Shared composite material property databases

For more than a decade, NASA, FAA, industry and academia have been working toward the goal of creating a centralized composite material property database similar to that for metals. Their efforts, while productive, have not come with the war-like strength that the standardization of metals did.

The composites industry is guided by Composite Materials Handbook 17 or CMH-17 (formerly known as MIL-HDBK-17). Many regard CMH-17 as the equivalent of the metals industry standards organization guide, MMPDS (formerly known as MIL-HDBK-5). However, MMPDS remains the only U.S. government-recognized public source of published design-allowable properties for commercial and military aircraft structures and mechanically fastened joints. The composite material allowances published in CMH-17 generally are not accepted by the FAA or the U.S. Department of Defense (DoD) for aircraft certification and airworthiness without additional substantiating evidence. But CMH-17 leadership, in partnership with the National Center for Advanced Materials Performance (NCAMP), is committed to changing this. As witness to this, the upcoming CMH-17 revision G datasets with Complete Documentation are designed to meet the rigors of U.S. government requirements for commercial and military aircraft structures.

The material property shared database approach adopted for CMH-17 revision G Complete Documentation datasets contains many new requirements. Data submitters must now provide material and process specifications along with the dataset. In addition, the material supplier must produce the material under a process control document (PCD). The specifications and PCD are designed to ensure that material properties are stable over time and must be prepared and maintained in accordance with FAA Advisory Circular (AC) 23-20. The new requirements encompass the entire material property data acquisition and qualification process, including detailed documentation of everything from the materials to the test panel fabrication and inspection and data analysis.

Traditionally, aircraft companies had to generate basic lamina and laminate composite material properties for individual composite material systems, as shown in the top diagram on p. 7. The same material system was often tested and qualified by multiple aircraft companies, resulting in different proprietary sets of allowances and separate specifications for essentially the same material system. Efforts to share material properties were unsuccessful, often because each company considered its data to be proprietary.

NASA AGATE Program

This began to change in 1995, when NASA started the AGATE program to revitalize the general aviation industry. The NIAR was put in charge of the AGATE Materials Working Group to develop a more efficient composite material qualification and property data acquisition process. The AGATE shared database process, as shown in the middle diagram on p. 7, was developed as a result of close coordination with the FAA. The process, published in DOT/FAA/AR-03/19, allows aircraft companies to share basic material properties and specifications similar to the shared database process that exists for the metals industry. After a multibatch material qualification program, the material property data, material and process specifications, and other necessary pedigree information, are included in the shared database. An equivalency process, which involves one batch of material only, is a fast and low-cost sampling process that is designed to show that a follow-on company can use the material and process specifications to reproduce the original material properties. This is necessary because the fabrication of composite parts, unlike that of aluminum parts, involves operations such as layup, bagging and curing, where process parameters could influence basic material properties.

The AGATE shared database process was recognized as an acceptable means of compliance by FAA Small Airplane Directorate Policy Memorandum PS-ACE 100-2002-006 entitled, “Material Qualification and Equivalency for Polymer Matrix Composite Material Systems.” After the AGATE program ended in 2001, the FAA and NIAR continued to support the shared database process by producing additional guidance materials, such as...
as recommendations for developing material and process specifications. The FAA also continued to support efforts to add more materials property data to the AGATE database, as evidenced by the generation of laminate properties for Toray Composites America’s (Tacoma, Wash.) 2510 and Park Electrochemical Corp.’s (Melville, N.Y.) Neolite E765. The industry also continued to support the effort. The material user base for materials qualified using the AGATE process continued to grow, and companies that were not originally in the AGATE program began using the AGATE process. For example, Advanced Composites Group Inc. (ACG, Tulsa, Okla.) generated properties for its MTM45 and MTM45-1 prepregs.

**NCAMP and beyond**

NASA scientists realized that the AGATE process should be extended beyond the general aviation segment to the entire aerospace industry. In 2005, NASA Langley established NCAMP specifically for this purpose: to refine and enhance the AGATE composite material property shared database process to a self-sustaining level in partnership with CMH-17 and FAA. Unlike AGATE, which was a “program” designed to end in 2001, NCAMP has been set up as a permanent national center within NIAR and operates independently of other NIAR laboratories and research initiatives.

The NCAMP process, as shown in the bottom diagram, at right, differs from the AGATE process in two ways: First, NCAMP uses additional guidance materials published by the FAA, namely DOT/FAA/AR-06/10, DOT/FAA/AR-07/3, and DOT/FAA/AR-09/10. Second, many aircraft companies are involved; one aircraft company fabricates the qualification test panels while other companies fabricate the equivalency test panels. The goal of conducting qualification and equivalency programs is to generate material properties and basis values that can be used by all aerospace companies. If deemed equivalent, the properties from the qualification and equivalency programs are then pooled to create a larger dataset, therefore providing aerospace companies with a better model of distribution. Such pooling is possible only if the equivalency programs are conducted at the same time as the qualification programs. NCAMP uses the latest CMH-17 guidelines and statistical analysis tools, such as ASAP (the AGATE Statistical Analysis Program) and STAT17 (the traditional MIL-HDBK-17 statistical analysis program), to generate basis values.

With initial funding from NASA, NCAMP is currently in the process of qualifying and generating material properties for ACG’s MTM 45-1, Hexcel’s (Dublin, Calif.) 8552, and Cytec Engineered Materials Inc.’s (Tempe, Ariz.) 5215 and 5260-5. Test panels are being fabricated by more than 22 aerospace companies. In early 2008, the Air Force Research Laboratories (AFRL, Wright-Patterson Air Force Base, Ohio) began funding NCAMP to generate material properties and qualify Renegade Materials Corp.’s (Springboro, Ohio) FreeForm14 polyimide. In the NASA- and AFRL-sponsored programs, NCAMP is only funded for coordination and testing costs. Material suppliers provide the material directly to participating aerospace companies where they fabricate panels. The aerospace companies that fabricate the qualification test panels benefit in that they may use the dataset to fulfill coupon-level substantiation requirements. Those fabricating equivalency
test panels also may benefit if equivalency can be demonstrated. FAA provides oversight and helps create pedigrees through conformity inspection and test witnessing. Several industry-funded NCAMP qualification programs are underway, including TenCate Advanced Composites USA’s (Morgan Hill, Calif.) TC250, Newport Adhesives and Composites’ (Irvine, Calif.) NCT4708, ACG’s MTM46, and Park Electrochemical’s Nolcote ET52. All NCAMP-generated data will meet the upcoming CMH-17 revision G requirement for Complete Documentation. The data will be submitted to CMH-17 as soon as they are verified to be stable.

As they bear the cost of generating basic material properties, material suppliers are freeing their customers from having to repeatedly regenerate the basic properties. Customers can focus more on process modeling and the testing and analysis of higher-level building blocks, such as joints and detail element properties, which, in most cases, are more relevant to safety and structural efficiency. There will be fewer material specifications covering the same materials, so there will be less material waste at material supplier, part fabricator and maintenance facilities. Material availability will increase because many customers will buy to the same specifications.

Ultimately, the success of this concept depends on aircraft manufacturers. If they use the qualified materials, the material suppliers will realize the value of the shared database and qualify more materials into it. The resulting standardization and greater availability of property data will lead to production of more fuel-efficient, less costly air transportation systems.

**Drilling Holes?**

**DIAMOND COATED AIRCRAFT DRILLS**

Crystallume is proud to introduce our new expanded line of diamond-coated aircraft drills. These drills will provide you with the most cost-effective and efficient way to drill holes in high-performance composite materials.

Most common rivet sizes are available from stock and custom diamond-coated tools for specific applications are also available. Call our engineers for more information.

**Crystallume**

Engineered Diamond Products
A Division of Rockwell Corporation

1-800-789-4322
www.crystallume.com