Abstract

Friction stir welding (FSW) is one of the relatively modern types of welding process. It is considered as a solid state joining for metal that is widely used for Al-Alloys that known to be difficult to be weld. This thesis is concerned with the study of friction stir butt welding for the aluminum alloys (2024-T3, 6061-T6), from which 3 mm sheets were chosen for the experimental work. A conventional milling machine was used to perform the welding processes, a threaded pin with a diameter of 3 mm and a shoulder of 10 mm was used with 900 rev\min rotational speed and 16 mm\sec travel speed. Two types of welding joints were done, similar joint materials (2024 T3 - 2024 T3) and dissimilar joint materials (6061 T6 - 2024 T3).

In the experimental study, a series of residual stress data were measured, using x-ray diffraction techniques, for the welded joints. The measured results revealed that the maximum compressive residual stress of similar 2024 T3 joint is higher than the yield stress of the 2024 T3 base metal.

The change of mechanical material properties due to high temperature exposure and forming the tensile residual stresses during the welding process was studied by conducting experiments on specimens. It was obtained that the tensile properties for the welded joints was lower than those of the base materials and the welding efficiency reached to 62.8% ,with respect to ultimate tensile strength, for the similar 2024 T3 joint.

The microhardness distribution was also investigated during this research. The minimum microhardness values recorded were 64.8% of base metal in the heat affected zone, 70% of base metal in nugget zone for similar 2024 T3 - 2024 T3 joints, and 66% of 2024 T3 base material in heat affected zone in 2024 T3 side and

80 % of 6061 T6 base material in heat affected zone in 6061 T6 side, for the dissimilar 6061 T6 - 2024 T3 joints.

The fatigue behavior under constant amplitude stresses were studied under different welding line positions for the similar and dissimilar FSW joints. Results showed that the fatigue strength at 10^6 cycles depended strongly on the welding line position, where for welding line at a distance 0.35L from loading side, the reduction in fatigue limit with respect to 2024 T3 base material was 45% for similar joints and 58% for dissimilar joints, and for welding line at a distance 0.7L, the reduction in fatigue strength was 56% for similar joints and 67% for dissimilar joints. While, there was a large reduction in the fatigue strength reaching to 70% in both similar and dissimilar joint for the welding joints at a distance L (i.e., at the fixing end). The heat treatments improved the fatigue strength about 31% more than non-heat treatments of the similar 2024 T3 joint at 0.7L in high cycle regime**.** Finally, the fatigue strength of non-finished samples were reduction in fatigue strength reaching to 10% more than the finished samples of the similar 2024 T3 joint at 0.7L.

A finite element model by the ANSYS 14.0 program was used to compare and satisfy the results of fatigue life for all cases. The comparison exhibited that the error is not more than 9% between the experimental results and numerical analysis; these errors are due to the conditions of expermental work that were not exact and can not be controlled at this condition, such as the environment, equipments, and surface finishing.