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Test Matrix for Heat Exposure of Aluminum Alloys at Various Times and Temperatures

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Abstract. The purpose of this study is to characterize the effects of heat damage on the electrical conductivity and static mechanical properties of aluminum alloys. The data resulting from the experiments of thermal exposure of several aluminum alloys are used to model the relations that describe the dependence of the electrical conductivity and hardness on the two main variables of these experiments: the temperature and the time of exposure. The dependence of yield strength and ultimate tensile strength on hardness values is characterized. For each case, different materials (alloys) exhibit similar general trends although there are different coefficients for each material to satisfy the general relation.

Introduction

High strength, age-hardenable Aluminum alloys are commonly used in the aerospace industry for their optimal combination of physical and mechanical properties. Among these properties are alloy strength, ductility, fatigue resistance, fracture toughness, and corrosion resistance. The correct combination of alloy composition and thermal mechanical processing is essential to obtain the desired set of alloy properties [1].

When components are in service within the aircraft, alloys could be subjected to thermal excursions beyond industry accepted limits, such as fire damage, impingement of engine exhaust, or other sources [2, 3]. This can compromise the structural integrity of the aircraft component. Nondestructive inspection (NDI) methods, such as electrical conductivity measurements, and non-detrimental mechanical testing techniques, such as hardness tests, are used to assess the extent of heat damage. NDI is used in order to avoid disassembling the component in question and conducting destructive tests, which will render the component unusable. While these techniques are commonly used in the aerospace industry, they suffer from insufficient data correlating electrical conductivity and hardness to alloy strength of different alloys [4, 5, 6, 7].

A previous work sought to correlate thermal exposure to electrical conductivity, hardness, yield strength, and ultimate tensile strength data in order to facilitate the disposition of aircraft exposed to thermal excursions [7]. The alloys and tempers examined included 2014-T6, 2024-T3, 6061-T6, 7050-T7451, and 7075-T6. The alloys were thermally exposed at 177^{o}C (350^{o}F), 204^{o}C (400^{o}F), 260^{o}C (500^{o}F), 316^{o}C (600^{o}F), 371^{o}C (700^{o}F), 427^{o}C (800^{o}F), 482^{o}C (900^{o}F) for 1 min, 10 min, 30 min, 1 hour, 3 hours, 10 hours, 1 day, 10 days, and 20 days. The details of this study are explained in Reference [7].