CHAPTER 1

RESEARCH BACKGROUND

1.1 Introduction

Aluminium alloys have been widely used in the automotive industry, as the trend nowadays is to achieve higher performance without increasing the weight. Therefore, more and more automotive components are made of aluminium alloys in order to reduce weight, at the same time maintaining or improving mechanical properties. Apart from their excellent casting characteristics, wear and corrosion resistance, aluminium-silicon casting alloys are used extensively because they also impart a wide range of mechanical properties and high strength to weight ratio.

Aluminium silicon foundry alloys with hypoeutectic (<12.7%) and eutectic (~12.7%) ranges are more commonly used due to their exceptional casting properties. Al-Si-Mg alloys such as A356 or LM 25 (Al—7Si-0.3Mg) are widely used for sand and permanent mould castings and they are found to be particularly useful for automotive applications. Sand casting offers high versatility and it is more economically feasible while permanent mould and die casting yield better mechanical properties in the castings.

The increasing demand and use of these aluminium foundry alloys, particularly in those critical service environments, have prompted a more in-depth research and development to enhance the casting and mechanical properties. Besides controlling the inclusions and gas, silicon modification is another important area that catches the interest of many researchers ever since its discovery by Pacz in the 1920s

(Polmear, 1981). It was found that silicon modification is able to improve the mechanical properties of Al-Si alloys by altering the structure of the silicon phase. Modification induces the change in silicon structure from a coarse acicular morphology, which can cause brittleness in the casting to a fine, interconnected, fibrous morphology that increases the tensile strength and ductility of the casting. There are many types of modifiers available in the market but the more commonly used modifiers are sodium and strontium. Antimony that is used to refine the silicon structures has not gained wide popularity if compared with the former modifiers due to its health hazard potential. Apart from modification through chemical additions, quenching or chill modification also enhances the mechanical properties of the castings.

Nowadays, in one of the environmental conservation efforts, aluminium-recycling operation is acquiring more and more momentum. The scrap metals are not only resourced from the return of aluminium castings but also from wrought aluminium. Bismuth has constantly been added as one of the alloying elements in aluminium wrought alloys with the purpose to improve the machinability of the alloys. However, little is known about the effect of bismuth on the microstructure of aluminium cast alloy (i.e. A356 (AA) or LM25 (BS) alloy in this research) and its interaction with the addition of other modifiers such as strontium and sodium. Some suggested that the presence of bismuth might actually interfere with strontium modification effect on the alloy. Moreover, the presence of antimony that is originally added as a refiner in some aluminium scrap materials also constitutes some poisoning effect especially when strontium modification is much intended in the subsequent process. Therefore, additional work is required to investigate the effect of bismuth addition in A356 alloy and its interactions with other modifiers and/ or refiners.

Casting process has often been the economical means of achieving high volume production of complex automotive parts. Aluminium castings offer significant weight reduction that eventually generates into improved fuel efficiency. As to attain sound castings, a good control of the melt treatment and casting processes in order to produce the desired microstructures has become an

utmost important task. The quality of the castings is often related to features such as silicon shape and sizes, porosity, inclusions and intermetallics phases. In the case of aluminium castings, porosity formation has always been a quality issue since it is extremely difficult to produce an entirely pore-free casting. Although a number of researchers have attempted to explain the nucleation and growth mechanism of porosity in aluminium castings using different approaches, there is still limited understanding on the subject. Most of the work relates porosity formation with modification in which strontium was added in higher amount (approximately 0.02wt%). Less investigation has been done on the effect of low strontium contents (less than 0.01wt%) on porosity formation in the aluminium cast alloys, even though modification could have been attained at lower strontium contents. Hence, more work has to be carried out in order to gain better understanding as well as to ascertain what others have postulated.

Heat treatment or thermal modification has long been practiced as one of the feasible means to enhance the mechanical properties of aluminium castings through spheroidising the plate-like silicon, apart from the usual chemical modification. This treatment improves the mechanical properties such as tensile strength, ductility and impact strength. Heat treatment often follows suit after casting process in order to maintain optimum mechanical properties of the castings, especially for those used in areas where structural integrity is a key concern. Some combine the chemical and thermal treatment processes to achieve greater improvement. Therefore, it is reasonable to perform heat treatment on the castings added with low strontium contents and their mechanical properties being evaluated against those in the as-cast condition. In addition, it is not uncommon to find varying cooling rates within a casting during solidification, particularly in an intricately designed casting. As solidification rate affects the mechanical properties of the cast section, the cooling rate factor should also be taken into consideration during the evaluation of the quality of the castings.

1.2 Objectives of Study

In response to the concerns identified above, the present research is aimed at:

1. Investigating the effect of bismuth addition and its interactions with strontium (modifier) and antimony (refiner) in aluminium foundry alloy (i.e. A356).

2. To study the evolution process of the porosity in order to gain a better understanding of the nucleation and growth characteristics of porosity with respect to strontium additions

3. To evaluate the mechanical properties of the castings produced and examine the effect of process parameters such, cooling rate of the casting, melt treatment and heat treatment.

1.3 Scope of Work

1. Examination of the effect of bismuth, strontium and antimony, which are added in different proportions, on the microstructure of the castings.

2. Study of nucleation and growth of porosity in aluminium silicon castings by conducting quench during solidification experiments.

3. Effect of process factors such strontium concentration, cooling rate and heat treatment (T6) on the mechanical properties of the castings.