UNIVERSITI PUTRA MALAYSIA

THE CHARACTERIZATION OF AGE HARDENING TREATMENT OF AA6061 ALUMINUM ALLOY THROUGH DESTRUCTIVE AND NON-DESTRUCTIVE TESTING TECHNIQUES

MEYSAM TOOZANDEHJANI

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By

MEYSAM TOOZANDEHJANI

Thesis Submitted to the School of Graduate Studies, University Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

August 2014

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Dedicated to

My parents

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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August 2014

Chairman : Faizal Mustapha, Phd

Faculty : Engineering

The aim of this research is to characterize the microstructural variation and mechanical properties of interest within the precipitation hardening of aluminum alloy of AA6061-T6 using conventional methods and non-destructive ultrasonic measurements. The study focuses on the using of ultrasonic non-destructive evaluation methods for the purpose of material characterization and consequently correlating the ultrasonic parameters; velocity and attenuation with the microstructure evolution and certain mechanical properties during the age hardening of 6061-T6 alloy.

To achieve the proposed research objectives, aluminum plates of 6061-T6 aluminum alloy solutionized at 530 ℃ followed by quenching in iced water. Then, specimens were subjected to artificial aging heat treatment at 220 ℃ for time periods of 30 min to 8 hours. The microstructure variation was analyzed using Scanning Electron Microscopy (SEM) and optical microscopy to observe the important feature of microstructure such as precipitates before and after being aged. Specimens were then undergone to destructive test including Vickers hardness test (HV) and tensile test. Microhardness, yield strength (YS), ultimate tensile strength (UTS) and elongation of specimens were evaluated. Fracture surfaces of tensile samples were analyzed by SEM. The ultrasonic parameters; ultrasonic velocity and attenuation were measured. Longitudinal waves employed to calculate the velocity and the attenuation coefficient of waves. In addition, data analysis fuction was employed in order to indicate the accuracy and reliability of the results and percentages of error.

A major part of the present work was dedicated to the effect of aging treatment parameter (aging time) on the microstructure and mechanical properties of 6061-T6 alloy. The results exhibited prominent microstructural changes and occurrence of different precipitation during aging as confirmed by SEM. The results indicated that a good combination of mechanical properties can be achieved by employing the heat treatment procedure. The optimum aging

condition was enhanced after two hours of aging at 220 ℃. It is believed that formation of precipitates contribute to variation in the mechanical behavior of the material. Further, ultrasonic measurement revealed a good correlation with microstructural features and mechanical properties measurements generated from destructive tests mentioned earlier. In the case of accuracy and reliability of results, data analysis showed a good consistency with a minimum error in the experimental results.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENCIRIAN RAWATAN PENUAAN PENGERASAN AA6061 ALUMINIUM ALOI MENERUSI TEKNIK UJIAN PEMUSNAH DAN TIDAK PEMUSNAH

oleh

MEYSAM TOOZANDEHJANI

Ogos 2014

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Penyelidikan ini bertujuan untuk menentukan ciri-ciri perubahan mikrostruktur dan sifat-sifat mekanik berkepentingan di dalam pemendakan pengerasan aloi aluminium AA6061-T6; menerusi kaedah konvensional dan tidak memusnahkan ultrasonik. Kajian tertumpu kepada penggunaan kaedah taksiran utlrasonik tidak memusnahkan untuk pencirian bahan dan berhubungan parameter ultrasonik dengan evolusi mikrostruktur dan sifat-sifat mekanikal tertentu dalam aloi AA6061-T6.

Untuk mencapai objektif kajian ini, aluminium AA6061-T6 aloi menjalani larutan rawatan haba pada 530 ℃; diikuti rendaman dalam air berais. Spesimen ini kemudiannya menjalani rawatan penuaan rekaan haba pada 220 ℃ untuk tempoh waktu antara 30 minit hingga 8 jam. Selepas penyediaan spesimen, variasi mikrostruktur aloi yang telah dirawat dianalisa mengunakan 'Scanning Electron Microscopy' (SEM) dan mikroskop optik, untuk meneliti tanda-tanda pemendakan kekerasan sebelum dan juga selepas proses penuaan rekaan. Pemusnah ujian kekerasan Vickers (HV) dan ujian tegangan dijalankan pada 6061-T6 spesimen selepas prosedur rawatan haba. Kerasan mikro, kekuatan beratan (YS), kekuatan tegangan muktamad (UTS) dan pemanjangan dinilaisis. Permukaan patah tegangan spesimen-spesimen dianalisa menggunakan SEM. Permukaan patah specimen tegangan dianalisis dengan SEM. Parameter ultrasonik; halaju ultrasonik dan pengecilan diukur. Gelombang membujur telah digunakan untuk mengira halaju dan koefisien pengecilan gelombang.

Sebahagian besar daripada penyelidikan yang diaksanakan ditumpukan kepada kesan parameter rawatan penuaan (penuaan masa) pada mikrostruktur dan kekuatan sifat- sifat aloi AA6061-T6. Hasil kajian menonjolkan perubahan besar kepada mikrostruktur dan kejadian yang berbeza zarah-zarah ketika proses penuaan yang telah disahkan SEM. Hasil kaian juga menunjukkan kombinasi yang baik sifat-sifat mekanik boleh dicapai dengan menggunakan proses rawatan haba rekaan. Keadaan optimum penuaan telah dicapai selepas dua jam penuaan

pada 220 ℃. Keputusan ini membawa kepada pemerhatian bahawa pembentukan mendakan menyumbang kepada perubahan dalam tingkah laku mekanikal bahan. Akhirnya, pengukuran ultrasonik mendedahkan korelasi yang baik dengan ciri-ciri mikrostruktur dan sifat-sifat mekanikal ukuran-ukuran, yang terhasil daripada ujian pemusnahan yang dinyatakan sebelum ini.

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I certify that a Thesis Examination Committee has met on 15 August 2014 to conduct the final examination of MEYSAM TOOZANDEHJANI on his thesis entitled "The characterization of age hardening treatment of AA6061 aluminum alloy through destructive and non-destructive testing techniques" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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