6.1 Conclusions

From the results which are presented from the experimental measurements and after discussing and comparing them with other researchers who had studied the FSW of aluminium alloys, it can be concluded that:

1. Double pass (FSP) is better than friction stir welding for same rotation and welding speeds and its achieved weld efficiency about 89.64%.
2. The best weld efficiency was (86.43, 81.78, 77.85) % at OWL 90^o, 60^o, and 45^o respectively.
3. In all tensile test the most failure occurs in advance side, at OWL 90^o, the failure occurs in HAZ and the fracture orientation perpendicular on applied load, while at OWL 60^o and 45^o the failure occurs in in the region between the SZ and TMAZ and the fracture orientation ~60^o and ~45^o with applied load for OWL 60^o and 45^o respectively.
4. The optimum case that gives higher ultimate strength was at (90^o, 1600 rpm, and 20mm/min), while optimum case that gives higher poof strength was (90^o, 1600 rpm, 32 mm/min), but optimum case that gives higher elongation was (60^o, 1600 rpm, and 20 mm/min).`
5. The most failure in fatigue test for base material occurs in the region very near to fixed point and in single pass (FSW), its occurs in welding Zone (WZ), while in double pass (FSP) at higher stress level, the fatigue failure occurs in welding zone while at a lower level of stress all failure occurs out the welding zone (very similar to base material).
6. The reduction in fatigue strength (endurance limit) for the optimum case was (30%) and for a double passes (FSP) was (10 %) only.

7. The Vickers hardness at the single pass in stir zone was 50.6 HV0.5 while at the double pass was 79.9 HV0.5.
8. Using double pass (FSP) lead to a reduction the residual stresses to 60% when compared with the single pass (optimum case) whereby was residual stress in single pass 726 MPa and for a double pass (FSP) was 294 MPa at same rotation and welding speeds.
9. Numerical analysis for fatigue behavior gives good agreement with experimental test.

6.2 Recommendations:

1. An experimental study for temperature distribution and using these effects to study the residual stress numerically by using code as appendix C.
2. Improving welding efficiency by using a wide range of welding parameters with friction stir processing (FSP).
3. Studying the effect of FSP (tool with and without pin) on tensile strength and fatigue behavior of AA 6061 and compared between them.