Experimental Study on Welded Aluminum Honeycomb Plate under Three Point Bending Test

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1. Introduction

Aluminum honeycomb structures have been extensively employed as lightweight composite components in aerospace, rail transit, architectural decoration and other fields due to their high capacity of stiffness, strength and energy absorption [1-2]. At present, the common honeycomb structures are adhesive honeycomb board. The strength and allowed working environment of adhesive honey- comb structures are restricted by the mechanical property of the adhesive to a large extent. It is difficult to achieve a leap in performance by improving the adhesive performance. Compared with adhesive aluminum honeycomb structure, the welded one has better mechanical properties [3-4]. Therefore, it is necessary to study the mechanical properties of welded aluminum honeycomb structures. There are many researches on the mechanical properties of aluminum honeycomb structure [5-6]. However, a few of literatures focus on the properties of aluminum honeycomb structure in the high temperature environment. This paper studies the shear performance of the welded aluminum honeycomb structures with different laying patterns by the three point bending (TPB) tests. The influence laws of shear properties under different factors, such as span, laying mode of honeycomb, temperature, were investigated.

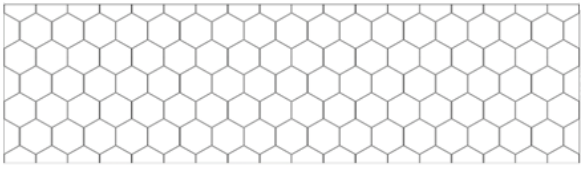
2. Body of abstract

Aluminum honeycomb specimen used in the present study consists of two layers of aluminum plate and aluminum honeycomb core, which were bonded together by welding. The aluminum honeycomb core has two lay-up styles, which were longitudinal laying and transverse laying, respectively. Fig. 1 illustrates the cross section shapes of longitudinal laying and transverse laying honeycomb specimen, respectively. The geometry parameters of longitudinal and transverse laying aluminum honeycomb specimen were 197 mm (length) × 43 mm (width) × 20 mm (thickness) and 195 mm (length) × 53 mm (width) × 20 mm (thickness), respectively.

Since there is not welded aluminum honeycomb test standard for the TPB test, the test performed according to GJB-130.9-86 standard [7]. Experimental setup is shown in Fig. 2. The span size is 150 mm, 100 mm and 50 mm, respectively. The TPB test was carried out at the normal temperature 20℃ and high temperature. In the high temperature experiment, the specimens were placed in the incubator at 20 ℃, 180 ℃, 220 ℃, 260 ℃ and 300 ℃ for 15 minutes before the specimens were loaded. The load was applied by INSTRON 5500R in the experimental tests and the loading speed was set to be 2 mm/min.

According to the experimental failure phenomena, the TPB shear strength test is usually accompanied by obvious shear and bending deformation. Generally, there are two failure modes as shown in Fig. 3. First, the core cell wall of the contact part between the specimen and gasket is basically intact and the adjacent parts were accompanied by bending and shear deformation. The core cell wall was wrinkled. Second, extrusion and shear deformation occurred at the edge of the specimen and gasket and the bending angle was formed accompanying wrinkle damage of the core cell wall. When the span size in TPB tests were 50 mm, 100 mm, 150 mm, the shear strength of longitudinal laying aluminum honeycomb structures at 20 ℃ were shown in Table 1. It can be seen that shear strength increases with the decrease of span in both transverse and longitudinal laying honeycomb TPB tests by comparing the shear strength under different span.

(a) Longitudinal laying



(b) Transverse laying

Fig. 1 Cross section shape of aluminum honeycomb specimen

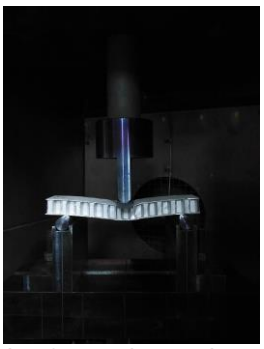
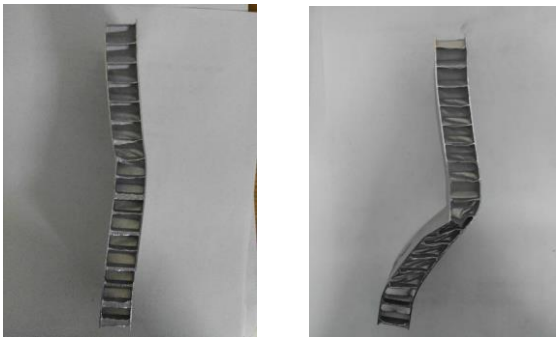


Fig. 2 Schematic of experimental setup for TPB test

The shear strength of longitudinal and transverse laying aluminum honeycomb structures under different temperatures were shown in Tables 2 and 3, respectively. The TPB test results indicated that the shear strength of longitudinal laying honeycomb structure was higher than the one of honeycomb transverse laying honeycomb structure at all test temperatures. Moreover, the shear strength of honeycomb structure decreases with the increase of the temperature. The relation between the shear strength and the temperature of longitudinal laying and transverse laying aluminum honeycomb structure were obtained by using the least square method.



(a) Mode Ⅰ (b) Mode Ⅱ

Fig.3 Shear failure modes

Table 1 Shear strength of longitudinal laying aluminum honeycomb structures under different span (T=20 ℃)

Span/mm	Shear strength/MPa
50	2.567
100	2.071
150	1.650

Table 2 Shear strength of longitudinal laying aluminum honeycomb structures under different temperature (Span=150 mm)

Temperature	Shear strength/MPa
20℃	1.651
180℃	1.257
220℃	1.049
260℃	0.818
300℃	0.630

Table 3 Shear strength of transverse laying aluminum honeycomb structures under different temperature (Span=150mm)

Temperature	Shear strength/MPa
20℃	1.338
180℃	0.761
220℃	0.677
260℃	0.522
300℃	0.414

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