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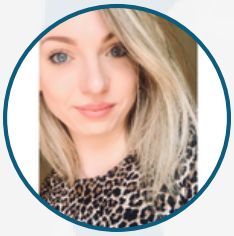

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Influence of Tool Geometry on Material Flow, Temperature Evolution, and Mechanical Properties in the Friction Stir Welding of AA6082

Abstract: The friction stir welding (FSW) process for joining AA6082 aluminum alloy was simulated utilizing computational fluid dynamics (CFD) to examine the effects of tool geometry on the resulting joints. Two distinct tool geometries were employed: a tapered cylindrical pin (simple pin) and a hexagonal pin with grooves (complex pin). The simulations were analyzed in terms of temperature evolution, total heat input, residual stresses, and material flow dynamics. The simulation results indicated that the use of the complex pin resulted in a miximum temperature of 406 °C, which is 5% higher compared to the simple pin. This increased temperature, coupled with higher shear stresses during the welding process with the complex pin, resulted in elevated residual stresses within the weld. Subsequent experimental evaluations of the produced welds included microstructural observations, hardness testing across cross-sections, and tensile strength assessments. The increased temperature during welding with the complex pin facilitated a more effective recrystallization process, leading to enhanced grain refinement in the stir zone (SZ). Specifically, the average grain size in the SZ was measured at 11 ± 1 µm for welds produced with the complex pin, in contrast to 14 ± 1 µm for those produced with the simple pin. Hardness profiles demonstrated that the welds fabricated with the complex pin exhibited higher hardness in the stir zone, recorded at 89.5 ± 1.3 HV, in accordance with the Hall-Petch relationship. The ultimate tensile strength (UTS) values corresponded to joint efficiencies of 72.5 ± 4.9% for the complex pin welds and 55.8 ± 8.6% for the simple pin welds. The findings underscore the significant influence of tool geometry on the thermal and mechanical properties of FSW joints.

Keywords: aluminum alloys, computational fluid dynamics, COMSOL, friction stir welding, mechanical properties, microstructure

Biography: Aleksandra Mirowska PhD, Eng, is an assistant professor at the Faculty of Mechanical Engineering and Ship Technology, Gdańsk University of Technology, Poland. The scientific disciplines she represents are mechanical engineering and materials engineering. Her research interests are related to metals science broadly, with a particular focus on aluminium alloys. She has completed numerous internships in scientific centres in Iran, Taiwan, Italy, Germany, Belarus and Slovakia. She defended her doctoral thesis entitled "Influence of friction stir welding technological parameters on the properties of the joints of selected aluminium alloys" with distinction in the mechanical engineering discipline. She is a reviewer for journals such as Journal of Materials Engineering and Performance, Steel Research International, Scientific Reports and more.

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