Mechanical Spectra in Various Weld Area of an Extruded Al-12.7Si-0.7Mg Alloy with MIG Welding

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Abstract. Mechanical spectra of ascending and descending temperature in the various areas of weld for an Al-12.7Si-0.7Mg alloy with an extruded states were measured under different frequencies. It is found that there is an obvious internal friction peak near~200 °C in the ascending temperature spectrum and the value of internal friction goes up started at~300 °C resulting in the ~200 °C peak lowered and appeared an peak nearly ~270 °C in the descending temperature spectrum for the matrix and heat affected zone; while there is not any peak in the weld zone, Discussion to the results was made.

1. Introduction
The Al -Si casting aluminum base alloy with low density, high wear resistance, high corrosion resistance and low thermal expansion coefficient have been widely used in producing engine, automobile industry, aerospace and other fields [1-4]. To solve the brittle fracture problem of deformation aluminum alloy containing high silicon, Northeastern University developed a new type of DC deformation aluminum- high silicon alloy containing magnesium of Al-12.7Si-0.7Mg. The yield strength and the elongation of the alloy extruded are better than that of a T4-state 6063 alloy having been widely used, while the alloy with T6 state which the yield strength and tensile strength were increased more than 100MPa still keep good elongation comparable with that of the 6063 alloy[5-8].

Because of fast welding speed and high deposition rate, metal inert-gas (MIG) welding is widely used in welding aluminum, in this work, hot extruded Al-12.7Si-0.7Mg alloy plates were welded by MIG. Mechanical spectra in the various areas of weld for an Al-12.7Si-0.7Mg alloy has been measured.

2. The Experimental Materials and Methods
Preparation methods including melded and extruded of the tested material are the same as the literature [5]. The chemical composition (wt%) of the alloy is : Si, 12.7; Mg, 0.7; Fe, 0.3; Cu, 1.5; Ni, 0.3; Ti, 0.3; and the rest is Al. alloys plates with dimensions of 250× 60× 3mm were cut from the extrusion profile. The longitudinal direction of the plate parallels the extrusion direction, prior to welding, the plates were polished with wire brush and were thoroughly washed with acetone to clean greasy dirt and impurities. The cuboids of 70 × 2 × 4mm were cut from the plate of the alloy by a wire cutting machine. The 70 × 2 × 1mm damping specimens were cut from the cuboid along the cuboid thickness (4mm) .The internal friction measurements were carried out in a multifunctional internal friction instrument of MFP-1000 model, and the measurement adopted a forced vibration method with the rate of both the heating and the cooling were 2 °C /min; Measuring frequency (Hz) were: 1.00, 2.01, 4.02, 8.04 and 11.25Hz respectively.
3. Results and Discussion

Mechanical spectra of ascending and descending temperature for extruded samples of the matrix and heat affected zone shown in figure 1 and 2. There is an observable peak at about 200 °C in heating curves, and with the increase of frequency, the peak position shifts to higher temperature. The measurement frequency and the peak temperatures were given in the table 1 for the matrix, a linear relationship of Ln(f-Tp) shown in Figure 3, activation energy calculated are 40.3kcal/mol. The value of internal friction goes up started at~300°C resulting in the ~200°C peak lowered and appeared a peak nearly ~270°C in the descending temperature spectrum; Mechanical spectra of ascending and descending temperature of weld zone shown in figure 4, unlike the situation of the matrix and heat affected zone, there is not peak in the spectrum.

Figure 1. Mechanical spectra of ascending and descending temperature of matrix with different frequency, rate were 2 °C/min
Figure 2. Mechanical spectra of ascending and descending temperature of heat affected zone with different frequency, rate were 2 °C /min
Table 1. Relation between peak temperature and frequency

| T_p (°C) | 192  | 201.5 | 207  | 214  | 221  |
|----------|------|-------|------|------|------|
| f (Hz)   | 1.0045 | 2.0089 | 4.0179 | 8.0357 | 11.25 |

Figure 3. Linear relationship of Ln(f) vs. 1/T_p
It is known from literature that the test material of the present work is polycrystal. There is generally grain boundary (Ké) peak [9, 10, 11]. As the aluminum base polycrystal alloy containing silicon and magnesium, would have aluminum grain boundary (Al-PM Ké) peak and solid solution grain boundary (SS Ké) peaks of both the silicon and the magnesium. All know that for Al-PM Ké

Figure 4. Mechanical spectra of ascending and descending temperature of weld zone with different frequency, rate were 2 °C /min
peak, the activated energy is 32 kcar/mol, the relaxation strength is $6.8 \times 10^{-2}$, and the peak temperature is of 280 °C to 315 °C[11,12]; obviously, here ~ 200 °C peak with an activation energy of 44.6 kcar/mol in both the ascending temperature spectrum and the descending temperature spectrum is not Al-PM Kê peak. Considering that the alloy contains silicon as high up to 12.7wt.%, and a lot of the free-silicon phase distributed predominantly along the grain boundaries[7], as well as according to the internal friction knowledge of grain boundary[10,13], it is believed that silicon atoms solved have completely replaced the aluminum atoms in the internal friction sources of the grain boundaries in the alloy resulted in that the Al-PM Kê peak was completely inhibited and replaced by the appearance of the Si-SS Kê peak; and the dissolution of the compounds contain magnesium when measuring temperatures reached above 300 °C, the magnesium atoms originated from the dissolution of the component and replaced partly the silicon atoms in the internal friction sources of the grain boundaries, the ~ 200 °C Peak lower and a 270 °C peak appears on the descending spectra of the alloy for the matrix and heat affected zone. and owing to that the precipitation particles of the free-silicon phase and others on grain boundary, have occupied a large amount of internal friction source of grain boundary, the relaxation strength of ~ 200 °C peak is only ~ $1 \times 10^{-2}$. Based on the TEM results of literature [7] and the suggestion of literature [13], it is easily pointed out that the precipitation particles containing magnesium occupied the internal friction sources of silicon in the grain boundaries of the alloys, resulted in the peak in the ascending and descending temperature mechanical spectrum of the weld zone is entirely disappeared.

4. Inclusion
Base on the results and the discussion given above may obtain following calculations:

1).~200°C peak and ~270°C peak in the mechanical spectra for the matrix and heat affected zone is respectively the Si-SS Kê-peak and the Mg-SSKê peak; the free-silicon phase and the precipitation containing magnesium occupied a lot of the internal friction sources of grain boundaries of the alloy results in all the peaks being very low.

2).The internal friction sources of grain boundaries are occupied by the precipitation particles containing magnesium resulted in the peak in the ascending and descending temperature mechanical spectrum of the weld zone is entirely disappeared

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6. References
[1] Matsuura K, Kudoh M and Kinoshit A H, 2003 materials chemistry and physics 81(2/3) 393-395
[2] Xiu Z Y, Chen G Q and Wang X F 2010 Transactions of Nonferrous metals society of china 20(11) 2134-2138
[3] Gupta M and Ling S. 1999 journal of alloys and Compounds 287(1/2) 284-294
[4] Ott R D, Blue C A, Santella M L et al, 2001 Wear 251868-874
[5] Liu F, Yu F X, Zhao D Z and Zhuo L 2011 materials science and engineering A, A528 3786-90
[6] Cao F R, Li Z L, Zhang N X and Ding H 2013 materials science and engineering A, A571 167-183
[7] Liu F, Yu F X, Zhao D Z and Zuo L 2012 light metals,435-439
[8] Hong T, Gong Y P, Tian N and Zhao G 2013 chinese journal of rare metals, 36(3) 368-372
[9] Ji J Wand Li S Y 1995 physics, 24 599-605
[10] Kê T S 2000 Solid internal friction theory foundation: Grain boundary relaxation and structure, Science Press, Beijing
[11] Kê T S 1947 Phys. Rev. 71(8)533-546
[12] Nowick A J and Berry B S1972 Anelastic Relaxation in Crystalline Solids, Acad. Press, New, York and London
[13] Ji J W and Yu N 2006 progress in physics, 26(34) 296-308