New Developments in Honeycomb Core Materials

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Introduction

Ultracor Inc. (previously YLA Cellular Products Co.) is a designer and manufacturer of specialty core materials. Ultracor has been on the forefront of honeycomb development for over six years and has an extensive space flight heritage. Some of the interesting types of honeycomb that have been developed are: Quartz/Cyanate, Carbon/Carbon, Mica/Epoxy, Spectra, Ceramic, Kevlar honeycomb, Phenylene benzobisoxazole (PBO), and over 50 types of carbon fiber honeycomb core. The most recent development honeycomb such as PBO, Ultra low density carbon, and triax carbon honeycomb core will be discussed in this paper. Corrugated carbon core materials will also be discussed. The backgrounds, development, and potential applications of each core product shall be addressed.

PBO/Cyanate Honeycomb

PBO fiber, an aramid developed by Dow in the early 90's and now made in Japan by Toyobo has remarkable properties. The similar properties of PBO and Kevlar fibers include low density, low dielectric, high tensile strength and toughness. However, PBO is superior in modulus, moisture absorption (<1%), and thermal stability. Table 1 below compares the PBO and Kevlar 49 fibers.

Table 1: Comparisons of PBO and Kevlar 49 fibers.

	Strength		Modulus		Elongation	Density	Moisture Regain
	Ksi	GPa	Msi	GPa	%	g/cm^3	%
PBO-hm	841	5.8	41	280	2.5	1.56	0.6
Kevlar® 49	406	2.8	16	109	2.4	1.45	4.5

Ref.: Aramid, LTD & Dupont

A very unique type of honeycomb is produced with the combination of the PBO fibers with a cyanate resin. The resulting honeycomb as shown in Fig. 1 is called UPF-165-1/4-2.5 and has a cell size of 1/4"and a density of 2.5 lb/ft^3. Mechanical properties are shown in Table 2.

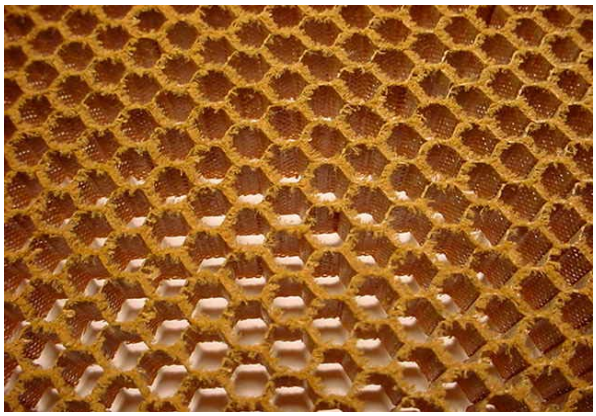


Fig. 1: PBO Honeycomb core, UPF-165-1/4-2.5

Table 2: Mechanical properties of PBO honeycomb core, UPF-165-1/4-2.5

		Compressive		L-Shear		W-Shear	
	Density	Strength	Modulus	Strength	Modulus	Strength	Modulus
	lb/ft^3	Psi	Ksi	Psi	Ksi	Psi	Ksi
UPF-165-1/4-2.5	2.5	129	11	115	25	65	12

Ultra low density Carbon/Cyanate Honeycomb

Based on a need in the space community for an extremely low density, high stiffness and excellent thermal conductivity honeycomb UCF-145-3/8-0.8 was developed (See Fig. 2). This honeycomb core consists of ±30° YSH-70A fibers and a space qualified cyanate ester resin. The orientation of ±30° was used to maximize the compressive properties and z-direction thermal conductivity while maintaining adequate shear properties.

Fig. 2: Carbon Honeycomb core, UCF-145-3/8-0.8

The YSH-70A fiber properties are shown in Table 3. The honeycomb has a density of 0.8 lb/ft^3 but yet is reasonably handable. Unlike 1.0 lb/ft^3 aluminum honeycomb, it can be vacuum bagged and will not dent. Mechanical properties shown in Table 4 are acceptable for the applications intended. Obtaining a consistent compression strength and modulus was challenging since the honeycomb core was so light. A new type of compression fixture was developed to minimize the edge effect and to fully stabilize the core (See Fig. 3)

Table 3: Properties of YSH-70A pitch carbon fibers

	Strength		Modulus		Elongation	Density	CTE	TK
	Ksi	GPa	Msi	GPa	%	g/cm^3	10^{-6}/K	W/mK
YSH-70A	530	3.6	105	720	0.5	2.15	-1.5	250

Table 4: Mechanical and Thermal properties of carbon honeycomb core, UCF-145-3/8-0.8

		Compressive		L-Shear		W-Shear		
	Density	Strength	Modulus	Strength	Modulus	Strength	Modulus	TK*
	lb/ft^3	Psi	Ksi	Psi	Ksi	Psi	Ksi	W/mK
UCF-145-3/8-0.8	0.8	37	9.3	25	19	14	12	84

* Thermal Conductivity measurement of the cell wall

One potential application for this core is for lightweight solar array panels. A requirement for a lower mass and better handling capability than the 1.0 lb/ft^3 aluminum core is critical.

Fig. 3: Ultracor Circular Compression Fixture

Carbon corrugated core Material

While working on a project we were required to produce precise corrugations from pitch carbon fiber. The corrugations as shown in Fig. 4 were needed in large quantities. This core material is quite interesting but as yet we really have not found a home for this product beyond the original requirement. Some mechanical characteristics are shown in Table 5.

Fig 4: Carbon corrugated core materials, UCCM-11-17/.270-7.0

Table 5: Mechanical properties of carbon corrugated core materials, UCCM-11-17/.270-7.0

		Compressive		Core Shear		
	Density	Strength	Modulus	Strength	Modulus	Flexural Stiffness
	lb/ft^3	Psi	Ksi	Psi	Ksi	lb-in^2
UCCM-11-17/.270-7.0	7.0	171	13	364	26	TBD

The corrugations are extremely stiff in one direction and quite formable in the other direction. A sandwich tube or cylinder can be made quite easily with this material as shown in Fig 5. Mechanical properties of corrugated sandwich cylinders are in development.

Fig 5: Corrugated sandwich cylinder

Triax Honeycomb

One type of honeycomb core on the X-33 vehicle was Ultracor product UCF-98-3/8-4.5 (See Fig. 6). The honeycomb was made from a leno fabric and was used in the bulkheads and septum of the LH_2 tank. The requirement was for an extremely open weave fabric which would produce a honeycomb with exceptional venting. The leno honeycomb worked very well in this application.

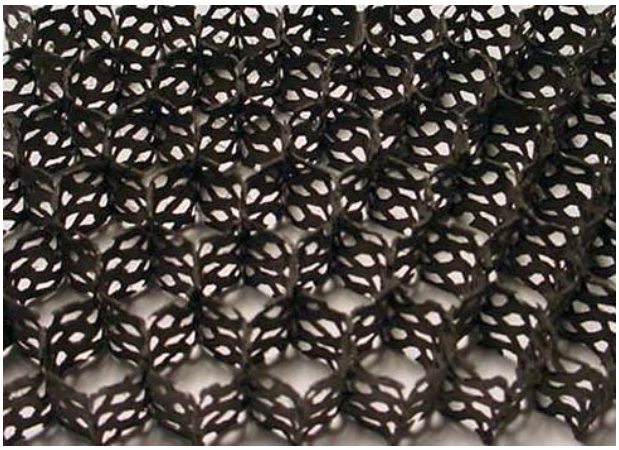
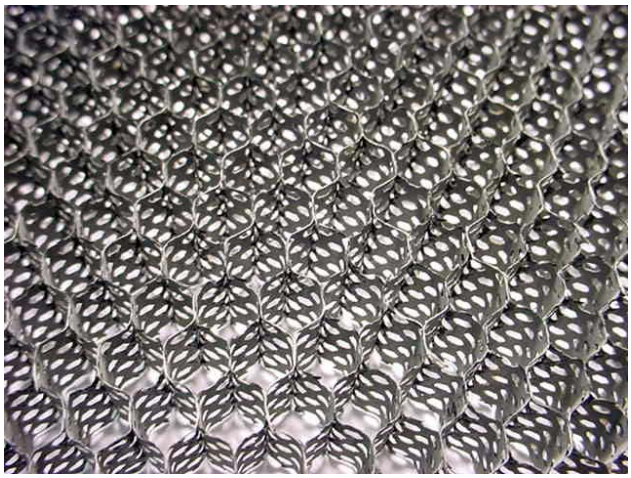


Fig. 6: Leno Honeycomb core, UCF-98-3/8-4.5

The initial idea for this core was to use a triax fabric. Since the project required a quick delivery of the honeycomb. Ultracor had to use the leno fabric since it was available immediately. We did feel however that the triax fabric would produce a more consistent, higher strength honeycomb core.



Just recently Ultracor produced UCF-121-1/4-3.0, a 1/4" cell size, 3.0 lb/ft^3 density, T300 triax honeycomb core (See Fig. 7). We were interested to see if the triax had any unique attributes. The mechanical properties are shown in Table 6.

Fig 7: Triax Honeycomb core, UCF-121-1/4-3.0

Table 6: Mechanical properties of carbon honeycomb core, UCF-121-1/4-3.0

		Compressive		L-Shear		W-Shear	
	Density	Strength	Modulus	Strength	Modulus	Strength	Modulus
	lb/ft^3	Psi	Ksi	Psi	Ksi	Psi	Ksi
UCF-121-1/4-3.0	3.0	392	47.4	301	26.9	185	19.1

Conclusion

Ultracor Inc. is continually developing new types of core materials, some with a specific application in mind or to meet customer's requirements, some as a fallout from a larger project and some based on new materials available. Ultracor honeycomb core can be tailored to most mechanical, physical, or dimensional requirements. Ultracor can produce honeycomb from almost any non-metallic web material and can do this in very small quantities or large production requirements.