CHAPTER 7  GENERAL CONCLUSIONS

On the basis of the results of a large number of experimental runs, the following conclusions can be drawn from this investigation.

1. The power is suitable between 4000W to 5000W for welding 11mm-thick AZ-series extruded plates.

2. For LV-SMW of AZ31B, AZ61A, and AZ91D, the harmful influence of SC and HAZ reaches at least 13%, 13%, 7% and 9%, 4%, 11% of UTS for base material, respectively.

3. Fracturing of the AZ-series weldments with SMW can occur in one of two modes: an irregular FZ fracture, or a regular HAZ fracture. AZ31B tends to exhibit the former mode, and AZ91D tends to exhibit the latter. AZ61A, on the other hand, exhibits the two fracture modes in equal proportion. This effect is due to the increasing concentration of brittle precipitates (γ phase, Mg17Al12) in the FZ, which can take on a variety of forms ranging from scattered particles to densely packed dendrites.

4. In the AZ-series magnesium alloys, defects such as cavities, HAZ, undercuts, and root concavities can create excessive SC and reduce the UTS and ductility of a weldment.

5. In terms of their joint efficiency, which is determined by the distribution of precipitates and defects, these alloys can be ranked in decreasing order as AZ61A, AZ91D, and AZ31B. AZ91D has the best process window, on the other hand, followed by AZ61A and then AZ31B.

6. Empirical formulas for the UTS and optimum LV-EBW parameters for each of the AZ-series alloys are as follows.

   AZ31B: UTS = 0.024 × V^{1.466} × I^{1.507} / S^{0.854}
   Condition: 50kV / 100mA / 60.6mm/s / focus at bottom

   AZ61A: UTS = 0.238 × V^{1.199} × I^{1.092} / S^{0.676}
   Condition: 50kV / 100mA / 60.6mm/s / focus at bottom
AZ91D: \[ UTS = 0.414 \times V^{1.127} \times I^{0.944} \div S^{0.533} \]

Condition: 40kV/113mA/73.3mm/s/focus at bottom.

7. The parameters for HV-EBW of AZ-series magnesium alloys may be ranked in order of decreasing influence as follows: beam oscillation, focal position, stress relief, material difference, beam current, welding speed, and accelerating voltage. A non-oscillating beam, a focus at the bottom, and no stress relief are generally the best choices. Joint efficiency follows the order of AZ61A, AZ91D, and AZ31B. Welding speed, accelerating voltage, and beam current are used to form an electron beam with symmetrical Gaussian distribution, which possesses fine adjusting functions.

8. Grey relational analysis reveals that the harmful extent of weld defects follows the order of crack (and cavity), undercut (or root concavity), and pore. The influence of each EBW parameter on various defects (or their shape) is obtained by multiplying parameter contribution and defect weight (or dimensional weight) together.

9. The mechanism of pore formation in welds in AZ-series forged alloys is such that the number of micropores will increase with the Al content of the alloy. This results from dissolution of a γ phase containing oxygen and recombination of oxygen atoms into molecules.

10. The cross-sectional area and shape of the welds are related to the input power and welding speed, and the cross-sectional area is not proportional to the input energy.

11. The HAZ formation mechanism for AZ-series weldments can occur in two modes: grain coarsening and submicron-sized crystal precipitating. AZ31B tends to the former mode, and AZ91D tends to the latter. AZ61A, on the other hand, exhibits the two modes and forms the narrowest HAZ.

12. The DMW weldment has only the regular HAZ fracture mode due to the quirky composition in the weld and the HAZ softening in low strength base metal.

13. Two factors decrease the strength of a weld butting pure Mg and Al: (1) the different
fluidities of chemical components cause turbulence in the weld pool. Even though alloys with higher Al content have higher fluidity and fill defects more easily, not all the pores can be expelled in time; (2) the brittle β and γ phases are not so uniform, and the variations in the thermal expansibility cause serious thermal stresses during solidification. This can lead to intergranular fracture, later propagated by transgranular fracture.

14. The formation of intermetallic compounds is not necessarily harmful. If a compound such as the γ phase precipitates uniformly in the AZ-series weld, it can raise the weld strength.