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M.C. Gill Corporation Delivers a One-Two Punch with New Patented GillFISTS™

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In recent decades, advanced composites have become the material of choice in the fabrication of new commercial aircraft. During the evolution of commercial aircraft design, sandwich constructions have emerged as a viable light-weight material. These materials have mechanical properties that make them ideal for cabin flooring, stowage bins, galleys and lavatories. Typically, composite sandwich panels contain honeycomb core between the facing sheets. The honeycomb core is usually made of aramid paper or aluminum foil and is hexagonal in shape. M.C. Gill Corporation entered the honeycomb core manufacturing business in the 1980s. Over time, the raw materials have been refined and manufacturing equipment improved, but the process has remained relatively unchanged.

THE MOTHER OF ALL INVENTION

Since the 1990s, aircraft designers have increasingly opted for more honeycomb products because of the varied mechanical properties inherent in their construction. Honeycomb is light-weight and offers high mechanical strength, durability and corrosion resistance. One of the challenges our scientists have faced has been how to improve on a product that is already successful and well-accepted in the market.

IDENTIFYING THE NEED

Through customer feedback and market research, we identified several additional qualities that would provide a significant improvement over honeycomb products currently used by the aerospace industry. Improved thermal insulation, better acoustic management and superior damage tolerance would result in a product with unique enhancements, but that meant the development of a new technology for both the manufacturing process and the finished product.

THERMAL INSULATION

SOUND MANAGEMENT

DAMAGE TOLERANCE

THINKING OUTSIDE THE BOX

In 2007, a team of M.C. Gill Corporation scientists began to meet the challenge set before them. Initially, a three-member team worked independent of the production department and the R&D group to encourage out-of-the-box thinking and limit outside pressures or bias. The team conducted a variety of tests in a lab-controlled setting. Its goal was to evaluate a variety of ideas for achieving results beyond traditional methods.

FILLING IN THE GAPS

Conventional honeycomb core has hollow cells that can accommodate significant amounts of air through which heat, noise and vibration can be transferred. Filling the honeycomb cells with a dampening material has been demonstrated to provide better acoustic and thermal insulative properties. Filling the honeycomb cells also offers the potential of improving the cores' resistance to compressive and shear loads in service.

However, conventional means of filling honeycomb cells comes with many objections and negative results. The team had already examined existing foam-filled honeycomb products. One way of filling honeycomb with foam is to press low density foam into the empty cells, but this limits the process to certain densities (usually very low density phenolic foams). Such foams are very friable and the process generates a lot of unwanted dust as the foam breaks down. The dust typically interferes with the bonding of the facing to the core, but may also potentially contaminate other materials in the sandwich layup process.

Another way of filling honeycomb cells is to pour an un-foamed material into the core and allow it to foam en-masse. However, this technique makes it hard to control the density of the foam, is messy and typically requires many additional steps to get a slice of core ready for making a part. These techniques generally lead to a reduction in the ability to bond facings to the core due to dust, other interference with the bonding surface, or out-gassing of the foam.

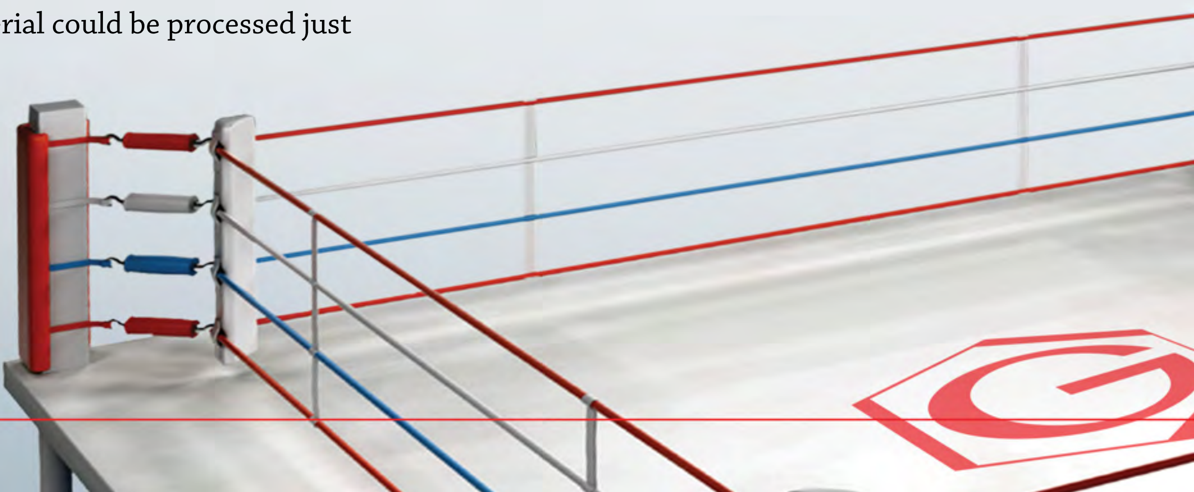
Success would depend on the creation of an innovative method of incorporating foam and honeycomb core to answer the objections caused by the conventional approaches, while producing a feature-rich, superior finished product.

"WHAT IF" TO "AH-HA!"

The team then pursued an idea that came from a "what if" discussion. What if we could put a secondary coating on the core that would foam when the core was used to make a sandwich construction? This method meant the end user wouldn't have to handle foam; we could control the density and properties of the foam and the material could be processed just like a regular piece of core. From "what if" to "ah-ha!" – an idea began to take shape.

Ideally, the coating should be one that is self-regulating and robust, yet easy to process. This led to a very environmentally friendly formulation that is easily manufactured with existing equipment and a coating process that was demonstrated to be robust, even with very simple and crude home-grown equipment (commercially available equipment allows for easy manufacturing and the ability to further tailor the product forms).

Another benefit over existing foam-filled methods was that the foam generates *in-situ* during the bonding process, which means the core behaves (during processing) much like regular honeycomb core.



GILLFISTS IS CREATED

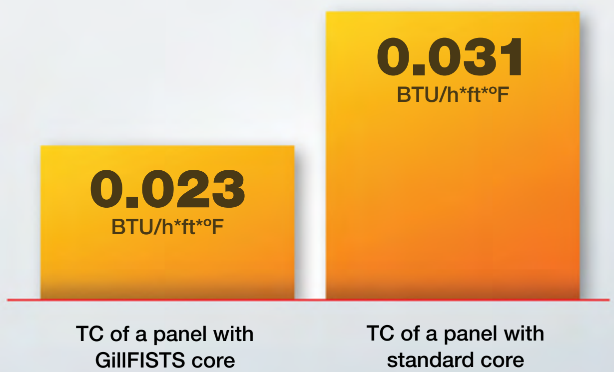
Satisfied they had finally identified a contender worth note, the team decided to run a full-sized block of honeycomb to validate the process. Their due diligence with this unique approach paid off with the development of GillFISTS.

GillFISTS: Foamed In-situ Thermosetting System is a patented (U.S. Patent No. 7,842,147) technology invented and developed by M.C. Gill Corporation.

The foaming process is very robust over a broad range of process windows. Honeycomb with GillFISTS can also be processed in vacuum bag, autoclave and conventional press processes. Foam density is a function of the coating formulation and can be tailored over a broad range of densities. Because whole blocks are subject to the FISTS process and the foam generates *in-situ*, the bonding of the facing is relatively unaffected. In addition, it is possible to produce machined core parts with GillFISTS and selectively coat sections of the core if a customer has a unique application.

This patented method would address our manufacturing concerns – but would the finished product score a knockout when tested for superior thermal insulation, acoustics and damage-tolerance properties?

Our team began with a thorough evaluation of the thermal insulation properties and conducted tests of actual thermal conductivity (TC) measurements on a panel (0.5´´ thick) with one layer of epoxy-coated glass on 3 pcf Nomex core to see the difference between the GillFISTS vs. standard core values. The TC is a measure of how much heat is transmitted through a standard thickness for every degree of temperature. Lab results (see values below) prove the GillFISTS product earned a better TC score than the standard core product.

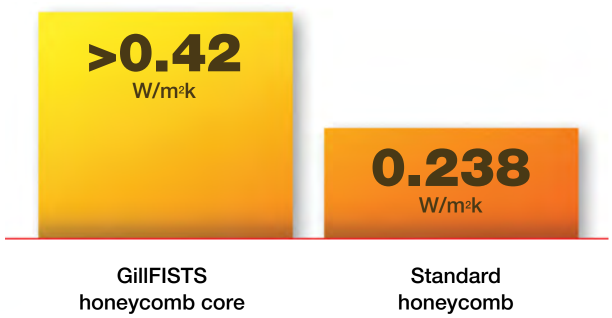


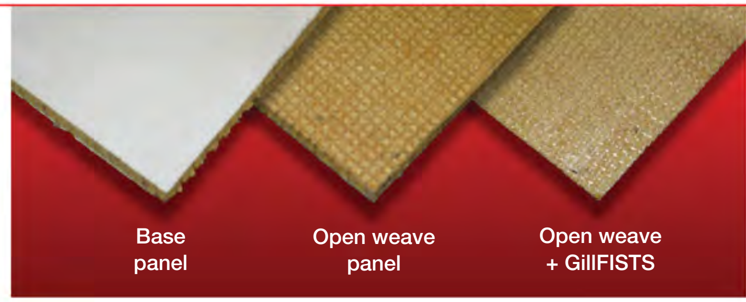
DELIVERING A ONE-TWO PUNCH WITH NEW PATENTED GILLFISTS™

Reciprocal to thermal conductivity, the insulative capacity of a material is dependent on the material thickness or the R value. Simply put, the better the insulative capacity, the higher the R value. The R value difference in this example is the equivilant of a brick wall 2.5 inches thick. GillFISTS succeeds with a significantly higher insulative effect. (Note: For sandwich structures using large-cell honeycomb and/or thicker core, the insulative effect would be even greater due to the convective transfer of heat within the honeycomb.)

Testing the thermal insulation properties was proven using a thermally insulated cabinet. Based on requirements of the customer specification (external conditions of 29°C/70%RH), the internal temperature must be stabilized within three hours and maintained for up to 21 hours. Standard honeycomb fell well short while the GillFISTS-treated materials exceeded the requirements.

Spec = 0.41 W/m²k
Minimum Thermal Coefficient.

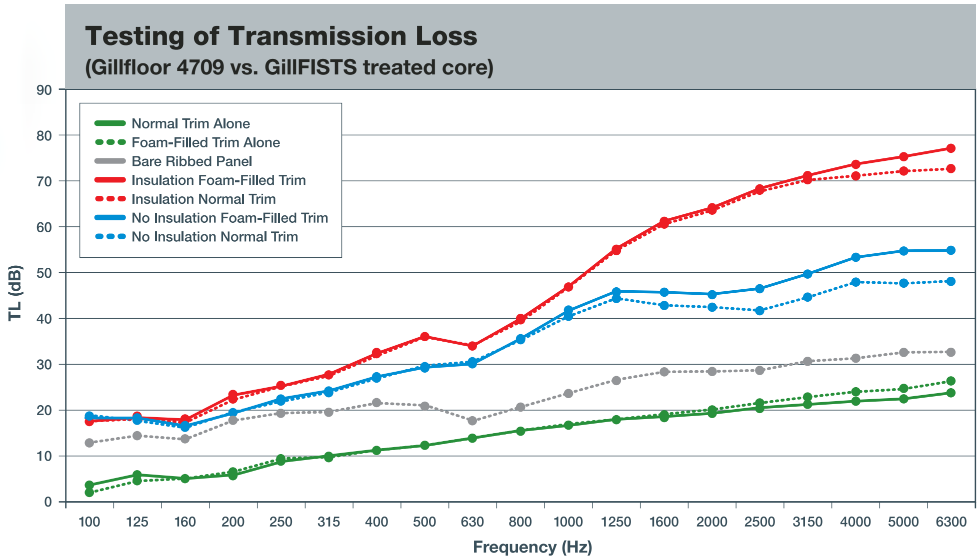




Next, the team initiated a series of tests to measure acoustic management performance. The scientists utilized a typical sandwich panel of standard honeycomb core with fiberglass cloth/phenolic resin facings. The panels were constructed from a combination of open weave facings, standard honeycomb and GillFISTS honeycomb. (GillFISTS densities = 0.5 pcf)

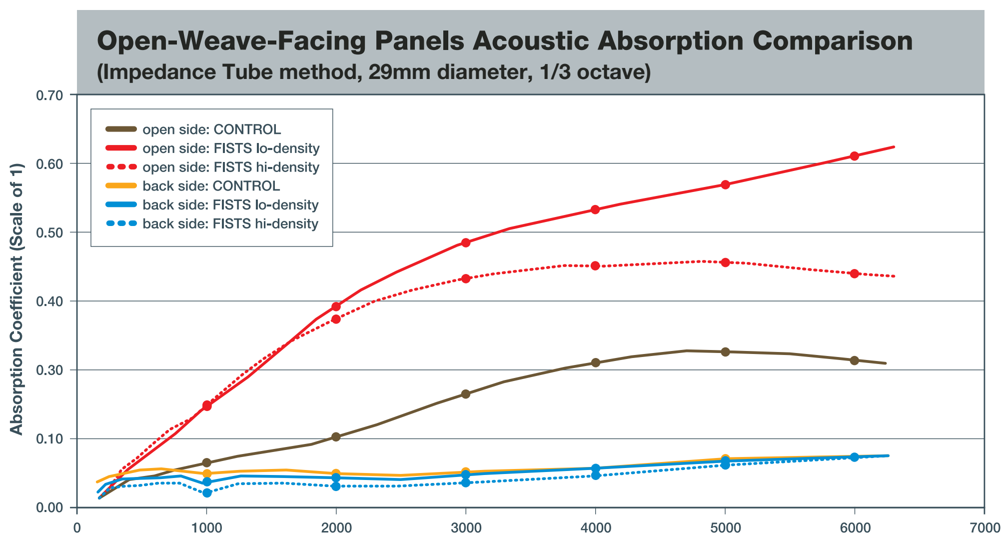
The cabinet mock-up consisted of an aluminum fuselage section with a window approximately 1.5 meters square. Testing was conducted with and without insulation using typical insulation blankets that were sealed to prevent sound around the installation. Results (top right, facing page) show significant improvements (3 decibels) that are noticeable in the higher frequency range.

Testing of transmission loss (Gillfloor 4709 vs. GillFISTS-treated core) suggests variables in filling core cells will offer modest improvements in the range of frequencies most important to passenger air cabin comfort. Accordingly, even modest improvements in transmission loss mean that other forms of acoustic management can be reduced, potentially saving weight and/or cost in actual field applications.



The brown curve below shows the absorption of sound on a porous facing made from standard 3 pcf Nomex core. The pink curves show the absorption of sound on a GillFISTS-treated panel (both high and low density). (Note: Sound that is incident on a solid surface of a panel shows almost no absorption, with sound being reflected away from the panel surface and back towards the source of the sound). These acoustic benefits are very interesting because they are achieved with very little additional weight to the sandwich construction. This offers the potential to reduce weight in the aircraft by replacing some, or all, of the heavier conventional means of managing sound with GillFISTS products.

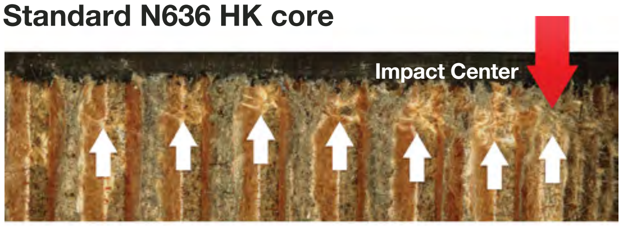
Another important element of acoustic management performance is acoustic absorption. Our scientists conducted tests using a control panel and a panel constructed with a single layer of phenolic-coated glass cloth forming a solid laminate facing, while the opposite side is a single layer of phenolic-coated glass that is very porous and forms an open facing that allows sound (air) to pass through. Testing of a control panel vs. GillFISTS material revealed dramatic results. The absorption of sound is significant when foam is present and acoustic absorption is clearly a benefit of the GillFISTS material.



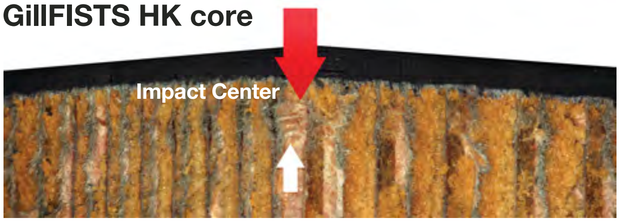
The remaining critical measure of performance was damage tolerance. For this study, high-impact-resistant sandwich structures were manufactured using core with and without GillFISTS. Panels were exposed to impact from a 1-inch diameter spherical dart with impact energy = 350 inch-lb. Afterwards, we took cross-sectional slices of the sandwich panels (standard N636 HK core) vs. the GillFISTS materials (HK core). The standard core shows core fracture damage extending at least six cells away from the point of impact, while the GillFISTS material sustained damage only one cell away from the point of impact.

This remarkable improvement in damage tolerance was achieved with only 1.5 pcf increase in core density by the application of GillFISTS.

Standard N636 HK core



GillFISTS HK core



The dramatic results indicate the GillFISTS material reacts to the impact damage due to a variety of complex factors including energy absorption, core cell wall stabilization and increased compression strength. In addition, we may also conclude that this will translate into greater residual strength in the damaged structure. Similar tests on both autoclave and press-processed materials delivered similar results.

As final proof, the team utilized a C-scan ultrasonic inspection technique often used to show unseen internal damage of composite structures.

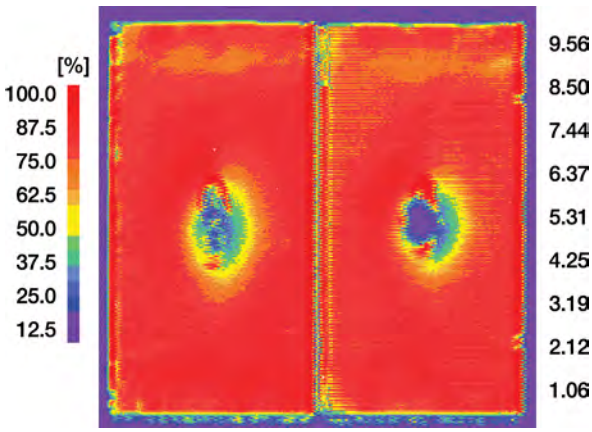
The standard core C-scan image reveals much greater damage than the GillFISTS core, affirming our other performance assumptions.

The dramatic test results we've shared confirm that GillFISTS products clearly offer the unique enhancements our customers seek:

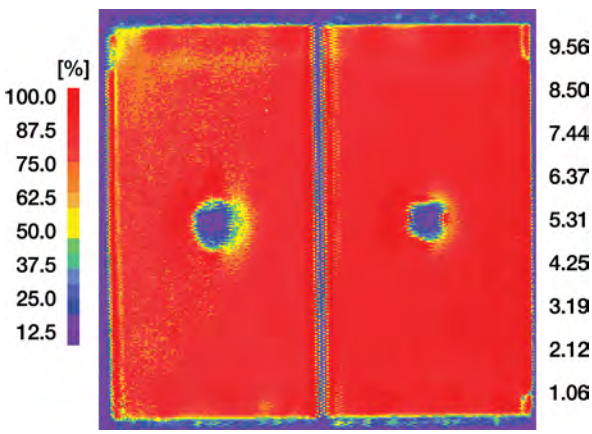
- **improved thermal insulation**
- **better acoustic management**
- **superior damage tolerance**

– all benefits of our exciting new patented manufacturing technology. In our book, we call that a knockout!

C-scan image of standard core after impact



C-scan image of GILLFISTS core after impact



For more information about GillFISTS products or any of the other quality M.C. Gill Corporation materials, please visit our website at: www.mcgillcorp.com

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Alcore does not sell sandwich panels. Contact M.C. Gill for these products.

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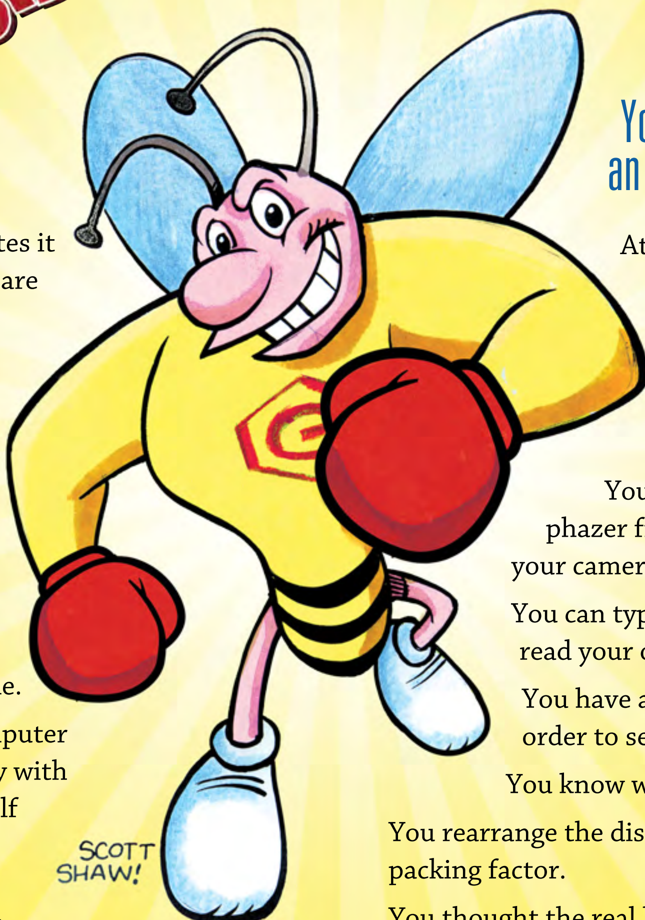
THE FUNNY SIDE



Computer viruses to watch out for

AT&T virus: Every three minutes it tells you what great service you are getting.

Government economist virus: Nothing works, but all your diagnostic software says everything is fine.

Texas virus: Makes sure that it's bigger than any other file.

Adam and Eve virus: Takes a couple of bytes out of your Apple.

Congressional virus: The computer locks up, screen splits erratically with a message appearing on each half blaming the other side for the problem.

Airline virus: You're in Dallas but your data is in Singapore.

Congressional virus #2: Runs every program on the hard drive simultaneously, but doesn't allow the user to accomplish anything.

Star Trek virus: Invades your system in places where no virus has gone before.

Health Care virus: Tests your system for a day, finds nothing wrong, and sends you a bill for $4,500.

You might be an engineer if . . .

At Christmas, you will be the one to find the burnt-out bulb in the string.

You are at an air show and know how fast the skydivers are falling.

You are convinced you can build a phazer from your garage door opener and your camera's flash attachment.

You can type 70 words a minute but can't read your own handwriting.

You have a habit of destroying things in order to see how they work.

You know what "http://" stands for.

You rearrange the dishwasher to maximize the packing factor.

You thought the real heroes of *Apollo 13* were the mission controllers.

Your favorite actor is R2D2.

Your favorite character on Gilligan's Island was The Professor.

Your favorite James Bond character is "Q," the guy who makes the gadgets.

Your IQ is a higher number than your weight.

Your laptop computer costs more than your car.

Best things to say if caught sleeping at your desk . . .

"They told me at the blood bank this might happen."

"This is just a 15-minute power nap as described in that time-management course you sent me."

"Whew! Guess I left the top off the White-Out. You probably got here just in time!"

"I wasn't sleeping! I was meditating on the mission statement and envisioning a new paradigm."

"I was testing my keyboard for drool resistance."

"I was doing Yoga exercises to relieve work-related stress."