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On the correlation of mechanical and physical properties of 7075-T6 Al alloy

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Abstract

The influence of varying the thermal processing parameters on the physical and mechanical properties of 7075 T6 aluminum alloy was studied. The variables altered were solution treatment temperatures, quenching media and artificial aging conditions. The influence of varying these parameters on the tensile strength, electrical resistivity and hardness of the alloy is discussed and an excellent correlation is found between the tensile strength and hardness.

Keywords: Heat treatment; Al 7075; Hardness correlations; Mechanical testing; Resistivity

1. Introduction

It has been discovered recently that some aluminum components may have experienced faulty heat treatments prior to installation in aircraft. Additionally many aircraft are reaching the end of their service life. Accordingly it is paramount to devise reliable methodologies that can predict the mechanical properties of these aluminum components without having to conduct destructive testing which would necessitate the removal of parts of structures and airframes of many aircraft.

Several techniques have been developed to detect the mechanical and corrosion resistance properties of aluminum alloys. Green [1] reviewed the non-destructive techniques that do not require the removal of components which minimizes aircraft down time. Electrical conductivity measurements (which were con-

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verted to a percentage of the International Annealled Copper Standard, % IACS) and hardness measurements are conducted on a routine basis by aircraft technicians. High conductivity measurements indicate high corrosion resistance [2–4] and high hardness numbers indicate high yield and tensile strengths [5]. In this study, several thermal treatments were developed which can encompass all the faulty heat treatments in an extensively used aluminum alloy, 7075-T6. These heat treatments will include variations of the solution treatment temperature, quenching in air to simulate the worst condition of delayed quenching in water as well as underaging and over-aging thermal treatments.

The heat treatment that has been deemed optimal for the 7075 alloy is the T6 temper [6]. This heat treatment involves solution treating the alloy at 480 °C for 1 h, followed by rapid quenching in water and finally age hardening at 121 °C for 24 h. The 7075-T6 is the strongest and most widely used form of this alloy.

The objectives of this study are first to provide a quantitative relationship between the variation, from the optimum T6 process, of the processing parameters (solution treatment temperature, quenching medium, age hardening treatment) on the physical and mechanical properties of the alloy. The second objective is to quantitatively correlate the physical and mechanical properties. This would provide a predictive tool for aircraft maintenance crews to know when aluminum components should be replaced.

2. Experimental

The Al 7075-T6 alloy was received in sheet form of 3-mm thickness. The alloy was machined into tensile bars and resistivity/hardness bars and then was subjected to 100 different heat treatments summarized in Table 1. The samples were exposed to five solution treatment temperatures (420, 450, 480, 510 and 530 °C), two quenching media (water and air) and then they were artificially aged. The 10 aging treatments were performed at 121 °C (underaged and peak aged) and 165 °C (slightly to fully overaged). One treatment was a two-step 107 °C/8 h followed by 163 °C/24 h (overaging). The 100 conditions accordingly consisted of five solution treatments times two quenching media times 10 artificial aging treatments. The optimal T6 temper which is solution heat treatment at 480 °C/1 h, rapid water quenching and age hardening at 121 °C/24 h is one of these conditions. Three tensile bars were tested for each condition (300 total) and 100 resistivity/hardness bars.

Electrical resistivity measurements were performed with a four probe method and then converted to a % IACS, hardness measurements were conducted with a Rockwell B (R_B) scale and tensile properties were tested using an Instron 4505 universal testing machine.

Table 1
Thermal processing to produce 100 conditions

Solution treatment (°C/1 h)	Quenching medium	Natural aging	Artificial aging treatment	
530	Air	Room temperature for 48 h	01	107 °C/8 h + 163 °C/24 h
			02	121 °C/3 h
510			03	121 °C/8 h
			04	121 °C/12 h
480	Water		05	121 °C/24 h
			06	165 °C/2 h
450			07	165 °C/4 h
			08	165 °C/8 h
420			09	165 °C/15 h
			10	165 °C/30 h