PREFACE

Over the past few decades, automotive and aerospace industries have increased the use of Al-Si alloys due to the ever-increasing demand for weight reduction to achieve higher performance efficiency It is well-known that the mechanical properties mainly depend on physical (porosity, density, and cooling rate) and metallurgical properties (grain structure, dendritic and columnar zones, size of α-Al phases, shape, size, and segregation of eutectic Si, and distribution of the constituent phases).

Porosity defect (shrinkage and gas) is one of the main problems in Al-Si cast alloys. Shrinkage occurs due to improper solidification, and gas pores arise due to the entrapped gases. Hydrogen is the only gas that is appreciably soluble in aluminium, but the solubility of hydrogen in liquid aluminium is much more than in solid form.

To get superior metallurgical properties several grain refinement techniques were practised, like chemical, physical, and post-processing techniques, e.g., rolling, extrusion, and heat treatment.

In the chemical method, the grain modifiers, e.g., Sr, B, Ti, Sr, B, change the shape of the eutectic silicon from a plate-type to a fibrous form. However, they require a substantial amount to be effective; it contaminates and makes it an antigreen technology.

As an alternative to chemical methods, physical (ultrasonic, electromagnetic, and mechanical) means were explored using high-intensity shearing action. The ultrasonic vibration gained early popularity due to its ability to refine both α Al and eutectic morphology and encourage degassing to reduce porosity. Although the practical application of these techniques is not much, similarly, electromagnetic vibration requires large amounts of current and costly equipment such as superconducting magnets and magnetic coils. The complete arrangement confines the casting shape and size. Making it less viable for an industrial requirement.

Besides that, the mechanical vibration method is easily practicable, economical, eco-friendly, and effective. As a result, this technique is more advantageous than others. In 1878 Chernov discovered in his early studies that mechanical vibration during solidifying steel led to the refinement of austenite. Mechanical vibration uses external forces to create forced convection, reducing porosity and improving density. It eliminates structural heterogeneity, speeds up crystallisation, generates more nucleation sites and alters the morphology of metallurgical characteristics to a more favourable one.

It can be introduced in two different ways, i.e., horizontally or vertically. So far, over the period, vertical vibration has been commonly used by most researchers as it removes columnar grains directly from the wall. The method shows vulnerability while increasing amplitude beyond the critical level due to possible splashing, limiting the method's applicability to smaller and lightweight castings. On the contrary, horizontal mould vibration is relatively uncommon, safe, robust, and suitable for heavier components also, this method can serve industrial requirements more aptly than any other method. As a result, this method was chosen for the present study.

The present dissertation "Solidification characteristics of die-cast A308 aluminium alloy under different vibratory conditions" consists of seven chapters.

Chapter 1 provides a brief introduction to Al alloy, its application in the automotive sector, the merits of Al alloy, research background and the aim and objective of the work.

Chapter 2 This chapter addresses the literature survey which deals with information about castability issues of Al-Si alloys including its characteristics, metallurgical aspects, process parameters of casting, effect of alloying elements, mechanism and classification of grain refinement methods and the effect of frequency and amplitude variation on the metallurgical and mechanical properties of castings. The extensive literature review and gaps in the literature are discussed at the end.

Chapter 3 This chapter addresses the experimental techniques employed in developing the in-house set-up, chemical characterization, melting, and pouring of the A308 alloy. It also discusses the physical, metallurgical, and mechanical characterization experiments. Characterization techniques, like optical microscopy, scanning electron microscopy, energy-dispersive X-ray spectroscopy and X-ray diffraction, are also discussed.

Chapter 4 In this chapter, the low-frequency range mould vibration of the die-cast A308 alloy is discussed. To determine the performance of the as-cast and vibrated cast samples, the physical, metallurgical, and mechanical properties of the samples were analyzed. Therefore, the chapter is divided into four sections (a) Physical properties, (b) Metallurgical properties, (c) Mechanical properties, and (d) Fractography. The chapter concludes with a summary of the results of the physical, metallurgical, and mechanical tests.

Chapter 5 This chapter focuses on medium frequency range mould vibration on the die-cast A308 aluminium alloy. Physical, metallurgical, and mechanical characteristics were evaluated to analyse the performance of the as-cast and vibrated-cast samples. Therefore, the chapter has also been divided into four sections. (a) Microstructural observation, (b) Density and porosity evaluation, (c) Mechanical properties, and (d) Fractography. The chapter concludes with a summary of the physical, metallurgical, and mechanical results.

Chapter 6 This chapter focuses on high-frequency range mould vibration on the die-cast A308 alloy. Samples that were cast as cast and vibrated cast were analyzed based on their physical, metallurgical, and mechanical properties. In light of this, the chapter has been divided into four sections. (a) Physical properties, (b) Metallurgical properties, (c) Mechanical properties and (d) Fractography. The chapter concludes with a summary of the microstructure, physical, and mechanical results.

Chapter 7 This chapter summarizes the effects of low, medium, and high-frequency range mould vibrations. Comparative analysis is performed under three sections (a) Physical properties, (b) Metallurgical properties, and (c) Mechanical properties, the chapter ends with concluding remarks, and the scope for future work.