Chapter 8
Fatigue Characterization and Fractographic Analysis of Aluminium 6063 Alloy

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ABSTRACT

Aluminium and its alloy are widely employed in various automobile and aircraft areas because of their unique specific strength and formability. Al alloys that have been employed in aerospace structural components will undergo dynamic loading, which leads to fatigue due to mechanical stress and thermal conditions. Considering studies toward the low cycle fatigue behaviour of Al alloys are significantly narrowed, this chapter sighted to the analysis of fatigue behaviour of Al 6063 alloy at the various total strain amplitude (TSA) of 0.4% and 0.8%, which performed through the low cycle fatigue testing machine at the frequency rate of 0.2 Hz. The test results show that for 0.4% TSA, the number of cycles to failure (N) is 1786, whereas as the TSA increases, N got reduced. For 0.8% TSA, the cycle to failure is 291 and samples undergone cyclic softening during the test. The rate of cyclic plastic strain raised up with the increase in the TSA. Crack propagation was observed along with the quasi-cleavage fracture for 0.4% TSA and cleavage fracture for 0.8% TSA.

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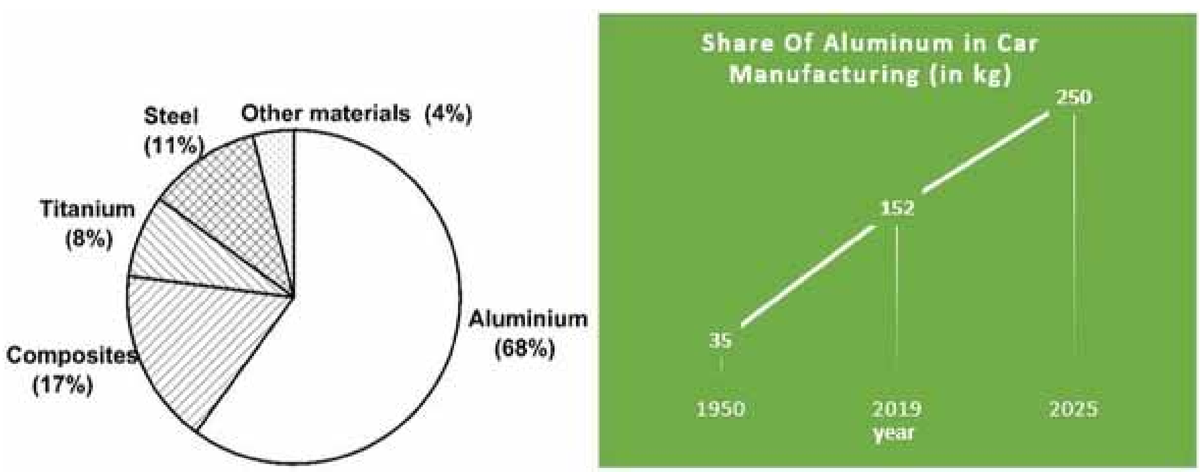
INTRODUCTION

Aluminium is one of the most commonly used lightweight materials in the automotive industry and the aerospace industry. The aluminium density is 2.71g/cc, which implies Al is lighter than Iron and Copper. The aluminium's corrosion resistance is excellent, and thin, adherent oxide layers contribute to these characteristics. Additionally, aluminium is also preferred in the aerospace industry because of its high specific stiffness and specific strength, fracture toughness, fatigue resistance, and ductility. The other important aspect of the aluminium alloy is the ability to fabricate since aluminium foil can be into micron thickness. In the automotive industry, aluminium alloys have been rooted since the nineteenth century. In modern days, aluminium alloys have replaced many steel parts to reduce vehicle weight and improve efficiency. By the early 1970s, the share of aluminium in a car only accounted for 35kg. The share of aluminium drastically improves to 153kg, and it is estimated that by 2025 the share will be 250kg, shown in figure 1. In aerospace, aluminium plays a vital role in producing weight-efficient aircraft components (P. C. Angelo & B. Ravisankar, 2018). This leads the aerospace industry to move ahead in fuel-efficient transportation and high speed and altitude flying. Among other lightweight materials such as magnesium, titanium, and fibre reinforcement materials, aluminium and its alloy account for more than 60% in the recent aircraft industry, as shown in figure 1. The below chart represents the approximate accountancy of various materials in aerospace manufacturing (Payne, 1976).

Figure 1. The contribution of aluminium alloys in car manufacturing.



Aluminium and its alloys are classified into wrought and casting alloys. Among the wrought alloys, some alloys alter their mechanical properties through a proper heat-treatment process. This series of wrought alloys are having a yield strength range of 450 to 600 MPa. This alloy series is used in semi-structural and structural parts on aircraft. Some wrought alloys did not react to heat treatment, so that those series may be subjected to cold working. This non-heat-treatable has a yield strength below 300MPa, so the application is restricted in the automotive and aerospace industry. Some particular cases of alloy respond to heat treatment, and also, it can be cold worked. The application of cast aluminium products