CHAPTER - 5

Conclusions and Future Scope

5.1 Conclusions

The phase-wise conclusions are given below:

5.1.1 Phase I

1. The high-temperature oxide addition alters the microstructure by changing the distribution pattern of the non-equilibrium eutectic solid solution and finer the α(Al) grains.
2. Nuclei of Al_3Zr phase confirmed by XRD analysis of ZrO_2-added Al7075 alloy.
3. SEM-EDS examination of ZrO_2 added Al7075 revealed the presence of 0.22 wt.% Zr, which hinders the recrystallization of the α(Al) grains, and generates a dark phase which confirms the presence of non-equilibrium eutectic phases like η($MgZn_2$), T($Al_2Mg_3Zn_3$), S(Al_2CuMg).
4. The distribution of the intermetallic phase influences the mechanical properties. ZrO_2 addition offers a 52% higher hardness value compared to as-cast Al7075. Tensile strength values remain almost the same in all cases.
5. By considering the localized Zn/Mg ratio, the EDS analysis confirms localized phases like (η) $MgZn_2$ and (T) $Al_2Mg_3Zn_3$.
6. Comparatively, 2.5 wt. % TiO_2-added Al7075 sample alters the mechanical properties by generating Al_1Ti_1 and Mg_1Zn_2 intermediate phase confirmed by XRD analysis.
7. In the case of 2.5 wt.% TiO_2 added sample, the dense discontinuous eutectic cluster with micro-porosities at discrete locations results in loss of mechanical properties.

5.1.2 Phase II

1. Quenching media alters the solidification pattern of the eutectic phase located at the boundary.

2. Due to the high thermal gradient, the independent nucleation results in an equiaxed grain structure observed in ice-quenched samples.
3. Hot water quenching for prolonged periods generates long and thin-columnar dendrites.
4. Hot water quenching for 30 min creates columnar and equiaxed dendrites and offers the highest tensile strength value of 197 MPa.
5. By changing the severity of quenching media, the hardness value varies from 59 BHN to 123 BHN in the case of as-cast and hot water quenching for a prolonged period.

5.1.3 Phase III

1. The microstructure and mechanical properties of oxide-added cast Al 7075 are compared before and after double-step ageing. The excellent mechanical properties of ZrO_2-added 7075 alloy are 212 MPa and 366 MPa before and after heat treatment.
2. Compared to other oxide additions, the average grain size of ZrO_2-added 7075 alloy is 28.39 μm, which provides maximum grain boundary nucleating sites for precipitation.
3. Also, grain size significantly affects the dissolution time and concentration of Cu over the grain diameter for getting a homogeneous microstructure.
4. The microstructure of ZrO_2-added 7075 alloy shows the uniform distribution of precipitates.
5. There is a substantial improvement in the tensile strength and hardness values (BHN) after the heat treatment of all the samples.

5.1.4 Phase IV

1. The grain structure of die-cast 7075 is columnar and equiaxed, while coarse globular grains are observed in the sand and investment cast 7075.
2. The eutectic phase segregation pattern in die-cast is within the inter-dendritic channels, while grain boundary eutectic phase segregation, mainly at the triple junction, is seen in sand and investment cast 7075.
3. The tensile property of die-cast 7075 is 183 MPa, the highest of all, but the BHN hardness value is increased by 69.49% and 45.76 % of the sand cast and investment cast, respectively, compared to as-cast.

5.1.5 Phase V

1. The successful development of Al 7075 is achieved after the 4^{th} successive heat.
2. The early addition at high temperature is an important condition to recover chromium to achieve the standard value.
3. The magnesium is added lastly so that maximum recovery of magnesium is achieved.
4. The tensile strength and hardness of developed 7075 are 212 MPa, which is higher than as-cast but lower than wrought.

5.1.6 Summarized Conclusion from all the Phases

1. 2.5 wt. % ZrO_2 addition altered the eutectic segregation phase and converted α-Al grains into small equiaxed grains.
2. XRD analysis of ZrO_2-added cast 7075 alloy shows the presence of eutectic phases like η($MgZn_2$), T($Al_2Mg_3Zn_3$), (Al_3Zr), and S(Al_2CuMg).
3. The highest mechanical properties are 196 MPa tensile strength and 112 BHN hardness observed in ZrO_2 addition.
4. Using localised chemical analysis by EDS and Zn/Mg ratios, (η) $MgZn_2$ and (T) $Al_2Mg_3Zn_3$ were confirmed.
5. The hot water quenching for 30 mins offers the highest tensile strength of 197 MPa and 100 BHN hardness value in the cast condition.
6. Double-step ageing treatment after ZrO_2 oxide addition offers 366 MPa tensile strength and 212 MPa before heat treatment.
7. By changing casting techniques, there is no significant to alter the eutectic phase segregation pattern, and finally, no substantial improvement in the mechanical properties.
8. Attempts were made to develop a cost-effective 7075 alloy by using scrap and changes in the alloying sequences.

5.2 Major Contribution

This thesis focuses on the subjective research gap of cast Al 7075. The following are significant contributions:

1. Development of ZrO_2, TiO_2, and ZrTiO4 oxide-added cast Al 7075.
2. Investigation of segregation pattern and phase morphology and their effect on

mechanical properties.

3. Study on the effect of quenching media during casting of Al 7075.
4. Study on the effect of double-step ageing on oxide-added cast Al 7075.
5. Comparison of the microstructure, mechanical, and tribology properties of cast Al 7075 after double-step ageing (before and after).
6. Study the changes in the different casting techniques to alter the segregation pattern of the eutectic phase.
7. Development of cost-effective cast Al 7075 by alloying additions.

5.3 Future Scope

- ✓ The future scope of the work can be extended by studying the corrosion properties of the samples.
- ✓ Further, heat treatment like homogenization, and RRA (Retrogression and Re-ageing) of the cast Al 7075 alloys.
- ✓ Apply the thermomechanical process.