Relationship Between Crack Growth Resistance K_R Curve and Specimen Width for 2060 - T8E30 Lithium Aluminum Alloy

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Abstract. K_R crack growth resistance curve can be used to predict crack propagation behavior, estimate the crack component bearing capacity after the crack, so K_R curve research occupies very important position in the fracture mechanics. Based on crack growth resistance K_R test curve of 2060 - T8E30 lithium aluminum alloy under the same thickness for different width, studies have shown that under the same thickness, the influence of the width on the resistance curve of crack propagation can be neglected. Empirical equation of resistance curve of crack extension of the smaller width specimen is given. Extending the fitting equation to that of larger width, it can be found that it is highly coincided with the experimental results.

Keywords: KR-curve； specimen width； 2060-T8E30; fitting equation

1Introduction

Crack growth resistance K_R curve can be applied to predict the crack propagation behavior and estimate the bearing capacity of cracking component after crack, thus study of K_R curve occupies very important position in the fracture mechanics and the related research has also been caught the attention of many scholars[1-5]. Currently, the study of K_R curve is mainly focus on specimen thickness influence towards the resistance curve of crack propagation while few researches have been conducted on the specimen width influence of K_R curve. The specimen with larger width needs large tonnage testing machine when testing K_R curve and is prone to buckling during the load process. Thus, it requires larger buckling-restrained devices with multiple test personnel cooperate together during the experiment process. On the contrary, the specimen with small width saves time and labor during the test of K_R curve.

This paper conducted the K_R curve tests towards the 2060-T8E30 aluminum lithium alloy with thickness of 3mm, 3.2mm, 3.6mm and 5mm through various widths (W=406mm and W=760mm). Test results show that for the same material under the same thickness, the influence of the width on the resistance curve of crack propagation can be neglected; K_R data point obtained through specimens with small width has been applied to fit the empirical equation. Then the author extend the equation to that of larger width, it can be found that it is

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highly coincided with the experimental results. This thus provides a theoretical base for the correlate crack extension resistance curve of specimen with small width with that of specimen with large width, which is convenient for the engineering application.

Test Materials and Methods*Static property*

Chemical component of 2060-T8E30 aluminum lithium alloy can be seen in Table 1. Static performance test was conducted through specimen as shown in Figure 1. The experimental method is taken by HB5143-96[6].The static tensile properties can be referenced in Table 2.

TABLE 1 CHEMICAL COMPOSITION OF 2060-T8E30 (MASS FRACTION[%])

Si	Fe	Cu	Mn	Mg	Zn	Zr	Li	Ag	Ti
<0.05	<0.07	3.56	0.28	0.77	0.36	0.11	0.64	0.30	0.04

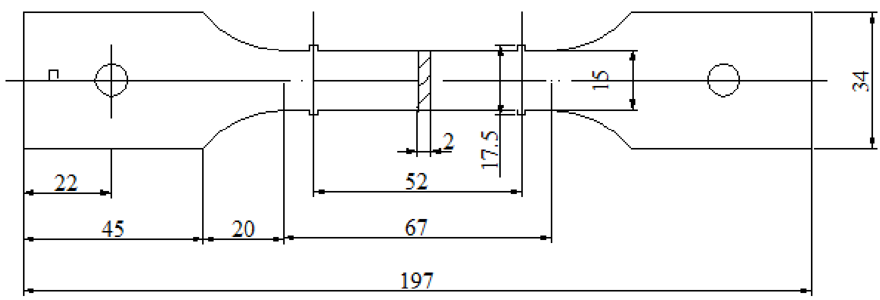


Fig. 1 room temperature tensile property test specimen

TABLE 2 TENSILE PROPERTY OF 2060-T8E30

Material	σ_b[MPa]	$\sigma_{0.2}$[MPa]	δ_5[%]	E[GPa]
2060-T8E30	533	468	13.3	74

K_R-Δa curve measurement

Choosing M(T) specimen (see Figure 2) to conduct the $K_R - \Delta a$ resistance curve test of 2060-T8E30 with the experimental method accorded with HB5261-83[7]. The thickness of specimen is 3.0mm, 3.2mm, 3.6mm and 5.0mm, and the widths of specimen W are 406mm and 760mm respectively.

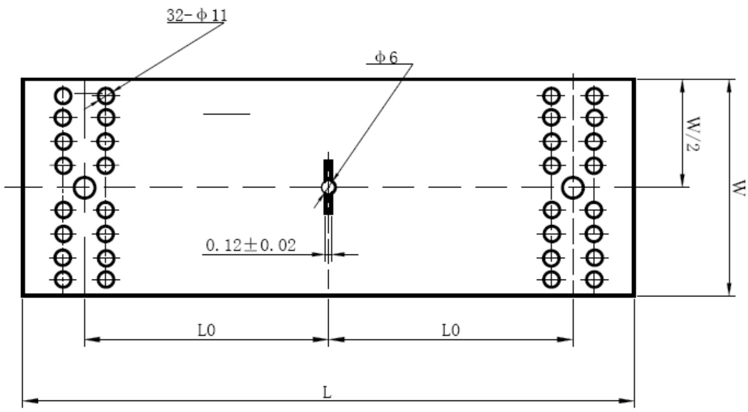


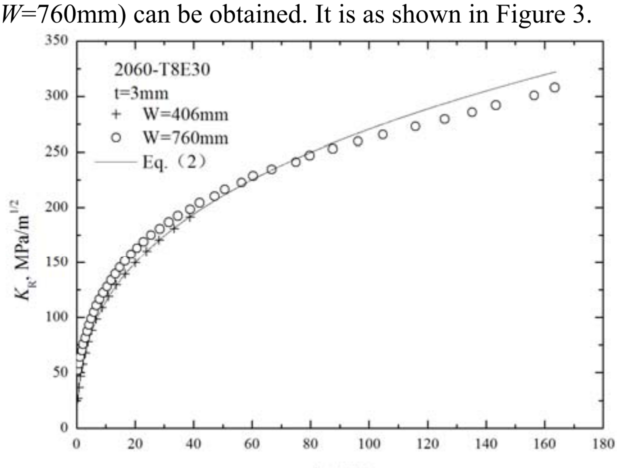
Fig. 2 K_R-Δa test specimen

K_R resistance curve represents the relation curve of crack growth resistance K_R and effective crack propagation Δa . Choosing data a series of point (*P*, *V*) (at least 20) over the linear elastic region on the *P*-*V* curve to make analysis and then calculate the limited crack size a_e of each chosen analysis point by appropriate flexibility equation plus with effective crack propagation $\Delta a = a_e - a_0$. Based on the load *P* and a_e, calculate the K_R value of each chosen analysis point. K_R computational equation of M(T) specimen is as follows:

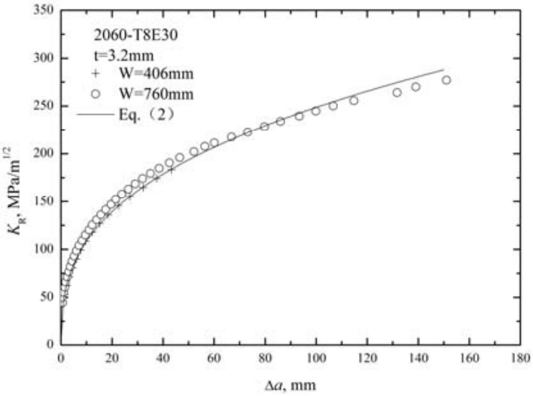
$$K_R = \frac{P}{Wt} \cdot \sqrt{\pi a \cdot \sec(\frac{\pi a_e}{W})} \quad (1)$$

where *P* is the applied load, *W* is width of specimen, *t* is the thickness of specimen, *a* is the initial crack length and a_e is the effective crack length.

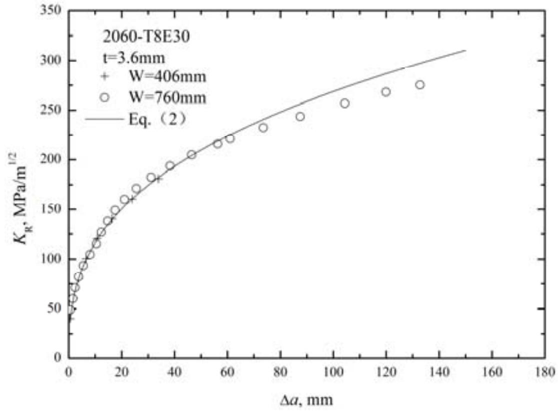
The test data were processed based on Eq.(1) and $K_R - \Delta a$ resistance curve of 2060-T8E30 with thickness of 3.0mm, 3.2mm, 3.6mm and 5.0mm under various widths (*W*=406mm and *W*=760mm) can be obtained. It is as shown in Figure 3.



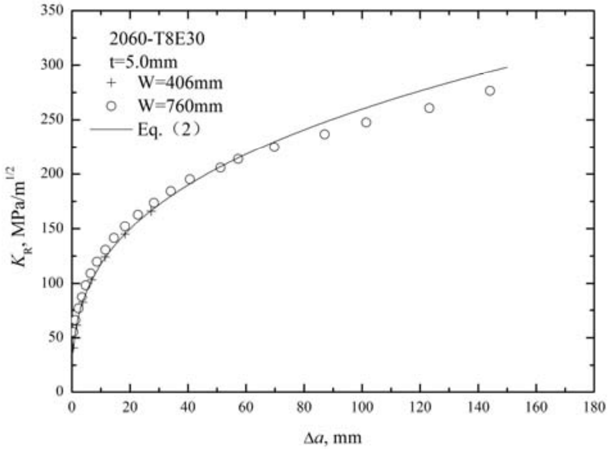
(a) *t*=3.0mm



(b) t=3.2mm



(c) t=3.6mm



(d) t=5.0mm

Fig. 3 K_R-Δa curve of 2060-T8E30

(a) t=3.0mm; (b) t=3.2mm; (c) t=3.6mm; (d) t=5.0mm

It can be seen from Figure 3 that under the same thickness, crack growth resistance $K_R - \Delta a$ curve of the same material does not change with the specimen width. This is due to that crack growth resistance $K_R - \Delta a$ curve shows the resistance of anti-fracture inside the material and thus the stress state of crack tip would be determined when the specimen thickness can be defined. Under the same stress state, the crack tip material has consistent constraint effect on crack propagation and the increasing of the specimen width does not change the stress state of crack tip.

K_R Resistance curve equation which can be practicably used in engineering could be obtained by effective data points of $K_R - \Delta a$ with *W*=406mm and adopted with the Eq. (2) as the fitted equation.

$$K = A \cdot (\Delta a)^{\mathrm{B}} + C \tag{2}$$

where

	t=3.0mm	*t*=3.2mm	*t*=3.6mm	*t*=5.0mm
A	65.4777	46.9643	56.1057	56.7714
B	0.3270	0.3611	0.3465	0.3341
C	-24.6656	0.8198	-8.0090	-4.7063

It can be seen from Figure 3 that $K_R - \Delta a$ curve of *W*=760mm extended by the $K_R - \Delta a$ fitted equation (Eq.(2)) with *W*=406mm is highly coincided with $K_R - \Delta a$ data points obtained through the experiment. During the application in the practical engineering, $K_R - \Delta a$ curve test of the specimen with large width wastes more time and energy. Based on the above analysis, $K_R - \Delta a$ curve can be obtained through the test of the specimen with small width and then fitted into the Eq.(2) and then extended this into $K_R - \Delta a$ curve with the larger width specimen, which greatly saves the test cost and time with the guarantee of accuracy.

2 Conclusions

(1) K_R curve tests has been conducted towards the 2060-T8E30 aluminum lithium alloy with thickness of 3.0mm, 3.2mm, 3.6mm and 5.0mm through various widths (*W*=406mm and *W*=760mm).

(2) As to the same material under the same thickness, the influence of the width on the resistance curve of crack propagation can be neglected.

(3) K_R data point obtained through specimens with small width has been applied to fit into the crack propagation resistance curve based on the empirical equation. Then the author extend the equation to that of larger width, it can be found that it is highly coincided with the experimental results. This thus provides a theoretical base for the correlate crack extension resistance curve of small width specimens with that of large width specimens, which is convenient for the engineering application.

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