Chapter 8

CONCLUSIONS AND FUTURE SCOPE

From the results derived from these experimentations following conclusions have been drawn.

- From four different tool pin profiles, the cylindrical tool with a tapered pin diameter have efficient stirring of the metal and efficient filling of the material in the gap formed during the welding process.
- No macrostructure defects were observed in the weld joints welded at tool rotational speed of 300 to 700 rpm, welding speed of 15 to 35 mm/min and axial force of 4 kN to 8 kN.
- Friction stir welding window was developed to decide the range of tool rotational speed, welding speed and axial force.
- A five level four factor design matrix based on the central composite rotatable design technique could be effectively used for the development of the mathematical models.
- Response surface design was found to be an effective technique for developing mathematical models to accurately predict the main, quadratic and two-way interaction effects of various input parameters on different responses.
- Mechanical properties of the joints increase with increase in tool rotational speed and reaches maximum at 500 to 600 rpm but again deceases with further increase in tool rotational speed.
- The tensile strength increases with increase in the tool rotational speed and reaches maximum and then decreases with further increase in tool rotational speed.
• The tensile strength obtained at tool rotational speed of 300 rpm, was 206 MPa. Increased 262 MPa as the tool rotational speed was increased upto 500 rpm. Then decreases to 235 MPa at the tool rotational speed of 700 rpm.

• Mechanical properties of joints increase with increase in welding speed and reach maximum at 25 and 30 mm/min but again decrease with further increase in the welding speed.

• With the increase in welding speed from 15 mm/min to 25 mm/min the tensile strength improved from 235 MPa to 262 MPa. But at higher welding speed (35 mm/min) the tensile strength of the joint decreased and reached 249 MPa.

• Mechanical properties of the joints increase with increase in axial force and reach maximum at 7 kN and slightly decrease at 8 kN axial force.

• Mechanical properties of the joint increase with increase in pin diameter and reach maximum with 7 mm pin diameter but again decreases with further increase in pin diameter.

• The micro hardness of the heat affected zone is almost 15% and the stir zone is 35% less than that of the base metal. The softening was most evident in the TMAZ on the advancing side of the weld that corresponds to the failure location of the tensile test.

• Numerical optimization of the generated data, supported by experimental conformity runs, showed that the maximum tensile strength obtained at optimized process parameter was 271 MPa. The optimized parameters were-tool rotational speed 530 rpm, welding speed 28 mm/min, axial force 7 kN and pin diameter 7 mm.

• Microstructure of the stir zone shows the fine grains but in the base metal grains were elongated.
Tool rotational speed was found to be the most influential parameter affecting mechanical and metallurgical properties of the friction stir welded AA 6082 joints.

It has been recommended that post weld ageing treatment is beneficial in the friction stir welded aluminium alloy 6082 joints.

As-welded joints of AA6082 alloy have the joint efficiency of 85% and the after post weld treatment the joint efficiency improves to 92%.

The micro hardness of the welded joints improved after post weld heat treatment in all the welding conditions.

Joint strength of FSW welds was compared to that of the base material. A joint efficiency of 85% was obtained of FSW weld joint whereas the joint efficiency of TIG weld joint was 65%.

The impact toughness of the FSW joints was almost doubled from the base metal but impact toughness of the TIG weld joints was almost half of the base metal.

Hardness of FSW weld joints was better than the TIG weld joints.

Fine equiaxed grain structure was observed in nugget zone of friction stir weld joints. On the other side coarse grain structure was observed in the TIG weld joints.

SCOPE FOR THE FUTURE WORK

1. Effect of other process parameters like tilt angle, tool material etc may be studied.

2. Different design of the tool could be used to investigate the effect of the tool design. The study could be extended to lap joints and investigated in the same way. Development of better tool profile, which is economical, may deliver better results.
3. Thermocouple may be used to measure the temperature at different zones—HAZ and base metal.

4. Study can be conducted on the preheating of base material with help of TIG torch.

5. Alloy elements in the form of powder may be added in the stir zone.

In addition, further study into welding of unequal gauge materials or dissimilar alloys would provide a more thorough understanding of the capabilities of friction stir welding and possible applications for use. The temperature needs for each different material will be important to consider while welding dissimilar alloys.

Research needs to be done in the area of FSP as it has proved to be a viable method that could be used to improve mechanical and metallurgical properties of various aluminium alloys. Aluminium alloys are normally grouped according to their applications in industry and the introduction of FSP tends to improve an otherwise good alloy by introducing super plastic properties and grain refinement of the parent material.

The research could be taken further by applying the same technique to other Aluminum alloys which are used in the automotive industry. This could help the increase of use of the friction stir welding in the automotive industry.