Abstract

Friction stir welding is a joining process, which involves the joining of metals without fusion or filler materials. In this study, the effect of tool pin profile on the mechanical properties of aluminum alloys AA2024-T351 joints produced by friction stir weldingwas investigated. Four different tool pin profiles weredeveloped,there are straight cylindrical, step cylindrical, straight triple-sided prism, and straight square blockwhich were used to weld the joints. All the welds were produced perpendicularly to the rolling direction for aluminum alloys. Tensile and bending tests were performed to evaluate the mechanical properties by using computerized universal testing machine. Among the four tools, straight square blockpin profile gives better tensile strength (265 MPa), elongation (4.9 %), maximum bending force (1450 N), and maximum welding efficiency (61%) in terms of tensile strength.

Statistical analysis was applied for obtaining mathematical models that relate the mechanical responses; elongation, tensile strength, and maximum bending force, with the input parameters; welding speed and rotational speed, to verify the adequacy of these models. The resultant quadratic models showed that as the rotation speed or welding speed increases, the tensile strength and elongation of the joint firstly increases to a maximum value and then decreases due to the occurrence of void defects. Increasing both welding speed and rotational speed leads to an increase in the maximum bending force to a maximum value and then decreases. However, the welding speed was found more significant than the rotational speed. A good agreement was found between the results of these models and optimization with the experimental ones with a confidence level of 95%.

ANSYS®14.0 software was used focusing on moving heat flux approach to simulate the temperature distribution and residual stresses induced by friction stir

welding process. The results of the simulation are in good agreement with that of experimental results. The peak temperature obtained was 766.57 K at (980 rpm) rotational speed and (20 mm/min) welding speed, which was less than the melting point of AA2024-T351(775 K).The experimental data showedthat the tensile residual stress measured during FSW at mid position of the weld joint is 262 MPa, and the numerical tensile Von-Mises residual stress value from the simulation is 248 MPa with discrepancy percentage of 5.28%, at rotational speed of 980 rpm and welding speed of 20 mm/min with optimum tool selection.