

# Quench Sensitivity Study of an Aluminum 7050 Alloy by Jominy End Testing

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## INTRODUCTION

An assessment of quenching sensitivity of a high strength, precipitation hardening aluminum 7050 alloy is very important, since there is an increasing requirement to use this alloy to produce thick primary structural parts for military and aeronautical applications. The *Jominy End Quench* is a well known as a hardenability test for ferrous alloys. However, there is little application of this method for non-ferrous alloys. In the present study, the quench sensitivity of the 7050 alloy has been investigated by the *Jominy End Quench* method to simulate the real continuous temperature gradient during quenching of a thick plate.

## EXPERIMENT

A bar sample ( $\phi 40 \times 110 \text{ mm}^3$ ) is solution treated at  $475^\circ\text{C}$  for 3 hours and then quenched from one end by spray water. Instantaneous temperatures are fed into data log system during the quenching process. The quenched bar sample is then aged at  $120^\circ\text{C}$  for 24 hours and Vickers hardness (Load = 3 Kg) is measured at different distances from the quenching end. Microstructures of samples under different cooling rates are characterized using TEM.

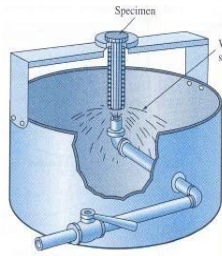


Fig. 1 Schematic illustration of Jominy End Quench test

## RESULTS

- The maximum hardness of  $\sim 197$  (HV) is achieved at the quenching end of the aged bar sample.
- A 10% reduction of the maximum hardness, defined as quench sensitivity value (QSV), is measured at  $\sim 60 \text{ mm}$  from the quenching end.
- The other end of the bar sample has a hardness value of  $\sim 172$  (HV), which is  $\sim 12\%$  reduction of the maximum hardness.

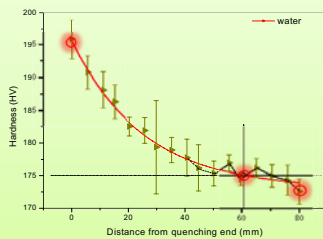


Fig. 2 Hardness curve of aged bar sample

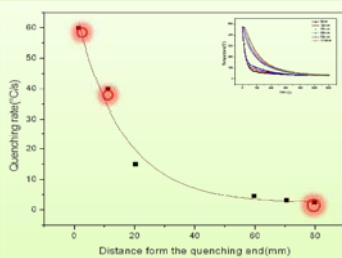


Fig. 3 Cooling rate curve and temperature curves of the specimen

- The cooling rate at the quenching end of the bar sample is  $\sim 60^\circ\text{C}/\text{sec}$ .
- The cooling rate at a distance of  $10 \text{ mm}$  from the quenching end is  $\sim 40^\circ\text{C}/\text{sec}$ .
- The cooling rate at the  $110 \text{ mm}$  end is equivalent to air cooling.

## CONCLUSIONS

- The quench hardnability can be measured by using a *Jominy End Quench*. The quench sensitivity value of aluminum 7050 alloy can reach  $60 \text{ mm}$  distance from the quenching end.
- The equilibrium  $\eta$  ( $\text{MgZn}_2$ ) phase can form during quenching process when cooling rate is slower than  $40^\circ\text{C}/\text{S}$ . Both the size and volume fraction of the  $\eta$  phase increase with a decreasing cooling rate.
- The size of metastable  $\eta'$  phase precipitated within the  $\alpha$ -matrix during the ageing treatment is independent to the cooling rate. And the size of the  $\eta'$  phase formed around the  $\eta$  is much larger than that in the  $\alpha$ -matrix.
- The PFZ width along grain boundary increases with a decreasing cooling rate.

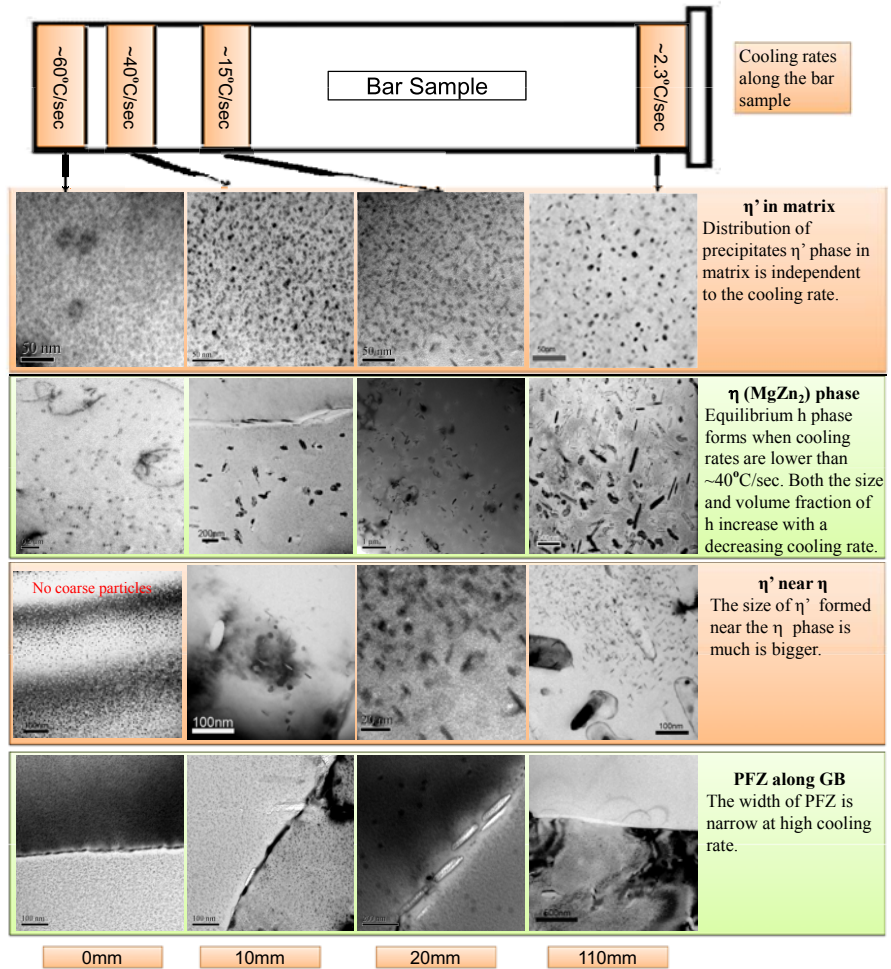


Fig. 4 Microstructure evolution of aged bar sample followed by Jominy End Quench

Table 1 Summary of microstructure features measured in Fig. 5.

Distance from quench end	cooling rate	$\eta'$ in matrix	$\eta'$ near $\eta$	$\eta$	PFZ
0 mm	$60^\circ\text{C}/\text{sec}$	$7.8 \pm 1.5 \text{ nm}$	-	-	$38 \pm 3.5 \text{ nm}$
10 mm	$40^\circ\text{C}/\text{sec}$	$8.4 \pm 2.1 \text{ nm}$	$12 \pm 2.2 \text{ nm}$	$85 \pm 4.5 \text{ nm}$	$66 \pm 4.3 \text{ nm}$
20 mm	$15^\circ\text{C}/\text{sec}$	$7.6 \pm 1.7 \text{ nm}$	$11 \pm 1.2 \text{ nm}$	$176 \pm 5.5 \text{ nm}$	$176 \pm 3.6 \text{ nm}$
110 mm	$2.3^\circ\text{C}/\text{sec}$	$6.7 \pm 1.9 \text{ nm}$	$19 \pm 1.9 \text{ nm}$	$375 \pm 5.1 \text{ nm}$	$293 \pm 2.8 \text{ nm}$