration and the connection of zinc layers occurred. This is an undesirable phenomenon (no connection of the main material, connection only in the area of the protective layer) and in the future corrosion centers could be formed in the area of these joints. The remaining samples of welded joints are of high quality, as evidenced by the results of ultrasonic tests (the number of return echoes, the lack of intermediate echoes and the value of the RWS parameter at the level of approx. 1.6÷1.8). Also the obtained weld nugget diameters after the tearing of samples, which are higher than the minimum required diameter confirm the high quality of connections.

Table I. Average values of parameters obtained during ultrasonic and mechanical tests of spot welded connections

Welding Current [kA]	Ultrasonic measurement			Shearing test		Uwagi
	Return intermediate echoes	Intermediate echoes	RWS	Force [kN]	Diameter [mm]	
5.0	5.2	3.2	1.65	1.86	Brak	Low quality of the connection – lack of fusion, no diameter of the weld nugget
5.9	6	0	1.77	4.01	4.2	High quality of the connection
6.9	5	0	1.72	4.86	5.8	High quality of the connection
7.9	6	0	1.66	5.11	6.9	High quality of the connection

Summary

Taking into account the research and the conclusions obtained, the following statements can be made:

- Ultrasonic method with the use of modern ultrasonic flaw detectors and a 20 MHz transducer with water delay line allows for non-destructive assessment of the quality of spot welded joints of modernly produced car bodies, including those made on 0.8 and 1.2 mm sheet metals electrogalvanized on both sides.
- The parameters used for the ultrasonic evaluation of the quality of welded joints are primarily the RWS number of echoes and intermediate echoes returning from the bottom of the sample and the area of the evaluated joint.
- With the increase in the welding current, the diameter of the weld nugget and the shear force necessary to destroy the joint also increased.

Ultrasonic and mechanical tests were performed for selected combinations of sheets, therefore it is necessary to perform tests for a combination of other (thicker) car body plates at a later stage.

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