Dynamic mechanical response and weldability of high strength 7A62 aluminum alloy

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Introduction

7A62 aluminum alloy (7A62 alloy) as one kind of Al-Zn-Mg alloys is the highest strength weldable aluminum alloy currently. Heat treatment of 7A62 alloy includes T6, T79, T77, T76, T74, T73. Plates and forgings of 7A62 alloy have been widely used in the defense system and main bearing parts of special vehicles.

The Cu content is controlled in 7A62 alloy, and the strength of this alloy can reach more than 600 MPa by appropriate heat treatment process. Strength, weldability and corrosion resistance (including SCC resistance) of 7A62 alloy are better than 7A52 alloy.

7A62 alloy is a new material integrating function and structure in vehicle fields. Its dynamic mechanical behavior and weldability are worthy of attention. Lots of experimental data shows that welding strength of 7A62 alloy is higher 20-30MPa than 7A52 alloy under the same welding condition.

Method

- Experimental materials are commercially produced 7A62 and 7A52 alloy plates with the thickness of 25mm, and the materials are in the T6 state. Their chemical compositions conform to GB/T 3190-2020.
- The dynamic strain rate tests were conducted using a Split Hopkinson Tensile Bar (SHTB) with strain rates from 10^2 s^{-1} to 10^4 s^{-1} at temperatures ranging from 25 to 500 °C.
- The welding wire of 7A62 alloy was RE5356.

Results

Mechanical properties

- It can be seen that the strength of the alloy can reach above 600 MPa and brinell hardness HB exceeds 160.

Table 1. Transverse mechanical properties of 7A62-T6 plate

Alloy	R_m (MPa)	$R_{p0.2}$ (MPa)	A (%)	HBW	KU_2 (J)	K_{Ic} ($MPa \cdot m^{1/2}$)
7A62	615～646	559～602	8.5～13.5	170	13.5	23

Microstructure

- The elongated grains are uniformly distributed along deformation direction, while a small number of coarse particles with sizes less than 10 μm are dispersed (Fig.1).
- Spherical nanoparticles with a volume fraction of 60% and near-spherical equilibrium phases with a volume fraction of 10% are densely distributed in Fig.2.
- The microstructure of the 7A62 base metal and the ER5356 filler are well fused and is composed of deformed grains and few equiaxed grains in Fig.3.

Results

Microstructure

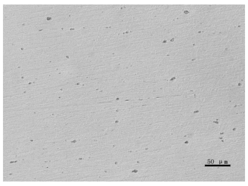
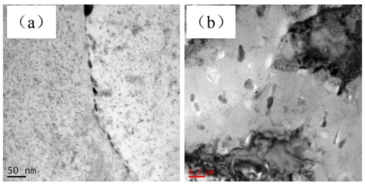


Figure 1. Optical morphology of 7A62-T6 alloy

Figure 2. TEM image of nano-precipitated phases of the matrix in 7A62-T6 alloy



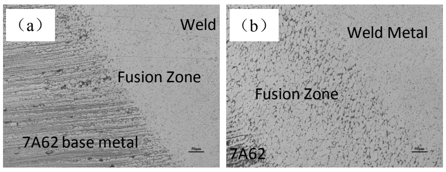


Figure 3. Optical morphology of 7A62 alloy and weld metal

Dynamic mechanical response

- Fig. 4a and Fig. 4b show that 7A62 alloy is more sensitive to strain rate than 7A52, and the plasticity of 7A52 alloy is better than 7A62.
- Fig.5a and Fig.5b show that the yield strength of 7A52 alloy is slightly more sensitive to temperature than that of 7A62 alloy under the same strain rate.

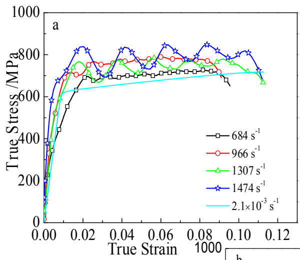
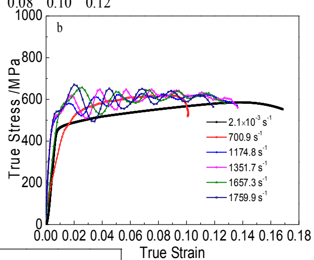
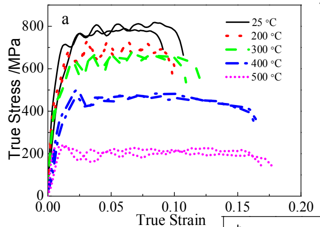


Figure 4. True stress-strain curves of the tensile tests performed at a range of strain rates, (a) 7A62 , (b) 7A52





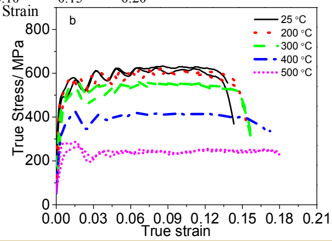


Figure 5. True stress-strain curves of dynamic tensile tests performed at different temperatures, (a) 7A62, (b) 7A52

Results

Weldability

- Using ER5356 filler wire and gas metal arc welding (GMAW) process, welding joint strength of 7A62 alloy is up to 260 MPa ~ 300 MPa.
- Fig.6 indicates that the lowest microhardness and the weakest joint appear in the weld metal.
- High-performance wire will be developed as necessary.

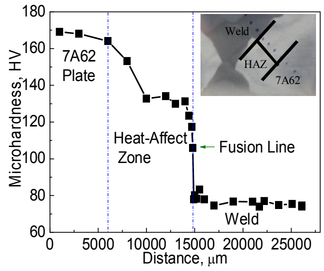


Figure 6. Microhardness distribution of 7A62 alloy weld, inset corresponding macrostructure

Discussion

Effects of composition and microstructure on dynamic behavior

- The strengthening phase of 7A62 alloy showed a trend of local density and the density was higher than that of 7A52, which made the sensitivity of dynamic strain rate of 7A62 alloy higher than that of 7A52.

Effects of composition and physical properties on weldability

- It is mainly regulated by Zn, Mg and Cu in 7A62.
- Melting point range, enthalpy value and specific heat capacity of 7A62 alloy are lower than that of 7A52 .

Conclusion

(1) There are numerous trans-nanoscale particles of strengthening phase of η' and T in 7A62-T6 alloy, which makes the alloy more than 600 MPa in strength, with high hardness and good plastic toughness.

(2) A large number of high-density trans-scale precipitates in 7A62 alloy make the strength of 7A62 alloy more sensitive to strain rate and less sensitive to temperature than 7A52.

(3) The weld of 7A62 base metal and ER5356 filler is a fine dendritic microstructure with small heat affected zone. 7A62 alloy has high welding performance, and the strength of weld can reach 260 MPa-300 MPa.

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