Sandwich Core Materials & Technologies – Part II

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The author previously offered a discussion in Part I (July-August 2008 *SAMPE Journal*) on non-honeycomb wood and foam core materials, their characteristics and their typical; applications. This tech note focuses upon honeycomb core applications and the materials of interest within our industry. As noted in the previous article, core materials offer low density, good shear and compression properties, and, are used quite often in sandwich construction designs where composites are used and need very low weight and associated effective high bending stiffness. For the interested reader, Ref. [1-5] offer more detail on the various core materials discussed within this tech note, and in particular Ref. [1-2]. Most honeycomb materials are a nested array of hexagonal cells that are often made from a variety of base materials (paper sheet, woven fabrics, metal foils, thin prepregs, fiber-resin hybrids, etc.). Non-hexagonal honeycomb forms are also available although the hexagonal versions usually offer higher strengths and a better of mechanical properties. Some of the cell configurations offered range widely as noted below:

- Hexagonal
- Flex-core
- Cross-core
- Reinforced hexagonal
- Double flex-core
- Circular (tube-core)
- Overexpanded (OX)
- Spirally wrapped (tube-core)
- Square

Table 1. General attributes of honeycomb core materials found within the composites industry (adapted from Ref. [5]).

Honeycomb Core Material	***Positive Attributes***	***Negative Attributes***
Kraft Paper	• Good insulation properties • Available in large quantities • Lowest cost	• Relatively low strength • More moisture sensitive • Used more in commercial products
Thermoplastics (Polyurethane, polypropylene, polyetherimide, polycarbonate, others)	• Good insulation properties • Good energy absorption • Smooth cell walls • Good moisture and chemical resistance • Relatively low cost	• Prone to creep
Aluminum (5052, 5056, 2024, 3003, 3104)	• Best strength-to-weight ratio • Excellent energy absorption • Good heat transfer • Electromagnetic shielding properties • Thinnest cell walls • Machinable • Relatively low cost	• Galvanic corrosion with carbon/graphite materials
Steel (Carbon steel, 300-series stainless steels, PH-series)	• Strong • Good heat transfer properties • Electromagnetic shielding properties • Heat resistance	• Heaviest of materials • Some may have galvanic corrosion issues
Specialty Metals (Titanium, Nickel-based and Cobalt-based alloys)	• Relatively high strength-to-weight ratio • Good heat transfer properties • Good chemical resistance • Good heat resistance to high temperatures	• Second heaviest of materials
Aramid Fiber Materials (Nomex, Korex, Kevlar)	• Good flammability resistance • Good fire retardance • Good insulation properties • Good formability • Lightweight	• Low compression and shear properties • Picks up higher degree of moisture • Inconsistent bonding properties
Glass Fiber Materials	• Tailorable shear properties by lay-up • Low dielectric properties • Good insulation properties • Good formability	• Heaviest of fiber-reinforced materials
Carbon Fiber Materials	• Good dimensional stability • Excellent high temperature properties • Very high stiffness • Very low thermal expansion coefficients • Tailorable thermal conductivity • Relatively high shear modulus • Lightweight	• Very expensive
Ceramic	• Heat resistance to very high temperatures • Good insulation properties • Available in many small cell sizes	• Very expensive • Typically higher in density

Metallic cell walls often provide the thinnest structures at very low core densities and have smooth, well defined wall structures. They are also available in either perforated ("vented") and non-perforated configurations. Perforated honeycomb cell materials (metallic or non-metallic) eliminate pressure buildup within the cell cavity. This was an early problem in space launch vehicles and payload covers as they went through upper atmosphere conditions and failed structurally by "blowing off laminated skin structures" in the airstream. Phenolic resins also are by far the dominant choice of resin matrix in any composite honeycomb material system. It is relatively low cost, has good bonding characteristics and is quite fire resistant. It's high and low temperature properties are also a "plus".

Honeycomb core materials are fabricated out of numerous materials in order to meet structural requirements over a wide range of temperatures and applications. Many are essentially weight-driven and use thermoset or thermoplastic resins either with or without fiber reinforcements, A number are made from metallic materials. The various classes of materials most often seen in honeycomb structural materials and the characteristics of the various materials used in the construction of honeycomb core materials are shown in Table 1.

Honeycomb materials often come in a density range covering 1-12 lbs/ft^3 or so (see Ref. [1] for an overview of properties). Space applications often require temperature endurance at or above 350F/177C and many of the honeycomb materials find their use within this industry all of the time. The carbon, specialty metals and steel honeycomb materials have the better performance properties, but are also at the upper end of the relative cost structure.

References

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