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ROZPRAWA DOKTORSKA

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Ocena właściwości mechanicznych i strukturalnych złączy spawanych pojazdów w warunkach dynamicznych obciążeń granicznych

Evaluation of mechanical and structural properties of welded joints in vehicles under dynamic limit loads

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Summary

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"Evaluation of mechanical and structural properties of welded joints in vehicles under dynamic limit loads"

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The thesis presents the results of strength tests conducted on welded joints subjected to high deformation rates. The tests were performed using a rotary hammer equipped with a system for recording rapid movements under bending and tensile loads.

The experimental research was preceded by a literature analysis of testing methods for welded joints.

The analysis revealed that the mechanical properties of welded joints are determined through standard strength tests, the procedures generally well-known and strictly defined by standards. These tests are typically carried out using a pendulum hammer, applying static tensile and impact bending conditions. The strength characteristics obtained from such tests were considered sufficient until recently. However, the utilization of new high-strength steels in the transportation industry has led to the development of strength testing methods that account for high deformation rates. The literature review demonstrates that current research also involves dynamic testing methods for welded joints, particularly for those made of high-strength steels and designed for applications such as tailored blanks.

The thesis of the work was formulated based on a literature analysis and personal experience: "The mechanical and structural properties of welded joints, as well as and their ability to withstand dynamic loads are significantly influenced by on the linear velocity of the external load, which is responsible for locally high deformation rates."

The research scope included bending and tensile tests as well as microfractographic evaluation of materials.

A research plan and methodology were developed during the course of this study. The research material selected was structural steel of the S355J2+N grade, known for its guaranteed weldability. Samples were prepared using the welded joint material, native material and weld metal. These samples were then subjected to strength tests conducted using a pendulum hammer. The tests examined linear velocities of the driving element at 10, 20 and 30 m/s, which corresponded to average strain velocities of 500, 1000 and 1500 s^{-1}, respectively, in the tensile tests. The results were compared with those obtained from static tensile and impact bending tests.

The assessment of the bending test results demonstrated an increase in the impact strength of the analysed materials with the linear velocity of strain. The dynamic tensile tests showed a significant increase in the materials tensile strength across the entire strain rate range, compared to the results obtained in the static tensile tests. Differences in fracture types were observed during the microfractographic tests of the samples, with the appearance of these differences depending on the loading method – either bending or stretching. In the dynamic bending tests, brittle fracture zones were identified, and their occurrence increased with the strain rate. However, this phenomenon was not observed in dynamically stretched samples.

When evaluating the strengthening and strain mechanisms in bending and tensile tests with high strain rates, it is important to consider the adiabatic conditions of strain which involve the absence of heat exchange with the environment. These conditions affect the temperature increase of the material and can influence the thermally activated structural phenomena - particularly the rise of plasticity.

The work has been completed with a summary and conclusions. Additionally, it has highlighted that the rotary hammer test can be considered a recommended method for strength testing of welded joints, primarily due to the suitability of the sample types used. This straightforward testing technique allows for a convenient comparison of results with those obtained from standard bending and tensile tests.