

EFFECT OF SOLUTION TREATMENT TEMPERATURE ON RECYCLED ALUMINIUM ALLOY 319

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Abstract

In the present work, the responses of artificial ageing process to different solutionising temperatures on recycled 319 series aluminium alloy are studied. The optimisation of solutionising temperature may lead to the formation of higher volumes of precipitates in the aluminium alloy during the artificial ageing process, which means the greater strength to the alloy. The aluminium alloy samples were sectioned from recycled automotive cylinder head and solutionised at three different solutionising temperatures, stated as 495°C, 510°C and 525°C for 10 hours. All samples were then artificially aged at 180°C for a period of 20 hours. The precipitation behaviour was monitored by Vicker's microhardness test and electrical resistivity measurement. The result showed that all solutionising temperature produced double peaks on the artificial ageing hardness profiles but at different ageing time. The similar trend was also observed by the resistivity measurement.

Keyword: recycled 319 series aluminium alloy, solutionising, artificial ageing, vicker's microhardness, resistivity

Introduction

Aluminium alloy has become a preferred materials for the automotive components because of its lightweight and good mechanical properties, hence offers the better strength-to-weight ratio material to these industries. The Al 319 series alloy is one of the commercially important alloys. It is widely used for structural application such as cylinder head component. This is account on its excellent casting characteristics and good mechanical properties (Cerri, 1999). Aluminum usage provides up to 55 percent weight savings when compared to steel—which translates into improved fuel economy and reduced greenhouse gas and polluting emissions—while offering the same, or better, stiffness and crashworthiness. The energy savings from lightweighting and the resulting increased in-use fuel efficiency far outweigh the energy cost of using prime aluminum. However, if the aluminum used is recycled metal, even the energy to produce the metal can be reduced significantly. The remelting of recycled metal saves almost 95% of the energy needed to produce prime aluminum from ore, and, thus, triggers associated reductions in pollution and greenhouse emissions from mining, ore refining, and melting (Gesing, 2001).

The Al319 series alloy becomes a preferred material in foundry application because of its excellent castability and mechanical properties. The alloy strength and ductility are optimised by heat treatment process comprising solution treatment and quenching followed by ageing. During solution treatment and quenching process, the magnesium and copper-rich intermetallic compound dissolved into Al matrix. This dissolution rate of intermetallic compounds is temperature sensitive and even a 10°C increase in temperature has an appreciable effect on optimum solution times and on mechanical properties (Wang, 2003).

Experimental Procedure

Samples from scrap Proton Saga's cylinder head were sectioned to a dimensions of (10x10x5) mm and cleaned from oil, dirt's and carbon deposits. A section of the sample was taken for XRF analysis to determine the elements exist in the aluminium alloy. Table 1 shows the main elements inside the Al319 series alloy and its composition.

Table 1 : XRF analysis of recycled Al-Si-Cu-Mg alloy

Chemical Component	Al	Si	Cu	Mg
Percent (%)	78.3	13.9	7.7	0.1

The other samples were divided into three groups for a series of heat treatment process. All the samples were heated to the designated solutionising temperature, followed by quenching process in the cold ice water and finally reheated to the ageing temperature for a period of time. The processes were schematically showed in figure 2.

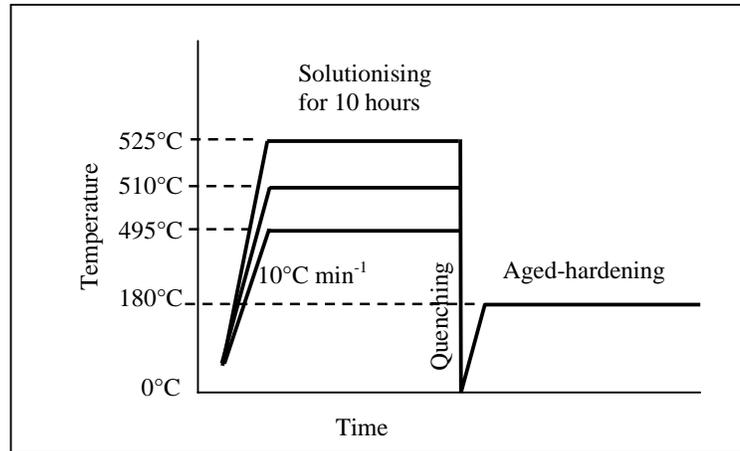


Figure 2 : The schematic diagram of solution treatment process

The solutionising temperature for Al-Si-Cu-Mg alloy was generally restricted to about 495°C because the higher temperature may lead to the incipient melting of the copper-rich phase. However, this temperature or less cannot fully take the copper-rich intermetallic compound to dissolve into Al matrix and also unable to sufficiently modify the silicon particle morphology [Sokolowski, 2001 and Wang, 2003]. Therefore, higher solutionising temperatures which were 510°C and 525°C were selected. Another group of sample was solution heat treated at 495°C as a control samples.

After 10 hours, all the samples were taken out immediately and quenched into the iced water. This process is to create the supersaturated solid solution in the aluminium alloys. The rapid quenching process was selected because it may prevent heterogeneous precipitation from occurring during slower quenches resulting in reduces ageing response (Robinson, 2004). The iced water temperature was measured at 0°C by using a thermometer prior to quench process. The samples were then kept frozen in the freezer to prevent any natural ageing process at room temperature.

After that, samples from each solutionising temperature set were taken for artificial ageing process. This process was carried out inside the Carbolite furnace at an ageing-temperature of 180°C. For every two hours, one sample from each set was taken out for resistivity measurement and Vicker's microhardness test.

The Vickers micro hardness test was carried out on the ageing samples. The test was conducted on the "Mitutoyo DX256 series, Japan" micro hardness tester with a force of 30N and dwell time of 10 s. The hardness value for each sample was obtained by an average of five measurements. Resistivity results were obtained by inverting the electrical conductivity measurement of the samples. This is applicable to measure the precipitates growth rate in the cast alloy since the precipitates have reduced the conductivity properties of the metal.

Results and Discussion

Figure 3 shows the age-hardening responses of the aluminium alloy 319 series solutionised at different temperatures. The graph shows a similar trend where as the hardness was increased to the peak-aged, then slightly decreased before reaching another smaller peak and finally recorded a lower hardness during the 20 hours ageing period. However, the age hardening responses for higher temperature are accelerated during the process with lower peak-age hardness. Since copper element are responsive to increase the age hardening response in cast alloy (Wang, 2003), this might be due to copper-rich phase has fully dissolved into the Al matrix.

In figure 4, the resistivity measurement shows that the resistivity is increased according to the hardness. The precipitates are steadily growth for samples solutionised at higher temperature as compared to the lower temperature. It is observed that the resistivity increments are continuous even after the peak-age. The resistivity increments for solutionising temperature at 525°C showing uniformity with the hardness profile at the initial hours of the age-hardening process. This trend was not observed on the other solutionising temperature.

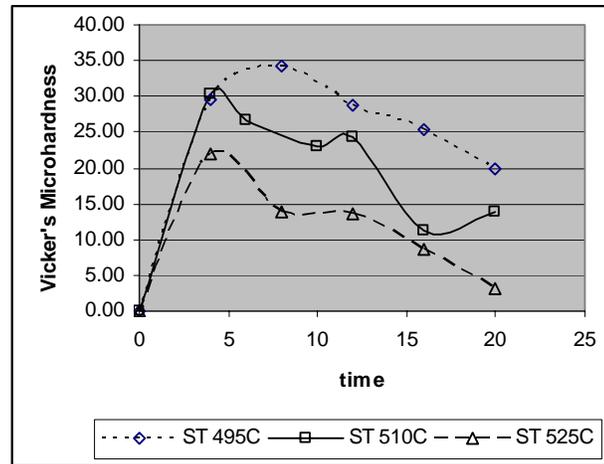


Figure 3: Age-hardening responses at different solutionising temperature

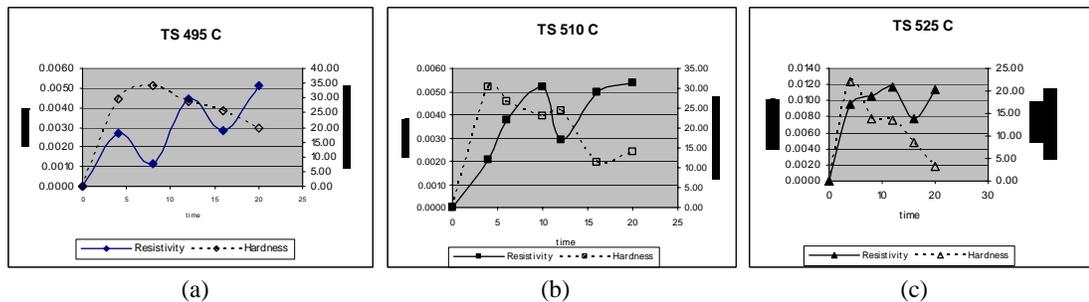


Figure 4: Vicker's microhardness and resistivity variation during solution treatment for recycled aluminium alloy 319 series at (a) 495°C, (b) 510°C and (c) 525°C

Conclusion

A study on the effect of solution treatment temperature on recycled aluminium alloy 319 has been performed using Vicker's microhardness and resistivity measurement. It was found that the higher solution temperature applied has accelerated the age-hardening response of recycled aluminium alloy 319 series. It is also believed that the higher temperature solution treatment may attribute to fully dissolved the copper-rich phase in the aluminium matrix as showed by the resistivity measurement.

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