Chapter 7

Summary and Conclusions

This chapter summarizes the findings of the present investigation, concluding remarks, and the scope for future work.

7.1 Summary of thesis and concluding remarks

This chapter summarizes the effects of low, medium, and high-frequency range mould vibrations on die-cast A308 aluminium alloy. To determine the performance of the as-cast and vibrated cast samples, the physical, metallurgical, and mechanical properties of the samples were discussed comparatively. 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.

The effect of low, medium and high-frequency range mould vibration on the physical, metallurgical, and mechanical properties were investigated and the following conclusions were made:

- XRD revealed the presence of Al, Si, Cu, Fe, Mn, Mg, and intermetallics, e.g., $Fe_{1.7}SiAl_4$ and Al_2Cu, and was confirmed by EDS and spectrometer analysis.
- 21%, 14% and 13% improvement in cooling rate and 84%, 62% and 56% reduction in porosity cause the density to increase by 2.5%, 1.63% and 1.61% respectively under low, medium, and high-frequency ranges compared to conventionally cast samples as illustrated in figure 7.1, due to forced convection, better mass feeding and reduced porosities.
- Metallurgical features i.e., α-Al, SDAS, length, width, and aspect ratio of eutectic Si particles were reduced by 53%, 34%, 47%; 63%, 59%, 53%; 71%, 56%, 65%; 18%, 10%, 12%; and 62%, 56%, 61% and the shape factor improved by 39%, 22% and 25% respectively under low, medium, high-frequency ranges as depicted in figure 7.2, due to turbulence created by vibration and rapid cooling.

- The mechanical properties i.e., YS, UTS, %EL, and HV increased by 16%, 8%, 13%; 25%, 13%, 20%; 17%, 17%, 15%; and 42%, 16%, 20% respectively under low/medium/high-frequency ranges compared to conventionally cast samples as illustrated in figure 7.3, due to significant improvement in physical and metallurgical properties.
- The SEM fractography showed transgranular brittle fracture with cleavage and brittle facets throughout the conventionally cast surfaces. where as mixed-mode fracture behaviour was observed at higher frequencies showing ductile tearing, and dimple morphologies.

The Figure 7.1, 7.2 and 7.3 shows a rising trend until 10, 30, and 100 Hz frequencies as the commencement of optimal vibration reduces structural heterogeneity, speeds up crystallisation, creates more nucleation sites, and affects the morphology of metallurgical characteristics. From the optimum to the highest vibration, a downward trend towards lower frequencies can be seen. Physical, metallurgical, and mechanical properties are gradually reduced. Additional turbulence leads to gas entrapments, increased porosity, and ultimately lower densities. Additionally, it has been found that increased turbulence lowers the metallurgical characteristics, which may be related to a slowing down of the alloy's cooling rate.

7.2.1 Comparison of physical properties under low, medium, and high-frequency ranges

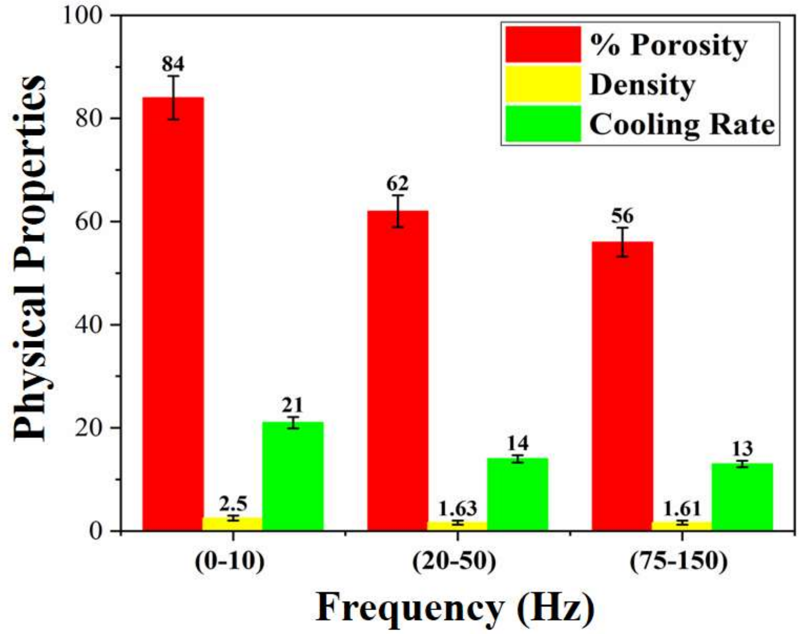

Figure 7.1: Comparison of physical properties under low / medium / high frequency ranges

7.2.2 Comparison of metallurgical properties under low, medium, and high-frequency ranges

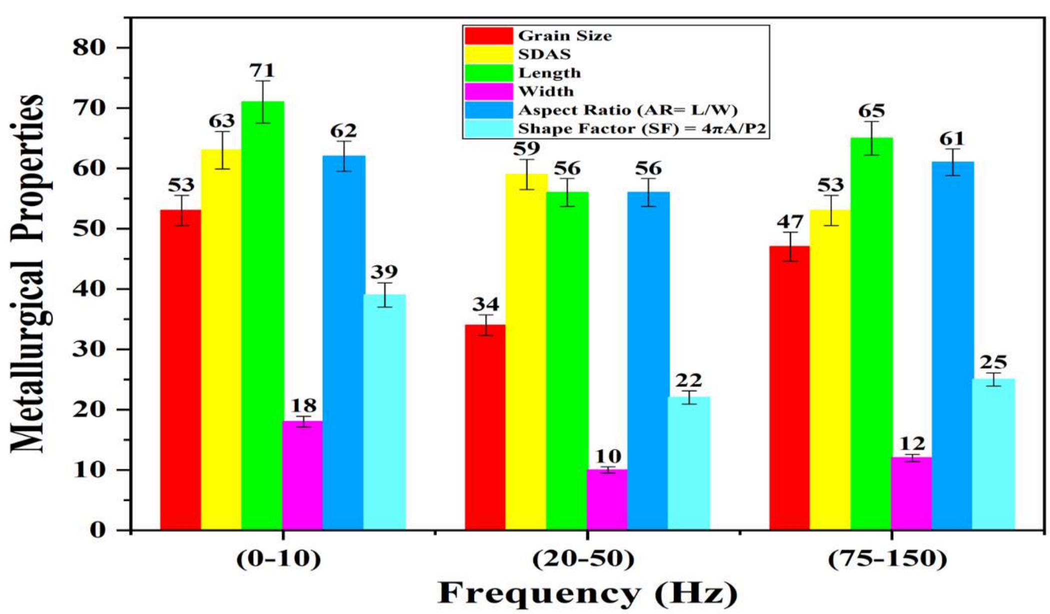

Figure 7.2: Comparison of metallurgical properties under low /medium /high-frequency ranges

7.2.3 Comparison of mechanical properties under low/ medium/ high frequency ranges

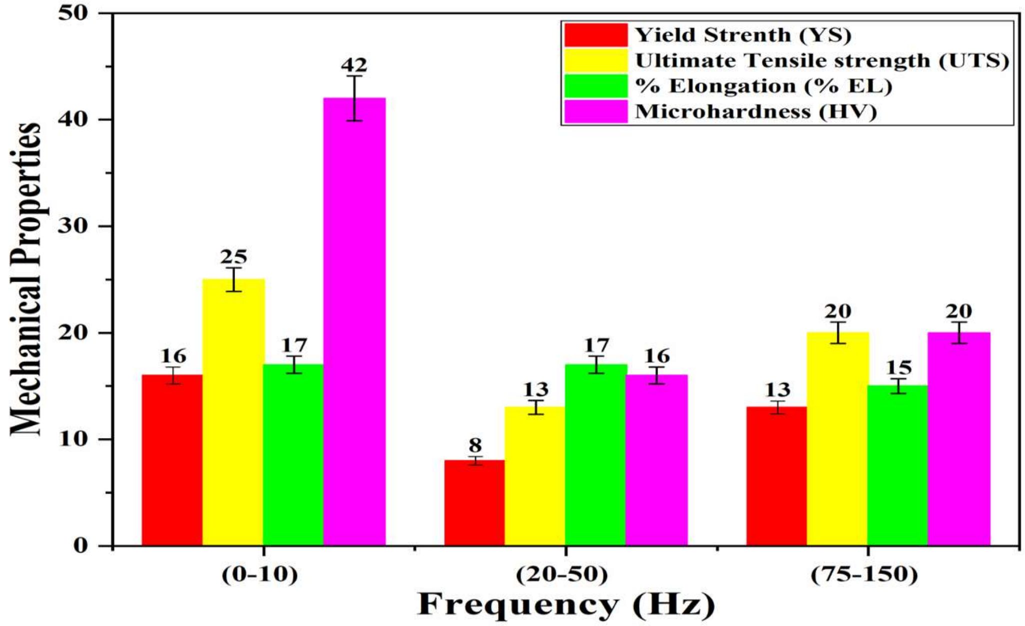

Figure 7.3: Comparison of mechanical properties under low / medium / high frequency ranges

7.3 Future perspective

The findings of the current study are significant and helpful for enhancing the physical, metallurgical and mechanical, characteristics of hypoeutectic Al-Si alloy (A308). It is suggested that there is further room for exploration into the process development of vibratory casting. The suggestions for future work are as follows:

A 308 hypoeutectic alloy has been studied in the current work. It is also possible to look into other ferrous and non-ferrous alloys such A 380 and A390 hypereutectic alloys.

i. In the present investigation physical, metallurgical, and mechanical properties were investigated keeping static load and ambient temperature requirements in consideration. Several hypoeutectic Al-Si and hypereutectic Al-Si alloy cast components are subjected to cyclic loads and tribological conditions respectively under high-temperature environments. Given this, it is interesting to study the dynamic mechanical properties of the alloys. Accordingly, microstructure has a critical role to play (SDAS and Si morphology) that can influence the fatigue and tribological behaviour of Al-Si cast alloys[15].

ii. To further improve the degree of grain refinement and mechanical properties, the combined effect of mould vibration and grain modifiers e.g., Sr, Na, B, and Ti on non-ferrous alloy castings can also be studied.

iii. The effects of tilted plate vibration on grain refinement and mechanical properties of alloys can be investigated.

iv. Investigations on the effects of different cooling media like water, oil, and air on alloy microstructure (e.g., SDAS and Si morphology) and mechanical properties are also possible.

v. Effects of higher frequency and amplitude, i.e., more than 150 Hz and 2.5 mm, can be investigated.

vi. Simulation can be used for different vibratory castings.