COMPOSITE CORE: FACTORS TO CONSIDER WHEN CHOOSING MATERIAL FOR YOUR APPLICATION
Composite core materials are used to complete the function of engineered structures by making up for a type of design or performance need, whether it’s weight reduction, providing energy absorption, impact resistance or adding stiffness.

It’s important to select the right composite core material that performs as intended and provides the properties specified for your application. However, with so many viable material options available, it’s imperative to identify the criteria it needs to meet the issues it needs to solve.

In this whitepaper, General Plastics will cover the many factors one should consider when selecting the right composite core material. We’ll also specifically discuss application considerations, important processes and material compatibility elements.

**CORE VALUES**

The role of a composite core material is to provide strength, stiffness and continuity throughout a structure without drastically increasing weight. Whether bonded between two composite skins to form a sandwich panel or over molded with self-skinning flexible foam or decorative cover, core material serves as the central member or foundation of a structure.

The aerospace industry is one of the primary users of composite materials, commonly used as interior floor and ceiling panels, cargo liners, overhead stowage bins, panels, window surrounds, lavatory modules, galleys, food and drink trolleys and bulkheads/class dividers. However, the use of composites is growing across other various industries including marine, transportation, medical and more. The U.S. composite end products market was valued at $26.7 billion in 2019 and is forecasted to grow at 3.8% compound annual growth rate (CAGR) in the next five years to reach $33.4 billion in 2025.

Typically known for its exceptional strength-to-weight ratio, composite core materials need to be evaluated for other qualities and characteristics such as durability, resistance to corrosion, moisture and chemicals, and other environmental exposures. However, these qualities depend on the material used, which makes analyzing and choosing the right core material to meet your structural demands exceptionally important. Core selection begins with careful consideration of the material qualities, manufacturing process and the desired performance.
Common Core Materials

**BALSA**

End grain balsa’s closed-cell structure consists of elongated, prismatic cells with a length (grain direction) that is approximately 16 times the diameter. Balsa is available in sheet form for flat panel construction or in a scrim-backed block arrangement that conforms to complex curves.

**HONEYCOMB**

Honeycomb materials include paper, aluminum, phenolic resin impregnated fiberglass, polypropylene and aramid fiber phenolic-treated paper. The physical properties vary to a large degree with the specific material and density. Fabrication of extremely lightweight panels is possible with honeycomb cores.

**PVC FOAM**

Polyvinyl chloride (PVC) foam cores are manufactured by combining a polyvinyl copolymer with stabilizers, plasticizers, cross-linking compounds and blowing agents. PVC foams offer a good combination of strength and weight with densities ranging from 4 to 30 lbs/ft³.

**POLYURETHANE FOAM**

PU foams are available in blocks, sheets or other shapes. They are sometimes also individually molded into discrete part-shapes. These foams can be useful (depending on formulation) to temperatures range of 275° - 350° F, depending on the formulation, while retaining a substantial portion of their strength and toughness. This allows them to be used in panel applications along with high-temperature curing prepregs, cured in ovens or autoclaves.

FACTORS TO CONSIDER

Design engineers typically focus on the core material's design or performance needs, property requirements needed to fit those needs and the end cost.

For instance, honeycomb, which is commonly used in composite core panel applications, has excellent strength to weight ratio, but can be susceptible to moisture and is also on the expensive end of the spectrum. Narrowing down the properties specifically needed for the application while also reviewing cost is a vital first step.

Typical types of composite core applications can be separated into two main groups: Sandwich Panels and Shaped Cores.

**SANDWICH PANELS**

Sandwich Panels are used in a number of applications in various markets such as aerospace and automotive. A typical sandwich panel consists of upper and lower skins with a much thicker core in the middle.

The main purpose of the core in the center of the sandwich panel is to provide as much spacing between the two skins as possible to create the panel stiffness, adding as little weight as possible, while resisting the forces created when the structure is loaded.
Important Core Material Properties to Consider

Compressive Strength
A material's compressive strength describes how much force a material can take before it yields to the force and deforms or breaks. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load.

Flexural Strength
The stress a material can sustain just before it yields in a flexure test. Also known as bend strength, it helps to measure how rigid a material is.

Flexural Modulus
The ratio of stress to strain in flexural deformation or the tendency for a material to resist bending. Flexural modulus is an important calculation as it relates to the resistance of a panel to deflect when used as a structural member.

Shear Strength
Measures the maximum amount of stress that can be sustained by a material before it tears or breaks when layers shift and slide.

Shear Modulus
The ratio of shear stress to the shear strain. This property tells us in advance how resistant a material is to shearing deformation. If a material is very resistant to attempted shearing, then it will transmit the shear energy very quickly.

Peel Strength
Used to measure the adhesive strength of two or more materials that have been bonded together, such as the two face sheets and core material within a sandwich panel.

Application Environment Considerations
What type of environment will the panel be exposed to? Will it come in contact with moisture? Mechanical properties are important, but there are critical environmental design parameters that could cause an issue with a core material's life expectancy, if not addressed.

Moisture Resistance
Any panel exposed to outdoor elements and high amounts of condensation or humidity, needs a core material that is water resistant to avoid saturation, softening, swelling, rot or bowing of the core. For instance, balsa and other wood core materials may eventually rot, swell or degrade with long-term exposure. It is also important to select a core material that does not support fungal growth.

Thermal Conductivity
Thermal conductivity measures how a material conducts or resists heat transfer, which is important to analyze if the panel needs to provide a thermal break or insulating properties.
Chemical and Corrosion Resistance
If exposed to industrial cleaners, solvents or chemicals, look for a material that is resistant to expected conditions. It should not support fungus or attract rodents and insects.

Flammability
Sandwich panels are used frequently for aircraft interiors, therefore, meeting aerospace’s stringent standards for flame, smoke and toxicity (FST) and heat release is very important. If your panel could potentially be exposed to fire, it needs to meet a number of requirements to guarantee that it will not propagate a fire if exposed to a flame. Is the material flame-retardant and self-extinguishing? Does it intumesce to form a protective carbonaceous char layer that assists self-extinguishment, insulates and protects the material from continued burning?

Weight
In aerospace and automotive markets, lightweighting has become increasingly important to OEMs, Tier 1 and 2 suppliers. Manufacturers are pressed to create new products that meet these industries’ growing needs and new government standards. It’s imperative to identify the right lightweight core material that also doesn’t sacrifice the other performance characteristics you need.

SHAPED CORES

The second group of core applications, shaped core, uses a core material as the base structure that is then over molded or covered with a cosmetic or performance-enhancing material. The core material is typically molded or machined into the desired shape or geometry required by the application.

Winglets, automobile bumpers, car dashboards, glare shields, crash pads, automotive seat backs and head liners would all be examples of shaped core applications.

All of the factors listed for sandwich panels should be considered for shaped core, however there are additional impact mitigation and energy absorption-related questions that need to be analyzed:

- Will the core material be load-bearing?
  If the shaped core is the load-bearing part of a structure, it has to be an extremely strong material that exhibits high performance load-bearing behaviors.

- Is the load static or dynamic, will it see movement or impact or should both be considered?
  The rate the force is applied, whether it’s buildup of energy (low strain rate) or rapid force (high strain rate), is important to review.
• Is it intended to absorb energy in a head strike application? Will a rigid or semi-rigid core, over molded with a softer self-skinning foam or decorative cover meet Head Impact Criterion (HIC) requirements? For instance, if there's turbulence or crash impact aboard an aircraft that causes a pilot to fall forward and hit their head on the glare shield pad, the core material inside should perform as a de-lethalization pad and actually crush and absorb the energy, similar to a bicycle helmet.

**PROCESS**

Solidifying a bulletproof design and identifying the right materials are critical to your project's success. However, selecting the right processing method for your materials can impact time-to-market, expenses, overall product quality and your bottom line. Common manufacturing methods involved when making sandwich panels or shaped core parts include:

**Machining/Shaping**
This process involves various machining techniques such as CNC machining, routing, turning, sawing, cutting, sanding, filing, carving, etc. CNC Machining uses computer software to control machine tools that cut complex 2D and 3D shapes out of blocks of material. Usually, a CAD drawing or other digital representation of the desired part is created, and then the drawing is translated into instructions (e.g., speeds, locations, and coordination) for the CNC machine.

**Bonding**
During this process it is important to consider the following features: resin compatibility, temperature resistance, contact surface area and open cell content. Also, materials not designed to operate at high temperatures for long durations may still be capable of withstanding the heat from resin exotherm or short term high-temperature exposure, so don't mistakenly eliminate materials because of this.

**Resin-infusion**
The process where the layers in an evacuated stack-up of porous materials are filled with a liquid resin. When the resin solidifies, the solid resin matrix binds the assembly of materials into a unified rigid composite. This is a helpful process to strengthen the core of a sandwich panel. Also, choosing the right resin could vastly improve the panel's fire resistance.

**Crush core**
A fast, economical process conducted at high temperature and pressure, in which a cored laminate is placed in a large press and crushed down to a predetermined thickness. This process is commonly used to create the desired thickness and contour in a panel.
Vacuum Bagging
A clamping method that uses atmospheric pressure to hold the adhesive or resin-coated components of a lamination in place until the adhesive cures. An alternative way of adding layers or skins to a core material.

Over Molding
This involves placing a pre-machined or molded core into a mold and molding or forming an additional covering around the core to complete the finished part. Parts with a shaped core that are produced in this manner can be selectively reinforced where needed with backing plates, fasteners, hard mounting points, etc.

COST

Once you've decided on your core material and manufacturing process, you must verify that it is the most cost-effective option for your budget. There are a number of core materials available that offer a product that may be considered over-engineered for the application.

Instead of paying a premium for capabilities you do not need, focus on a material that provides the properties and capabilities that fit the necessary function for your project.

For instance, Honeycomb is typically used in aerospace applications since it is one of the lightest weight core option available, and has excellent fire-resistant properties. However, the exposed edges and cutouts of a honeycomb panel are susceptible to ingress of moisture unless they are sealed with rigid foam edge closeouts or labor-intensive potting compounds to seal the edges. In addition, mounting and fastener locations across the panel surface needs a substrate with suitable fastener pullout strength properties. A more cost-effective material that may be considered is polyurethane foam, especially when material cost is factored in. Polyurethane foam is typically offered in a wide range of densities and has excellent thermal properties. Some PMI and PVC foams may also be considered, however these exhibit some changes in shape when exposed to humidity over time. Ultimately, the core material switch may reduce a company's processing and materials costs.

(http://www-materials.eng.cam.ac.uk/mpsite/interactive_charts/strength-cost/basic.html)
COMPANY AND PRODUCTS

General Plastics Manufacturing Company has been manufacturing flexible and rigid polyurethane materials, aircraft assemblies, molded parts and other specialty foam products for over 70 years. Our LAST-A-FOAM® closed- and open-cell polyurethane foam products provide versatile solutions in the aerospace, defense, nuclear, construction, marine and tooling & molds industries stemming from chemistry-based solutions and a commitment to excellence and quality.

Our composite core products are flame-retardant, deliver long-lasting performance and uniformity over time and offer an excellent alternative to wood, honeycomb and other core materials. Our product line includes core material that passes fire, smoke and toxicity requirements and heat release standards for interior aerospace applications. LAST-A-FOAM® products are non-decaying polyurethane composite cores that support fiberglass laminating, are flame-retardant, strong and light weight, durable, resistant to chemicals and extremely cost-effective. LAST-A-FOAM® composite core materials have been used for years in the aerospace and automotive industries in place of aluminum, as well as for sports equipment and insulated doors and windows. In the marine industry, General Plastics’ composite core foams provide a non-decaying alternative to wood that supports fiberglass laminating production processes.

From the impact resistance required for a hockey stick blade to the durability of a wing tip, General Plastics’ LAST-A-FOAM® offers high-strength, low-weight solutions for diverse manufacturing processes. Whether you need board stock or machined parts, we can meet your exacting specifications.

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<th>LAST-A-FOAM®</th>
<th>Density (lbs/ft³)</th>
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<th>Shear Strength (psi)</th>
<th>Tensile Strength (psi)</th>
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Further information about General Plastics’ LAST-A-FOAM® products, helpful composite core information and general inquiries can be found on our website at: www.generalplastics.com.

2 http://compositesmanufacturingmagazine.com/2020/01/2020-state-of-the-industry-report/5/
4 https://www.sciencedirect.com/topics/earth-and-planetary-sciences/shear-modulus