

Investigation on Adhesion Properties of Sandwich Composite Structures Considering on Surface Treatments

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Abstract : Recently, various kinds of study on light weight structure are performing in the world. The Al honeycomb sandwich structural type adopt for improvement of lightness and structural stability to major part structure of aircraft or spacecraft. Adhesion badness properties of adhesive and adhesion properties of fillet mainly studied about al honeycomb structure. But study for adhesive properties of sandwich construction with surface treatment of Aluminum alloy barely performed. In this study, adhesive film was used between Al and honeycomb core of honeycomb panel[1]. The study for adhesive properties of sandwich construction with surface treatment of AA 5052 skin was performed.

Key Words : Sandwich Composite Structure, Honeycomb core, Failure of Adhesive Bond, Drum Peel Test, Floating Roller Peel Test, Flatwise Tensile Test

1. Introduction

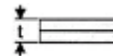
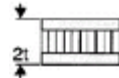
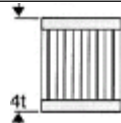
Due to their high stiffness and strength to weight ratios, composite sandwich structures have proven their usefulness in a large number of applications in various technical field, especially in aeronautics and automotive. Table 1 shows mechanical properties of core with thickness.

Al honeycomb are widely used in aerospace and civil structures. Variously the badness adhesive characteristic of adhesion and adhesive as fillet was performed but study for adhesive characteristic of sandwich construction with surface treatment of Aluminum alloy barely performed.

In this study, Adhesive characteristic as surface treatment when adhesive film was used between panel and al honeycomb core was investigated. Fig. 1. shows failure of adhesive bond in sandwich

panels after degradation[2].

Table 1 Mechanical properties of core with thickness

	Solid material	Core thickness(1t)	Core thickness(3t)
			
Stiffness	1.0	7.0	37.0
Flexural strength	1.0	3.5	9.2
Weight	1.0	1.03	1.06

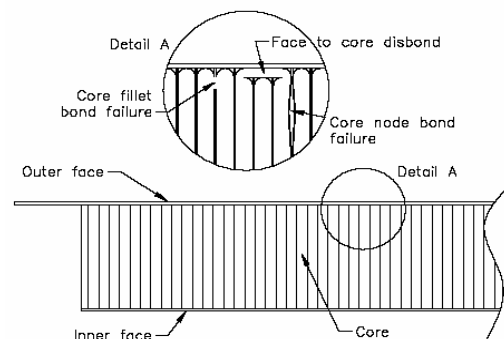


Fig. 1 Failure of adhesive bonds in sandwich panels after degradation

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2. Experimental Test

2.1. The Method of Test

In order to evaluation the adhesion properties, AA honeycomb sandwich panel manufactured using laminate method like fig. 2. Adhesive film was used bondex 606(250° F curing epoxy resin system) on Hankuk Carbon Co., Ltd. AA honeycomb core(AA 3104 H16) was used that foil thickness is 70, Cell size is , 3.44pcf(1pcf=0.016g/cm3), honeycomb thickness is 35.7mm. Drum-peel(ASTM D 1781), floating roller peel(ASTM D 3167) and flatwise tensile(ASTM C297) tested following ASTM spec. Each experiment tested 5 times for reliability of test result. Table 2 shows honeycomb panel facing material. Specimens for test were made 12 case as surface treatment. Table 3 shows the method of surface treatment

Table 2. AA honeycomb panel facing material

	Yield point (Kgf/mm2)	Tensile strength (Kgf/mm2)	Strain (%)
AA5052	22-27	16	5

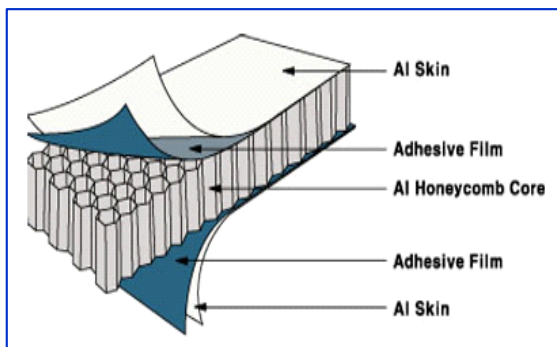


Fig. 2 AA honeycomb S/W panel

2.2 The Result of Drum-peel Test

Adhesive strength test between AA skin and AA honeycomb core were performed by ASTM D 1781[4]. The direction of drum-peel is transverse direction of honeycomb. The results of test were confirmed

Table 3 AA 5052 surface treatment

case	Item	Primers	
1	No Treatment	-	5052
2	Sand Blast Treatment	Sand	
3	Phosphoric Acid Anodizing	Phosphoric acid	
4	Sand Blasting /Phosphoric Acid Anodizing	Sand(Silica) Phosphoric acid	
5	Phosphoric Acid Anodizing / Epoxy Adhesive Primer	Phosphoric acid EAP(BR 127)	
6	Sulfuric Acid Anodizing	Sulfuric acid + Chromic acid	
7	Chromate	Nitric acid+ Chromic acid + dichromic acid+ unsaturation soda	
8	Etching	Sodium hydroxide	
9	Anodizing / Epoxy Paint Primer	EPA: (MIL-P-23377),(MIL-C-5 3022)	
10	Chromate / Epoxy Paint Primer	EPA: (MIL-P-23377),(MIL-C-5 3022)	
11	Chromate	chromium (VI), chromium (III)	
12	Chromate / Epoxy Clear Back	Fine coat No.9400	

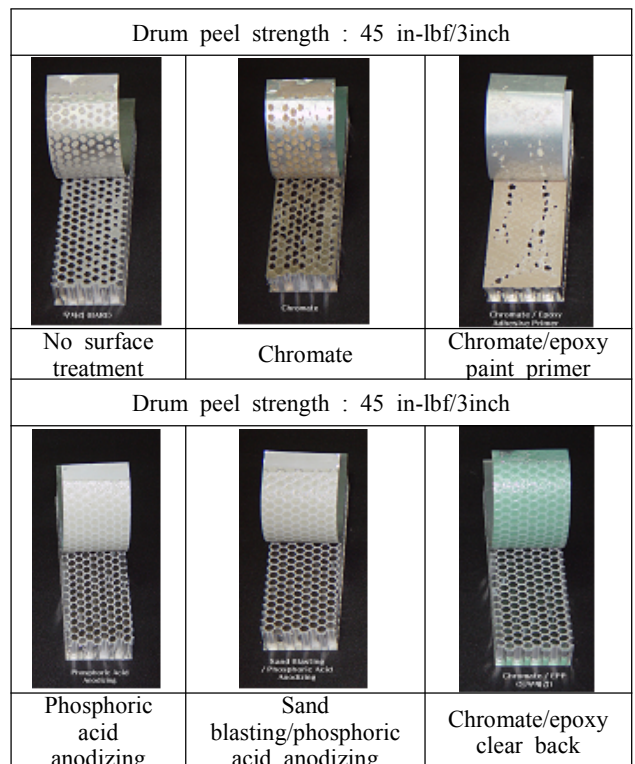


Fig. 3 The result of drum-peel test

that the method of surface treatment using phosphoric acid anodizing, sand blasting/Phosphoric acid anodizing, chromate and chromate/epoxy clear back were excellence properties. Fig. 3 shows exfoliation shape about each surface treatment and table 4 shows the results of drum-peel test.

Table 4 Drum-peel strength (ASTM D 1781)

case	Item	Drum-peel (cm-kgf/7.62cm)	Drum-peel (in-lbf/3inch)
1	No Treatment	34.8	30.18
2	Sand Blast 처리	41.4	35.94
3	Phosphoric Acid Anodizing	70.1	60.88
4	Sand Blasting /Phosphoric Acid Anodizing	71.3	61.87
5	Phosphoric Acid Anodizing / Epoxy Adhesive Primer	52.0	45.16
6	Sulfuric Acid Anodizing	63.8	55.38
7	Chromate	18.7	16.25
8	Etching	62.7	54.42
9	Anodizing / Epoxy Paint Primer	24.5	21.25
10	Chromate / Epoxy Paint Primer	6.0	5.22
11	Chromate	70.1	60.84
12	Chromate / Epoxy Clear Back	72.7	63.09

2.3 The Result of Floating Roller Peel Test

Adhesive strength test on AA Sheet were performed by ASTM D 3167[5]. Fig. 4 shows exfoliation shape. The case which adhesive strength is lower occur exfoliation between Al sheet and surface treatment. The case which adhesive strength is strong occur failure on surface. Table 5 shows floating roller peel strength.

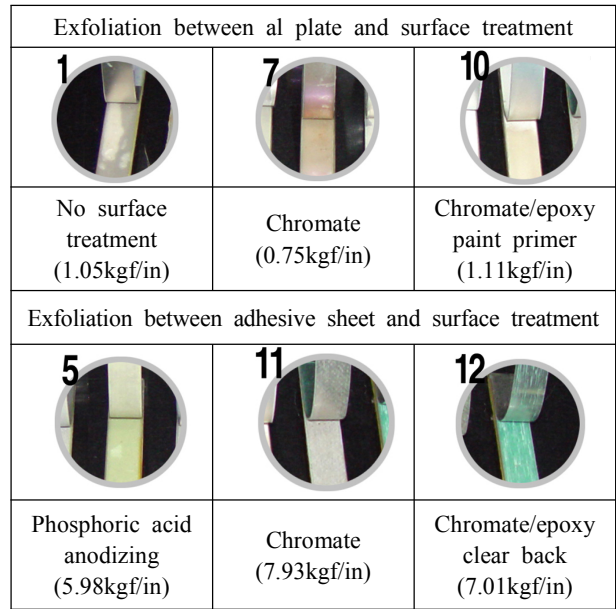


Fig. 4 The result of roller peel test

Table 5 Floating Roller Peel Strength(ASTM D3167)

case	Item	Floating Roller Peel (kgf/in)
1	No Treatment	1.05
2	Sand Blast Treatment	3.72
3	Phosphoric Acid Anodizing	3.97
4	Sand Blasting /Phosphoric Acid Anodizing	6.59
5	Phosphoric Acid Anodizing / Epoxy Adhesive Primer	5.98
6	Sulfuric Acid Anodizing	0.9
7	Chromate	0.75
8	Etching	1.36
9	Anodizing / Epoxy Paint Primer	1.43
10	Chromate / Epoxy Paint Primer	1.11
11	Chromate	7.93
12	Chromate / Epoxy Clear Back	7.01

2.4 The Result of flatwise Tensile Test

Surface adhesive strength test on Al Plate and Al honeycomb were performed by ASTM C 297[3]. The experiments were tested about the case of proofing

excellence properties to drum-peel and floating roller peel test. Table 6 shows flatwise tensile strength test. The strength of case 11(chromate), case 12(chromate/epoxy clear back) are excellent.

Table 6 Flatwise tensile strength(ASTM C 297)

Case	Type	Flatwise (kgf/ cm ²)
3	Phosphoric acid anodizing	46.0
4	Sand blasting / phosphoric acid anodizing	45.1
5	Phosphoric acid anodizing / Epoxy adhesive primer	31.0
11	Chromate	52.4
12	Chromate / Epoxy clear back	54.1

Pell Rsistance of Adhesivesives" Strength of Honeycomb Core Materials

3. Conclusion

In this study experimental test about bond characteristics of the Al honeycomb panel of AA skin due to surface treatment was performed.

(1) The bond test results of Drum Peel, Flat-Wise and Floating Roller Peel under room temperature are like the following. Some cases have excellent bond strength like that case 3 (Phosphoric Acid Anodizing), case 4 (Sand Blasting/phosphoric Acid Anodizing), case 5 (Phosphoric Acid Anodizing/Epoxy Adhesive Primer), case 11 (Chromate) and case 12 (Chromate/Epoxy Clear Back). The 5 kinds of products didn't peel in the treatment surface. We can show that the peeling is development between adhesive film and Al. honeycomb. The results previously obtained for the Flat shape of Al. honeycomb. Though same chromate treatment, the strength was obviously different 4 to 10 time, the related primers like case7 and case11. Bond strength was excellent between chromate and

adhesive. But that is because difference of membrane configuration of aluminum with chromatic acid.

(2) The 5 series products showed good adhesive strength in the normal temperature are as follows.

a) Honeycomb and adhesive film are peeled when Drum Peel Testing in the normal temperature, but peel value decrease more than approximately 80% because of plenty of peel at between Al. plate and surface treatment when weatherability testing. When we are bend Al. skin an angle of 90 degrees, there was no peel in 5 series products. However, when we bend test material that finished weatherability testing, case 3, case 11 and case 12 were peeled at adhesive film except case 4 and case 5. And the strongest peel is happened at case 12.

b) In the Floating Roller Peel Testing, there was peeling at surface treatment like a Drum Peel, so the decrease of case 3 and case 12 is rapidly decrease about 75~90%. In the case of case 4, case 5 and case 11, it is peeled about a half of the surface treatment.

c) As a result of Flatwise Tensile, all of the cases are break at the middle of honeycomb and adhesive. The results were caused by rapid decrease of shear stress between surface and adhesive line.

(3) Overall a), b) and c), case 5(Phosphoric Acid Anodizing/Epoxy Adhesive Primer(BR127)) is the lowest decrease in weatherability testing and the result of weatherability testing of case 11(Chromate) is similar with case 5 because of high property value though the decrease is somewhat high than case 5. In case of case 12(Chromate/Epoxy Clear Back), the result of weatherability testing is substantially decreased than the test result in the normal temperature.

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