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SUMMARY OF THE DISSERTATION

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Influence of linear energy of the welding arc on the structure and properties of joints DD11 and DD14 steel

The main directions in the development of special-purpose rims are focused on enhancing their strength properties and corrosion resistance, driven by the demanding operating conditions. One crucial criterion for designing rims is their compatibility with welding technologies, where the properties of the joint depend on the thermal cycle, which in turn is influenced by the linear welding energy. Determining the impact of energy of the welding arc on the structure and properties of joints ensures the safe operation of such components.

This study attempts to determine the influence of linear energy of the welding arc and laser beam on the structure and properties of joints made from DD11 and DD14 steels, which are used in the production of specialized rims. Based on this, the potential for using innovative joining technologies — such as laser welding, hybrid welding, and double-pulse MAG welding — was evaluated. These methods offer increased process efficiency compared to the currently used MAG method and resistance buttwelding technology employed for rims smaller than 20 inches.

In collaboration with the Welding Center of the Silesian Institute of Technology (GIT) in Gliwice and the Yokohama-TWS Lipawa manufacturing plant in Latvia, technological trials of laser, hybrid (laser + MAG), and double-pulse MAG, as well as resistance buttwelding and MAG welding, were conducted. Non-destructive and destructive testing was performed to assess the quality of the welded joints. Non-destructive tests included visual, penetrative, and radiographic examinations. Destructive tests involved static tensile, impact, bending, and hardness tests. The collected data were used to develop finite element welding process models and to perform statistical analyses of the results. It was confirmed that the joints met the quality level B criteria for the respective welding methods, except for the laser-welded joints, which exhibited numerous pores. The joint strength averaged 400 MPa for DD11 steel and 320 MPa for DD14 steel. The average impact strength at 20°C was 145 J/cm² for DD11 steel and 166 J/cm² for DD14 steel. At -40°C, it averaged 142 J/cm² for DD11 and 161 J/cm² for DD14. No cracks were detected during the bending test.

Additional metallographic and corrosion resistance tests were conducted on the joints in a salt fog and humid sulfur compound atmosphere, simulating operating conditions for rims. No significant differences in corrosion resistance were found between the base material and the welded joints. Technological guidelines were developed for qualifying the welding technology for DD11 and DD14 steel in specialized rim production. The study demonstrated that resistance welding is the most efficient process based on the time required to join the cylinder and perform machining. Hybrid welding and double-pulse MAG welding are three times slower than resistance welding but twice as fast as the currently used MAG method.

The results confirmed the hypothesis that linear energy of the welding arc and laser beam influence the structure and properties of joints. Consequently, modern, high-efficiency joining processes can be applied in the production of specialized rims, meeting customer requirements according to ETRTO guidelines.

Keywords: special-purpose rims, modern welding technologies, low-carbon steels for cold forming.