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mgr inż. Łukasz Wszołek

Faculty of Transport

Silesian University of Technology

Summary of doctoral thesis

Estimate of the operational properties of aluminium alloy wheels welded with micro – jet cooling technology

In the doctoral thesis it was decided to check how welding using the innovative method of micro-jet cooling affects the operational properties of wheels made of aluminium alloys. On the basis of preliminary tests, it was found that micro-jet cooling affects the quality of the formed joint and allows controlling its structure.

At the initial stage of the thesis, it was checked how micro-jet cooling welding affects the formation of micro surface cracks. Tests were performed on a silumin AlSi11 alloy and the results clearly confirmed the positive effect of micro-jet cooling, which significantly reduces the depth of the micro-cracks.

Next, tests on the effect of micro-jet cooling on the metallographic structure of the formed joints was carried out. At this stage of the tests, it was decided to use elements of Volkswagen and Daewoo vehicle wheels. On the basis of the analysis of the metallographic structure of the formed joints, it was found that the β phase fragmentation in welds formed with micro-jet cooling was on average about 40%, compared to the size of the β phase grains in the welds after welding without additional cooling. The finer and more evenly distributed beta phase allows to achieve higher plastic properties of the weld. It was also decided to perform a phase analysis of joints welded with micro-jet cooling. For this purpose, Volkswagen and Daewoo wheels were also used. A phase analysis showed that the MIG joints welded with micro-jet cooling, in addition to the presence of two basic crystalline phases, have an additional phase with the structure Fm-Z3m and the chemical formula Fe3Si. The presence of this phase is very beneficial because it corresponds with β phase fragmentation. Based on the analysis, it was found that despite differences in chemical composition, joints made using micro-jet cooling show β phase fragmentation, which means higher plastic properties of the joint.

The next step was conducting tensile strength tests. The use of micro-jet cooling resulted in the lowering of tensile strength and yield stress, while it significantly increased relative elongation, which improved the operational properties of the wheels. On the basis of the tensile strength test results, it was once again proven that the use of micro-jet cooling is the right way to improve the properties of welds formed during welding of aluminium alloys.

One of the stages of the presented thesis was checking the impact of micro-jet cooling on the formation of welding imperfections using non-destructive testing. They made it possible to conduct quality control of aluminium welded joints. After inspection of the welding imperfections in the joints it was found that micro-jet cooling had no influence on the imperfections.

The main objective of the thesis was to undertake activities aimed at improving the operational properties of aluminium alloy car wheels after welding repairs. In order to prove the thesis of the doctoral thesis, tests on a real object were carried out. It was decided to compare

the properties of never repaired original wheels with the properties of wheels repaired with welding methods. Due to its prevalence among available methods in regeneration establishments, the MIG method was used as the welding method. Volkswagen light alloy wheels were chosen for the tests and they were carried out in Pronar Sp. z o.o. in Narew on a device specially designed for testing wheels in real conditions of wheel-to-ground interaction. The results of the tests carried out on real objects in conditions imitating the real interaction of the wheel with the road clearly showed the beneficial effect of micro-jet cooling used during repair of wheels with welding methods, resulting in a significant extension of the service life of the repaired wheels. Based on the analysis of the test results, it was found that wheels welded with micro-jet cooling had fatigue strength higher compared to wheels repaired with the traditional MIG method.