

Composites Contents

Listing of current literature of interest to the composite community as a service to our readers.

Introduction

In this section, the relevant portions of the tables of contents of current journals which publish composites articles will be reproduced. The entire tables of contents will be reproduced for dedicated composites journals, but in order to conserve space and reduce printing costs, only the composites-related contents of non-dedicated journals will be reproduced. At this time, permission to reproduce the tables of contents has been granted by the following journals:

- AIAA Journal
- Composite Science and Technology
- Composite Structures
- Composites
- Computers and Structures
- Engineering Fracture Mechanics
- Experimental Mechanics
- Experimental Techniques
- International Journal of Analytical and Experimental Model Analysis
- International Journal of Cement Composites
- International Journal of Fracture
- International Journal of Solids and Structures
- Journal of Adhesion
- Journal of Applied Mechanics
- Journal of Composite Materials
- Journal of Engineering Materials and Technology
- Journal of Materials Science
- Journal of Reinforced Plastics and Composites
- Journal of Sound and Vibration
- Journal of Testing and Evaluation
- Mechanics of Composite Materials
- Polymer Composites
- SAMPE Journal
- SAMPE Quarterly
- Shock and Vibration Digest

The editor welcomes suggestions for improvements to "Composite Contents," although library acquisition and accessibility may prevent some additions to the list of journals surveyed.

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World of Composites

News articles and announcements of interest to the composites technical community

Editor's Note

It goes without saying that the World of Composites has expanded tremendously during the ten years that the *Journal of Composites Technology & Research* has been published. It is my hope to reflect these changes in an expanded World of Composites section in the Journal. In addition to reporting composites activities within ASTM Committees D-30, E-24, and E-9, we hope to regularly summarize activities of the other societies concerned with composite materials. We will begin in this issue with notes on the American Society for Composites and the Suppliers of Advanced Composite Materials Association. Similarly, recognizing that universities are centers of composite material technology, we hope to routinely review their programs. The Center for Composite Materials at the University of Delaware has submitted a program summary for this issue. In closing, I would like to take this opportunity to solicit news articles and announcements for the future issues of the Journal.

John E. Masters, Co-Editor

ASTM Committee D-30 Best Paper Presentation Award

This is the first Committee D-30 Best Paper Presentation Award. This recognition of the "best" presentation is intended to encourage all the speakers to prepare their presentations to be the best possible, thus resulting in a better symposium. The recipient of the award is selected based upon evaluations of all the symposium speakers by at least three members of the audience.

Dr. P. Sriram is the recipient of this first award for his presentation of the paper entitled "Fracture Analysis of Transverse Crack-Tip and Free Edge Delamination in Laminated Composites," which was co-authored by Prof. E. A. Armanios and Mr. A. Badir. The paper was presented at the Third Symposium on Composite Materials: Fatigue and Fracture held 6-7 Nov. 1990 at Lake Buena Vista, FL, and chaired by Dr. T. K. O'Brien. Below is a short abstract of the winning paper and a brief article about the authors. Congratulations for a job well done!

Fracture Analysis of Transverse Crack-tip and Free Edge Delamination in Laminated Composites

E. A. Armanios,¹ P. Sriram¹ and A. Badir¹

Summary: Delamination is a predominant failure mode in continuous fiber reinforced laminated composite structures. Based on the location and direction of growth, there are two distinct types of delamination, namely, free edge delamination and local or transverse crack-tip delamination. In many cases, both types occur concurrently with varying levels of interaction. In this paper, a shear deformation model including hygrothermal effects is developed for the analysis of local delaminations originating from transverse cracks in 90° plies located in and around the laminate mid plane. A sublaminar approach is used and the model is combined with previously developed edge delamination shear deformation models. Hygrothermal effects are included in all the models to make realistic predictions of experimental behavior. The unified code is applied to $(\pm 25/90)_n$, T300/934 Graphite/Epoxy laminates for n values between 0.5 and 8. Critical loads and delamination modes are identified and found to be in agreement with published experimental results as shown in Fig. 1.

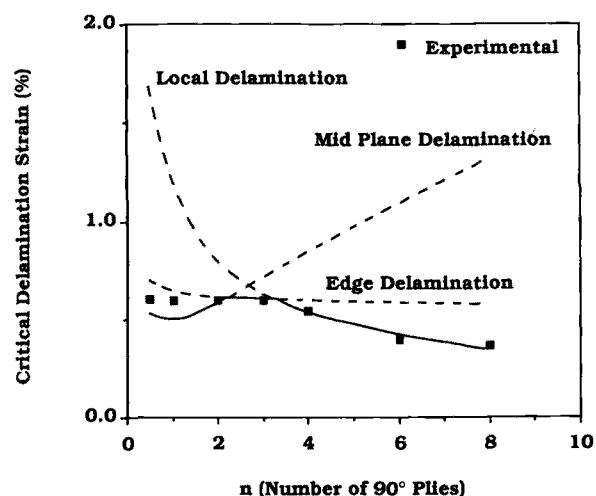


FIG. 1—Critical delamination strains for $(\pm 25/90)_n$, T300/934 graphite epoxy specimen.

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About the Authors

E. A. Armanios is an Assistant Professor of Aerospace Engineering at the Georgia Institute of Technology, Atlanta, Georgia (Fig. 2). His research interests are in the areas of modeling, stress analysis and failure processes of advanced composite structures. P. Sriram is a Post Doctoral Fellow in the School of Aerospace Engineering at the Georgia Institute of Technology and works in the areas of analysis and testing of composite structures and the development of sensing techniques for structural response measurements. A. Badir is a Ph.D. candidate in Aerospace Engineering at the Georgia Institute of Technology. His research interests are in the field of stability of structures, damage characterization and failure modes in laminated composites.



FIG. 2—E. A. Armanios (left), P. Sriram (center), and A. Badir (right), winners of the ASTM Committee D-30 Best Presentation Award.

ASTM Composites Activities

Committee D-30 on High Modulus Fibers and Their Composites

This committee has been chartered by ASTM to develop standards, sponsor symposia, stimulate research, and exchange technical information pertaining to fibers having a Young's modulus greater than 20 GPa (3×10^6 psi) and composites fabricated from these fibers. It recently completed a very successful meeting on 24–27 April in San Francisco, CA. Significant progress was made on each of the committee's mandates. Details of the committee's activities will be reviewed below.

Tenth Symposium on Composite Materials: Testing and Design

Dr. Glenn C. Grimes of Lockheed Aeronautical Systems organized and chaired this two day symposium, which served as the focal point for the committee meeting. A total of 33 papers were presented in the eight sessions that comprised the symposium. A variety of topics were addressed. They included: Damage, Flaws, and Repair; Interlaminar Fracture; Quality Assurance and Process Control; Structure Certification; Compression Testing; and Failure Criteria.

Dr. James M. Whitney of the Materials Laboratory at the Air Force's Wright Aeronautical Laboratory delivered the keynote address titled "Reflections on Development of Test Methods for Advanced Composites."

A Special Technical Publication featuring all the papers presented in the symposium will be issued by ASTM.

Subcommittee D30.02

This subcommittee houses several task groups and study groups that address current and long-range composite material testing problems. In addition to the symposia, a large amount of technical information is transferred during these working group meetings. Brief summaries of the individual group's progress are as follows.

Interlaminar Fracture Toughness (Chairman: Kevin O'Brien)

This task group was originally organized in 1981 to evaluate candidate interlaminar fracture toughness measurement test methods by conducting interlaboratory "round-robin" test programs. Several test methods have been evaluated. These include the Double Cantilever Beam (DCB) test for Mode I, the End-notched Flexure (ENF) test for Mode II, and the Edge Delamination Tension (EDT) test and the Cracked Lap Shear (CLS) tests for mixed Mode I and Mode II delamination. Tests were conducted on graphite reinforced composites with matrices that ranged from brittle epoxy (AS4/3501-6), to toughened epoxy (AS4/BP 907), to tough thermoplastics (AS4/PEEK). Several issues were resolved after two rounds of testing for the pure mode (DCB and ENF) tests. However, it was clear that several critical issues remained.

A third round of testing was initiated in Nov. 1989. Because of the growing interest in these test methods around the world, this next round will be conducted as an international round robin with the European Group on Fracture (EGF), and the Japanese Industrial Standards (JIS) group. ASTM, EGF, and JIS representatives set up a timetable for conducting DCB tests on AS4/PEEK in 1990. The DCB test protocol and test specimens have been sent to the participants. A similar timetable will be established for conducting ENF tests. Furthermore, a Mixed Mode Bending (MMB) test for characterizing mixed Mode I and II delamination has been proposed. Analysis indicates that it is more promising than either of the two mixed mode tests evaluated in previous round-robin tests. The MMB test will also be included in the international round robin.

The task group's charter was recently expanded to include delamination fatigue characterization. A fatigue round robin is currently underway using the Mode I (DCB) specimen. The recommended procedures for obtaining $G-N$ curves for delamination onset characterization have been mailed to participants. Test specimens are to follow shortly. The ultimate goal of all these round-robin programs is to develop ASTM, and hopefully international, test standards for measuring interlaminar fracture toughness.

Compression Testing (Chairman: Paul Lagace)

The task group is currently developing five draft standards for the compression testing of composite materials. Round-robin testing has been initiated on two of the methods; the remaining three

will be underway soon. The progress of each of the efforts was reviewed at the last meeting. Bill Davis of 3M presented data from the Modified D 695 Test Specimen evaluation. Considerable variation existed on the data, and further statistical analysis will be required. Preliminary results of the open hole compression test specimen evaluation were reviewed by Steve Lubowski of BASF. Further analysis will also be required on these data. Specimens required for the compression after impact tests are still being fabricated but should be distributed to participating labs before the next meeting. Crystal Newton reported that transverse compression of filament wound cylinders test specimens would, likewise, be distributed to investigators shortly. The laminate compression study group decided to adopt the draft standard from the open hole compression study as a working document for its work. They will initiate round-robin testing in the near future. This group will also discuss the use of 0/90 laminates to generate lamina properties at the next meeting. Results of a MIL-HDBK-17 Committee study will be reported at that time. As a final note, the thick (that is, >0.5 in. [12.7 mm]) laminate compression method written by Gene Camponeschi of NSRDC/Annapolis will be sent to Subcommittee D30.04 for development as a standard practice.

Specimen Preparation (Chairman: Richard Hall)

Under Mr. Hall's direction, this group has completed work on a document titled "Specimen Preparation through Data Reduction of Aramid, Carbon, and Glass Composite Test Laminates." The document addresses the necessary steps required to assure proper preparation of composite laminates. It specifically addresses techniques required when curing prepregs via autoclave or press techniques. The preparation and testing of laminates are modeled in a 15 step process that extends from laminate lay-up and cure to test operation and data reporting. The document will be sent to Subcommittee D30.04 for balloting to the membership. Once the document has been reviewed and accepted, it will be offered as a guideline. James Ferrell of Hercules will assume Mr. Hall's duties and usher the document through the review process.

Metal Matrix Composites (Chairman: Steven Johnson)

Details of the task group's round-robin test program were finalized during the past meeting. The tests are scheduled to begin in the late fall or early winter. Silicon carbide (SCS-6) fiber reinforced titanium (B21s) matrix specimens, donated by the National Aerospace Plane (NASP) program and Textron Specialty Materials, will be studied. At least six laboratories will be involved. Each laboratory will conduct tension and fatigue tests on unnotched specimens consisting of three lay-ups ([0], [0/90], and [0/+45/-45/90]). Tests will be conducted at room temperature and 900°F (482°C). Dave Harmon on McDonnell Aircraft is the round-robin coordinator. Paul Bartolott of NASA-Lewis Research Center is in charge of the tension tests; Steve Russ of the Air Force is heading the fatigue effort.

Fractography and Failure Analysis (Chairman: John Masters)

Ms. Pat Stumpff of the Materials Laboratory at Wright Aeronautical Laboratory presented a seminar summarizing the Air Force/FAA sponsored work in this area. She discussed a series of logic networks called Failure Analysis Networks that have

been developed to aid the investigator in conducting an investigation of a failed composite component. Several case studies that demonstrated the application of the networks were also presented. Details of this work are contained in Air Force Reports AFWAL-TR-86-4137, AFWAL-TR-86-4033, and AFWAL-TR-87-4011.

Bolt Bearing Tests (Chairman: Thomas Bitzer)

This newly formed task group held its first meeting to define the scope of its efforts. It decided to consider both restrained and unsupported test procedures. Three test methods currently proposed by SACMA, the MIL-HDBK-17 committee, and by the Air Force will be investigated and discussed at the next meeting.

NDE/NDI Techniques (Chairman: Don Petit)

A planning session was held to define the scope of the task group. The group's objectives as defined at that meeting are to evaluate NDE techniques to determine physical properties, quality, and damage in composite materials. The group will also draft standards, procedures, and practices and will contribute its input to D-30 activities as related to NDE. Having considered the draft of a test method to measure composite resin content via ultrasonic NDE, the task group established the framework for round-robin testing. Test results may be available by the next meeting.

International Standards Coordination (Co-chairmen: David Adkins, Rod Martin)

This new study group has been set up to harmonize ASTM and international standards and test methods. Current ASTM and international standards will be reviewed and any noncompatibilities will be flagged. Noncompatibilities may be minor, such as terminology, specimen dimensions, etc., or major such as type of test used, data reported, etc. The study group will modify the current ASTM standard to encompass the minor discrepancies between methods. A dialogue with the key personnel responsible for the international standard will be set up to resolve major differences.

Volunteers who would be willing to review ASTM and international standards are urged to contact either of the study group's co-chairmen. Participation will involve reviewing two or three standards from Europe, Japan, ISO, and ASTM, detailing the differences, and, if required, participating in panel discussions to resolve the differences. Contact either Dr. David Adkins, E. I. DuPont, Composites Division, P.O. Box 6100, Newark, DE 19714-6100, Tel. (302) 733-8275, or Dr. Rod Martin, Mail Stop 188E, NASA Langley Research Center, Hampton, VA 23665-5225, Tel. (804) 864-3482.

Subcommittee D30.04

As indicated in the Spring issue of the Journal, this subcommittee is given the responsibility of developing and administering the committee's test methods, specifications, and standard guidelines. Committee actions at the last meeting included the review of comments received from the balloting of five standard test methods: D 3529, Standard Test Method for Resin Solids Content of Carbon Fiber-Epoxy Prepreg; D 3530, Standard Test

Method for Volatiles Content of Carbon Fiber-Epoxy Prepreg; D 3039, Standard Test Method for Tensile Properties of Fiber-Resin Composites; D 3410, Standard Test Method for Compressive Properties of Unidirectional or Crossply Fiber-resin Composites; and D 3518, Standard Practice for Inplane Shear Stress-Strain Response of Unidirectional Reinforced Plastics. Two of the methods, 3529 and 3530, passed this concurrent subcommittee and committee balloting and will be sent for society balloting. Negative votes on the remaining three standards, however, were found to be persuasive. These methods will be returned to the subcommittee for rewriting. Negative votes were also found persuasive on the proposed V-Notch Shear Test method, which had been submitted to ballot previously. It too will be sent back to the subcommittee for rewriting.

In addition to the work described above, several other standard test methods are being revised and rewritten. Major revisions are being prepared on D 4018, Standard Test Methods for Tensile Properties of Continuous Filament Carbon and Graphite Yarns, Strands, Rovings, and Tows, on D 3800, Standard Test Method for Density of High-Modulus Fibers, and on D 4255, Standard Guide for Testing Inplane Shear Properties of Composite Laminates. Actions are also underway to rewrite and potentially consolidate D 3171, Standard Test Method for Fiber Content of Resin-Matrix Composites by Matrix Digestion, and D 3553, Standard Test Method for Fiber Content by Digestion of Reinforced Metal Matrix Composites. The Standard Terminology of High-Modulus Reinforcing fibers and Their Composites, D 3878, is also under revision.

The subcommittee also accepted transfer of three test method/guideline activities, Mode I Delamination, Open Hole Tension, and Specimen Preparation, from D30.02. D30.04 will begin preparing the draft procedures developed by the D30.02 task groups for balloting.

Future Symposium: Damage in Composites: Nov. 1990

ASTM Subcommittee D-30 and the American Society for Composites will jointly sponsor a symposium titled Damage Detection and Quality Assurance in Composite Materials on 13–14 Nov. in San Antonio, TX. Eighteen papers are planned for the one and a half day symposium that will focus on the application of NDE techniques to identify defects and the use of this information to assess material response. Information on a variety of NDE techniques, composite materials and defects will be presented. The effects of porosity, impact, and fatigue were monitored in graphite and glass reinforced composites. X-Ray tomography was applied to metal matrix and organic matrix composites. Ceramic matrix composites were examined via acousto-ultrasonics and scanning acoustic microscopy. More information on this symposium is available from Symposium Chairman John Masters, Mail Stop 188E, NASA Langley Research Center, Hampton VA 23665-5225, Tel. (804) 864-3478 or from Steve Mawn, ASTM, 1916 Race Street, Philadelphia, PA 19103-1187, Tel. (215) 299-5521.

Committee E-9 on Fatigue

As indicated in the Spring 1990 issue, composites activities in this committee are based in subcommittee E9.03. This subcommittee, which is titled Fatigue of Advanced Materials, is headed

by M. R. Mitchell of Rockwell International. Subcommittee E9.03 is concerned primarily with the thermal mechanical and multiaxial fatigue and lifetime predictions of heat resistant materials such as metal matrix and ceramic matrix composites. A number of standards writing and research activities are planned.

Round-Robin Testing

The subcommittee is planning round-robin testing of aluminum matrix silicon carbide whisker reinforced metal matrix composites, Al-SiCw(orientated), in conjunction with E24.07. E9.03 will conduct a series of low cycle fatigue tests on this material to determine if ASTM E 606 is applicable to whisker reinforced aluminum. In addition, the committee will conduct a damage analysis investigation. The loading and unloading moduli, peak stresses, etc., will be monitored throughout the fatigue cycling to assess damage. The ultimate objective is to ascertain if E 606 is applicable to metal matrix composites and to compare contemporary damage and the continuum damage model for these materials.

Future Symposium: Fatigue and Fracture of Advanced Materials, Nov. 1990

Plans have been finalized for the Symposium on Cyclic Deformation, Fracture, and Nondestructive Evaluation of Advanced Materials which will be jointly sponsored by E9, E24, and D30. The symposium will be held on 12–13 Nov. 1990 in San Antonio, TX. A total of 21 papers will be presented during the 1½ day long symposium. Topics to be covered include fatigue of alumina, directionally solidified superalloys, ceramic matrix composites, and metal matrix composites. Papers discussing the deformation and fracture of oriented polypropylene, aluminum-lithium, ceramics, and ceramic matrix composites will also be presented. The final session of the symposium will concentrate on NDE techniques. These papers will discuss the application of ultrasonics, acoustic emission, and acousto-ultrasonic techniques to metal matrix, and ceramic matrix composites. More information on this symposium is available from Symposium Chairman M. R. Mitchell, Rockwell International Science Center, 1049 Camino Dos Rios, Thousand Oaks, CA 91360, 805/373-4173; Otto Buck, Iowa State University, Ames Laboratory, 126 Materials Division, Ames, IA 50011, 515/294-4446; or from Patrick Barr, ASTM, 1916 Race Street, Philadelphia, PA 19103-11187, 215/299-5449.

Fall Meeting Agenda

In addition to the symposium, E9.03 will be conducting a subcommittee meeting in November. The status of the round-robin testing will be reviewed at that time. Further information may be obtained from M. R. Mitchell or Patrick Barr. Future directives will be established and various subcommittees will be established within this relatively new subcommittee at that time.

Committee E-24 on Fracture Testing

Subcommittee E24.07 on the Fracture of Advanced Materials, chaired by Noel Ashbaugh of the University of Dayton Research Institute, houses the composites materials activities within this committee. The committee has undertaken two initiatives to in-

investigate the application of fracture mechanics to composites. Translaminar fracture and fatigue crack growth in composites are being studied.

Task Group E24.07.02 on the Translaminar Fracture of Advanced Materials is specifically charged with promoting research and developing standard test methods to measure the translaminar fracture properties of advanced composites. John Underwood of the Army Armament Research, Development, and Evaluation Center heads this task group. This group is preparing to begin middle-notch tension, edge-notch tension, and edge-notch bend testing of carbon/epoxy, carbon/bismaleimide, and SiC/aluminum composites. Proposed analysis of these tests is to include characterization of load-displacement plots, development of K and displacement expressions, investigation of configuration and orientation effects, and assessment of damage and failure.

The task group conducted a panel discussion on 24 April 1990 in San Francisco to finalize test and analysis plans. Panel comments will be incorporated as fully as possible into the initial program, which will be ready for sign-up of participants at the next meeting in Nov. 1990 in San Antonio, TX.

Subcommittee E.24.07 also finalized the approach for a round-robin test program on silicon whisker reinforced aluminum alloy in the recently concluded meeting in San Francisco. One of the purposes of this program will be to evaluate the validity of the procedures in the current standards on fracture toughness (E399) and fatigue crack growth (E647) tests. Sixteen laboratories volunteered to participate in the program. Test information and instructions are being prepared and will be sent to the participants. The test material and specimens should be available by the next E-24 Committee meeting.

American Society for Composites

Introduction

The American Society for Composites (ASC) was founded in 1985 to provide a forum for organizing conferences, symposiums, and workshops to disseminate information about composite materials within the scientific and engineering communities. Particular emphasis is placed on the interdisciplinary nature of composite materials technology. According to 1990 ASC President Dick J. Wilkins (Director of the Center for Composite Materials at the University of Delaware and Professor of Mechanical Engineering), "The Society has a number of goals, all of them underpinned by a common theme—communication. ASC, as the only organization in the United States devoted strictly to composites, can play a strong role in linking other related societies in this country and in reaching out to similar organizations in Europe, Japan, and Canada."

In the five years since its inception, the Society has grown to almost 500 members. ASC is governed by an executive committee consisting of the officers (president, vice president, recording secretary, membership secretary, treasurer, and editor), the immediate past president, division/chapter chairmen, and two elected members at large.

Following are brief biographies of this year's president and vice president and a summary of the Society's 1990 Annual Meeting. The Executive Committee is finalizing ASC's strategic plan

for the coming decade; an overview of the plan will appear in the next issue.

ASC Executive Profiles

1990 President Dick J. Wilkins

Dick J. Wilkins has been Director of the Center for Composite Materials (CCM) and Professor of Mechanical Engineering at the University of Delaware since 1986. He spent the earlier part of his career at the Fort Worth Division of the General Dynamics Corporation, developing methods for designing, analyzing, and testing composite structures. He was responsible for fatigue and fracture analysis and testing for the F-16 airplane's vertical and horizontal tails, which were the U.S. Air Force's first primary, safety-of-flight components to employ carbon-epoxy.

Trained as an aerospace engineer, Wilkins has recently focused his research interests on design integration, creativity, composites manufacturing science, durability and damage tolerance, and structural mechanics. He is the author of more than 35 papers and technical reports on these and other composites-related subjects. Wilkins has served on a number of advisory boards and review panels, including committees for the National Materials Advisory Board and the Congressional Office of Technology Assessment. He oversees CCM's design research group and has recently become very interested in the workings of the human brain, particularly with regard to education, creativity, and design.

1990 Vice-President James H. Starnes, Jr.

Jim Starnes holds B.S. and M.S. degrees in Engineering Mechanics from the Georgia Institute of Technology and a Ph.D. in Aeronautics from the California Institute of Technology. He has been an instructor in aeronautics at the U.S. Naval Postgraduate School and is now Assistant Chief of the Structural Mechanics Division at NASA Langley Research Center in Hampton, VA.

Jim's research interests include mechanics of composite structures, failure mechanisms and analysis, damage tolerance and containment, experimental mechanics, structural analysis, and structural optimization, design, and tailoring.

Society Holds Annual Meeting in Michigan

As this issue was going to press, ASC was finalizing plans for its annual meeting (12–14 June 1990) at Michigan State University in East Lansing, MI. The goal of the Society's Fifth Technical Conference, "Composite Materials in Transition," was to address the problems that must be solved for composite materials to make a successful transition from aerospace use to a wider variety of applications. Conference session topics follow:

- Vibration and Damping
- Joining, Fastening and Fabrication
- Interfaces
- Biotechnology and Composite Materials
- Processing I: Novel Methods
- Mechanics I: Experimental
- Toughness and Damage Tolerance

- Processing II: Control and Modelling
- Structural Mechanics
- Metal Matrix Composites
- Processing III
- Impact
- Contemporary Issues in Design
- Cementitious Composites
- Thermal Aspects of Composites
- Compression
- Ceramic Composites
- Non-Destructive Methods
- Mechanics II

The broad-based program was selected for its potential appeal to a diverse audience: engineers, scientists, academics, and technical personnel involved in research, processing, and manufacturing of composite materials in the aerospace, automotive, and related industries. According to Lawrence T. Drzal, General Chairman, "We hope that this comprehensive program will facilitate the transition of composites to a new and changing world environment."

For more information, please call 1-800-447-3549 or write to

American Society for Composites
Engineering Lifelong Education
A394 Engineering
Michigan State University
East Lansing, MI 48824-1226

Suppliers of Advanced Composite Materials Application

The **Suppliers of Advanced Composite Materials Association**, commonly known as SACMA, is a non-profit international trade association of manufacturers that produce materials used in the construction of fiber-reinforced products as well as composite parts manufacturers and other interested organizations that provide ancillary support and service to the advanced composite materials industry.

Headquartered in Arlington, VA, the Association's 1989 membership roster included 78 companies who in terms of supplier participation equates to 90 to 95% of all the heretofore. "Free World" capacity of advanced fibers and prepreps.

Although international in scope, SACMA's principal mission is **"To support growth of the U.S. advanced composites industry based on common, not competitive, interests."** The operative words are "common, not competitive, interests." SACMA is neither in the business of promoting specific products nor subverting corporate initiatives in emerging markets. SACMA is in the business of providing a forum to discuss common obstacles and opportunities plus effect desired changes in the industry via proactive committee outreach programs.

Recognizing that a few, functionally oriented committees provide a greater degree of freedom in responding to industry problems and in launching new Association initiatives, SACMA narrowed its committee focus to concentrate member company expertise in three general areas: Technical Affairs, Public Affairs, plus Environmental, Health & Safety.

Technical Affairs

This column will focus on the organization (Fig. 3), objectives, and current activities of SACMA's Technical Affairs Steering Committee.

SACMA's Technical Affairs Committee objectives are to promote industry standardization, to address technical issues that facilitate expansion and diversification of advanced composite materials usage, and to expand the advanced composites industry technical skill base.

Within the past two years, Committee activities have led to the following:

- Development of nine recommended mechanical test methods for testing composite materials. Currently, four of the nine recommended methods are undergoing round-robin testing under the auspices of ASTM D-30.
- Publication of a recommended practice for printing and applying bar code labels to harmonize identification of advanced composite prepreps and fibers, as well as other products sold by advanced composite materials suppliers.
- Preparation of a recommended method for lot acceptance of carbon fibers along with recommended test methods for density, mass per unit length, sizing content, twist and tow tensile. Earlier this year, SACMA transmitted draft copies of the recommended test methods to ASTM D-30 and encouraged their use in revising ASTM D-4018.
- Sponsorship, in cooperation with the Navy and National Institute of Standards and Technology (NIST), of a Workshop on "Fire Issues in U.S. Navy Applications of Composite Materials."
- Collection of information on continuing education courses in advanced composites for assimilation into a catalogue for use by the practicing professional.

Committee plans for 1990 call for finalizing a recommended test method for bearing strength; drafting recommended test methods related to physical and chemical properties of advanced composites, for example, flow, drape and tack, etc.; advocating a national plan for industrywide standardization of composite material characterization practices; responding to governmental rulemakings, for example, FAA, relative to the certification of

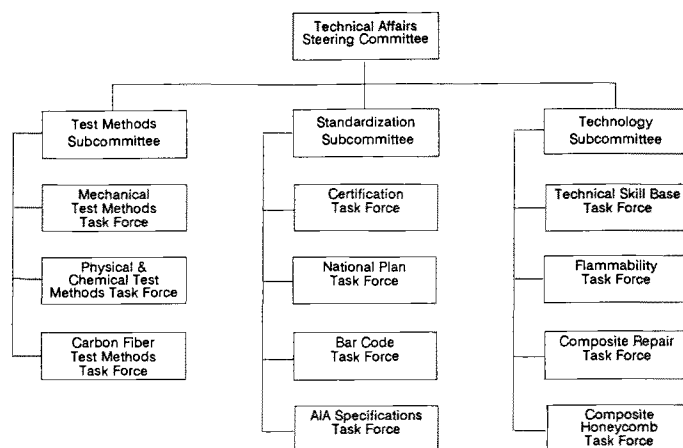


FIG. 3—Organizational objectives for SACMA.

advanced composites; coordinating development of composite repair guidelines with allied organizations, for example, SAE, IATA, etc.; and expanding familiarization with composite honeycomb design concepts.

In summary, that's what SACMA has done or plans to do in the technical affairs arena. For additional information on these activities, please contact Gigi Healy, SACMA Director of Public Affairs, at 1600 Wilson Boulevard, Suite 1008, Arlington, VA 22209; Telephone: (703) 841-1556.

Center for Composite Materials University of Delaware Research Highlights

Background

The University of Delaware's Center for Composite Materials (CCM) was founded in 1974 to address basic research issues in processing science, materials science, engineering mechanics, durability, and engineering design of composite materials. The goal of the program was to remove the fundamental science and engineering knowledge barriers blocking high-volume industrial use of composite materials. Basic research in the traditional thrust areas has since been augmented by work in several manufacturing science thrust areas. The two are highly interactive—designed to converge and provide the Center with a unique capability for conducting the basic research that combines engineering design and manufacturing science.

The following briefly summarizes work in CCM's five traditional and six manufacturing science research thrust areas. Because the work is highly cross-disciplinary, these categories have been designated largely for discussion purposes; most of the projects do not fit neatly into one category but instead bridge two or more of them. The Center for Composite Materials publishes an Annual Report and Poster Book that provide further information on its research programs.

Traditional Activities at CCM

The CCM has conducted research in the traditional areas of processing science, materials science, mechanics, durability, and design. This research provides a fundamental understanding of the behavior of composite materials and is frequently incorporated into the Center's work in manufacturing science.

Processing Science

The goal of the processing science research is to lay the engineering science foundation of the physical and chemical phenomena common to a wide variety of processing techniques. Research in reaction and crystallization kinetics, heat transfer, solidification, cure monitoring and modeling, and rheology has led to the development of process simulations and the design of better cure cycles. Accomplishments during the past several years include the development of flow models that predict fiber orientation states for polymer-matrix composites, a new understanding of processing-induced chemical gradients, and techniques for processing ceramic-matrix composites.

Materials Science

Research in materials science focuses on clarifying the relationships among processing, microstructure, and physical behavior. Work in predicting the stress-strain behavior of anisotropic short-fiber composites has been augmented by research dedicated to establishing structure-property relationships for strength and toughness and to modeling the electrical and thermal transport properties of these systems. Recent work has focused on characterizing the complex interphase region of thermoplastic composites, paving the way toward an understanding of how the interphase affects composite mechanical properties.

Engineering Mechanics

The goal of the work in engineering mechanics is to predict how structures will behave under actual service conditions. Capabilities in this area stem from an interdisciplinary research program that couples fundamental mechanical principles to process simulations and structure-property relationships. The Center's strategy enables the influence of processing on performance to be modeled and cure cycles to be optimized. Work has been done on a variety of materials, including thermosets and thermoplastics, thick and thin sections, and continuous, discontinuous, and textile reinforcements.

Durability

Work in durability is geared toward end-user concerns, including fatigue, fracture, failure, and long-term performance under service conditions. Delamination has been investigated as well as crack propagation, fracture toughness, and wear, and erosion behaviors. Recent efforts have focused on newer materials, including ceramics and three-dimensional fabric composites.

Engineering Design

The goal of the design work is to make the use of composites more cost-effective through simultaneous consideration of materials, configuration, and processing early in the design effort. Historically, this work has been aimed at integrating results from the other thrust areas in a manner that allows a designer to conduct benefit trade-off studies. Recent work has focused on paradigms for making critical decisions during the early design phase in light of uncertain and incomplete information.

Manufacturing Science Thrusts

CCM has defined manufacturing science as the fundamental understanding of manufacturing processes in terms of basic science and engineering disciplines. Thus, the work in the Center's six manufacturing thrust areas draws on the findings of the more fundamental research being conducted in the traditional areas.

Online Consolidation

Work in online consolidation is aimed at developing and understanding new techniques for the impregnation, placement, and consolidation of unidirectional reinforced tapes. The research has resulted in a technique that simultaneously impreg-

mates and consolidates thermoplastics, processes for in-situ consolidation of thermoplastics using laser and hot gas heating sources, and an interactive CAD package for filament winding.

Sheet Forming

Sheet forming is the most widely used method for producing curvilinear surfaces of complex geometries. Research is underway to make the technique usable with a variety of thermoplastic-based materials, including long discontinuous fiber sheets and commingled fabrics, as well as more traditional laminates laid-up from unidirectional preregs. In addition to development of the diaphragm-forming process and identification of the acceptable range of processing parameters, a theoretical model has been developed to predict final part thickness, fiber volume fraction, and void content given the processing conditions.

Textile Preform Processing

Techniques developed for manufacturing textiles are being adapted for application to composite materials. Researchers are braiding and weaving advanced fibers, including ceramics, to make preforms of various geometric shapes. The work has resulted in the fabrication of 3-D structures that reduce delamination failures and enable production of near-net shape designs. The Center has also developed and applied for patents on new textile equipment.

Liquid Molding

Liquid molding—an inclusive term for RTM, RIM, SRIM, and other similar processes—involves forcing a low-viscosity resin into a mold containing a pre-placed reinforcement. The goal is to develop a rapid, reproducible, and verifiable manufacturing technology in this area. Recent developments include three-dimensional process models, as well as theoretical and experimental quantification of resin flow through the reinforcement.

Injection Molding

Injection molding has traditionally been used for low-cost, high-volume, net-shape manufacturing of parts made from short-fiber materials. CCM's work in this area has focused primarily on four issues: mold filling, resin cure or solidification, the final microstructure, and the properties of the molded component. Recently, a special interest has been developed to "long-fiber" compounds.

Joining

CCM's newest manufacturing thrust area, joining, has assumed increased importance as composites are used more extensively in automotive, military, and aerospace structural applications. Research includes investigation of various fusion bonding methods for thermoplastic composites and examination of the role of molecular mobility in the consolidation and bonding of composites. The work has already led to the development of several process models.

Call For Papers

4th Symposium on Composite Materials: Fatigue and Fracture

A call for papers is issued for the Fourth Symposium on Composite Materials: Fatigue and Fracture, sponsored by ASTM Committee D-30 on High Modulus Fibers and Their Composites. The symposium will be held 6–7 May 1991 in Indianapolis.

Previously unpublished papers are requested covering the Fatigue and Fracture of fiber reinforced composite materials, components, and structures. Topics of particular interest include:

- Failure Modes
- Failure/Instability Criteria
- Failure Analysis
- Evolution of Damage
- Micro/Macro Mechanics of Failure
- Nondestructive Inspection and Evaluation
- Damage/Performance Relationships
- Fatigue/Creep Interactions
- Life Prediction
- Damage Tolerance and Durability
- Test Methods
- Multiaxial Loading
- Environmental Effects
- High Temperature Composites
- Repair Criteria

Prospective authors are requested to submit a title, a 500 to 1000 word abstract with key figures, and an ASTM Paper Submittal Form by 6 Aug. 1990 to Dorothy Savini, ASTM, 1916 Race Street, Philadelphia, PA 19103. For additional paper submittal forms, call Ms. Savini at 215/299-5413. More information is available from Symposium Chairman Dr. Wayne Stinchcomb, Engineering Science and Mechanics Department, 227 Norris Hall, Virginia Tech, Blacksburg, VA 24061, 703/231-5316, FAX 703/231-9452.

A Special Technical Publication (STP) based on the symposium proceedings is anticipated by ASTM. Main authors will receive a complimentary copy of the volume(s) containing their papers. The main author is the author corresponding with the ASTM publication staff. All published authors may purchase reprints of the papers at cost.

Final manuscripts for the STP based on this symposium are due by 6 March 1991. This deadline will be rigidly enforced. All papers not submitted to ASTM by this deadline will not be accepted for the STP. If a paper is submitted after the deadline, it may be forwarded to the appropriate ASTM journal to be considered for publication. Please contact Dorothy Savini or the Symposium Chairman if you cannot meet the deadline. ASTM may print and distribute accepted abstracts with the approval of the chairman.

Creep and Fatigue of Metal Matrix Composites

A call for papers is issued for the Symposium on Creep and Fatigue of Metal Matrix Composites to be held 17–21 Feb. 1991 at New Orleans, LA, sponsored by the TMS Composite Materials Committee. Abstracts are due 31 July 1990.

This symposium will focus on recent developments that improve the theoretical and experimental understanding of creep and fatigue behavior in metal matrix composites (MMCs). Papers are solicited in the following areas: fatigue crack initiation and propagation, cyclic deformation, thermo-mechanical fatigue, creep deformation and fracture, and creep-fatigue interactions. The role of matrix microstructure and reinforcement volume fraction, size, type and morphology will also be explored. Papers detailing mechanistic studies, micromechanical and continuum mechanical modeling of creep elevated temperature deformation, and fatigue of MMCs are especially encouraged.

Submit abstracts on TMS Abstract Form D (3 copies) to:

Dr. John E. Allison
Room S2065, Sci. Res. Lab.
Ford Motor Co.
Dearborn, MI 48121
Telephone: 313 845-7224
FAX: 313 390-1710

or

Prof. J. Wayne Jones
Dept. of Materials Science and Engineering
University of Michigan
Ann Arbor, MI 48109
Telephone: 313 764-7503
FAX: 313 763-4788

Delaware Composites Design Encyclopedia, Volume One Published

The first volume is now available in a new six-volume design encyclopedia for advanced composite materials and components. The *Delaware Composites Design Encyclopedia* will provide users with basic knowledge about the design and analysis of

composite materials and structures. It is intended for use by engineers, materials scientists, designers, and other technical personnel involved in the applications of composite materials to industrial products.

The material contained in the encyclopedia was written by international experts in the field and compiled at the University of Delaware's Center for Composite Materials (CCM). The CCM is supported by a university/industry consortium and several U.S. federal research agencies. The encyclopedia was originally offered as a special benefit to consortium members. It is now being offered for the first time to the composites community at large, in an updated and expanded format.

Volume 1/Mechanical Behavior and Properties of Composite Materials begins with a basic introduction to the roles and properties of the constituents and their relationship to the mechanics of composites. These sections provide the background information for more detailed subject matter on static strength and fatigue and elastic properties of continuous, discontinuous, and woven fabric composites. Authors of the first volume are Dr. H. Thomas Hahn, The Pennsylvania State University; Dr. Carl Zweben, General Electric Company; and Dr. Tsu-Wei Chou, University of Delaware.

According to Dr. Tsuyoshi Hayasi, Councillor (First President) of the Japan Society for Composite Materials, "The University of Delaware has compiled its Composites Encyclopedia with the same high standards as the research for which its Center for Composites has long been known."

The remaining volumes of the encyclopedia will be published during 1990. They are *Volume 2/Micromechanical Materials Modeling* (ISBN: 0-87762-699-5); *Volume 3/Processing and Fabrication Technology* (ISBN: 0-87762-701-0); *Volume 4/Failure Analysis of Composite Materials* (ISBN: 0-87762-702-9); *Volume 5/Design Studies* (ISBN: 0-87762-703-7); and *Volume 6/Test Methods* (ISBN: 0-87762-704-5). An *Index to Volumes 1-6* (ISBN: 0-87762-705-3) will also be published. The set is intended as an ongoing series, to which new volumes will be added as needs arise and new knowledge is gained. Each volume is Smythe sewn for years of library and desktop use.

Calendar on Composites

The following meetings may be of interest to researchers in the field of composite materials

26-28 June 1990

22nd National Symposium on Fracture Mechanics

Atlanta, GA

Contact: Dorthy Savini, ASTM, 1916 Race St., Philadelphia, PA 19103; Telephone: 215-299-5431

27-30 June 1990

Advanced Structural Inorganic Composites

Montecatini Terme, Italy

Contact: 7th CIMTEC Satellite Symposium 2, PO Box 174, 48018 Faenza, Italy; Telephone: 546-664143

23-28 July 1990

4th International Congress on Computational and Applied Mathematics

K. U. Leuven, Belgium

Contact: R. Piessens, K.U. Leuven, Department of Computer Science, Celestijnenlaan 200A, B-3030 Heverlee, Belgium; E-MAIL: PIESSENS&CS.KULEUVEN.AC.BE
FAX: + + 32 16-20 53 08

29 July - 3 August 1990

International Conference on Advances in Structural Testing, Analysis and Design

Bangalore, India

Contact: Professor B. Dattaguru, Department of Aero Engineering, Indian Institute of Science, Bangalore 560 012, India; Telephone: 344411 EXT 2438, FAX: 0812-341683

1-3 August 1990

SEM: Experimental Mechanics for Composites

Blacksburg, VA

Contact: Society for Experimental Mechanics, Inc., 7 School Street, Bethel, CT 06801; Telephone: 203-790-6373, FAX: 203-790-1658

20-24 August 1990

9th International Conference on Experimental Mechanics

Copenhagen, Denmark

Contact: Vagn Askegaard, Afdelingen for Baerende Konstruktioner, Structural Engineering, Tech University of Denmark, Bldg. 118, DK 2800 Lyngby, Denmark

20-24 August 1990

3rd International Symposium on Advanced Composites in Emerging Technologies

Patras, Greece

Contact: Professor S.A. Paipetis, COMP'90 Symposium, P. O. Box 1134, 261 10 Patras, Greece

27-30 August 1990

2nd World Congress on Computational Mechanics

Stuttgart, Federal Republic of Germany

Contact: Conference Secretary, Institute for Computer Applications, Pfaffenwaldring 27, D-7000 Stuttgart 80, Federal Republic of Germany; FAX: 0711-685-3500

27-31 August 1990

Durability of Polymer Based Composite Systems for Structural Applications

Brussels, Belgium

Contact: Durability 90, Mrs. Bourlau, VUB-T.W. (KB), Pleinlaan, 2, B-1050 Brussels, Belgium; Telephone: 32/2/641.29.22
FAX: 32/2/641.2928

25-28 September 1990

ECCM-4 4th European Conference on Composite Materials: Eurocomposites and New Materials

Stuttgart, Federal Republic of Germany

Contact: DLR, Institut Fur Bauweisen und Konstruktionsforschung, Pfaffenwaldring 38-40, D-7000 Stuttgart 80/Federal Republic of Germany

1-5 October 1990

Eighth European Conference on Fracture

Torino, Italy

Contact: Conference Secretariat, IGF C/O Centro Congressi Internazionale C.SO Tassoni, 32 - 10143 Torino, Italy; Telephone: 39-(0)11-740625-761870, FAX: 39-(0)11-761640

10-12 October 1990

14th Polish Symposium on Experimental Mechanics of Solids

Jadwisin, Warsaw, Poland

Contact: Professor Jacek Stupnicki, DSC, Warsaw University of Technology, Nowowiejska 24, 00-665 Warszawa, Poland; Telex: 81 33 07, Telephone: 21 54 63, FAX: 21 68 92

16-18 October 1990

The 61st Shock and Vibration Symposium

Pasadena, CA

Contact: Dr. Ben K. Wada, Jet Propulsion Laboratory, Bldg. 157, Room 507, 4800 Oak Grove Drive, Pasadena, CA 91109; Telephone: 818-354-3600

12 November 1990

Symposium on Cyclic Deformation, Fracture, and Nondestructive Evaluation of Advanced Materials

San Antonio, TX

Contact: Dorthy Savini, ASTM, 1916 Race St., Philadelphia, PA 19103; Telephone: 215-299-5431

12-13 November 1990

Fretting Fatigue Test Methods and Apparatus

San Antonio, TX

Contact: Dorthy Savini, ASTM, 1916 Race St., Philadelphia, PA 19103; Telephone: 215-299-5431

13-14 November 1990

Symposium on Damage Detection and Quality Assurance

San Antonio, TX

Contact: Dorthy Savini, ASTM, 1916 Race St., Philadelphia, PA 19103; Telephone: 215-299-5431

13-15 November 1990

Symposium on Composites: Processing, Microstructure and Properties

Orlando, FL

Contact: Michael D. Sacks, Program Chair, Department of Materials Science and Engineering, 157 A Rhines Hall, University of Florida, Gainesville, FL

3-6 December 1990

EUROMECH 269; Experimental Identification of the Mechanical Characteristics of Composite Materials and Structures

St. Etienne, France

Contact: Professor A. Vautrin, Department of Mechanical and Materials Engineering, Ecole Des Mines De Saint-Etienne, 42023 St. Etienne Cedex 2, France

2-5 January 1991

The Second Pan American Congress of Applied Mechanics (PACAM II)

Valparaiso, Chile

Contact: Professor D. Mook, Department of Engineering Science and Mechanics, Virginia Tech, Blacksburg, VA 24061-0219, USA; Telephone: 703-231-6841

7-12 January 1991

Third International Conference on Constitutive Laws for Engineering Materials: Theory and Applications and Workshop on Innovative Use of Materials in Industrial and Infrastructure Design and Manufacturing

Tucson, AZ

Contact: Professor Chandra S. Desai, Department of Civil Engineering Mechanics, University of Arizona, Tucson, AZ 85721; Telephone: 602-621-2266, FAX: 602-621-2550

17-19 January 1991

Interfacial Phenomena in Composite Materials

Leuven, Belgium

Contact: Janet Miles, Conference Organiser, Butterworth Scientific Ltd., P. O. Box 63, Westbury House, Bury Street, Guildford, Surrey GU2 5BH, United Kingdom; Telephone: 0483 300966, TELEX: 859556 SCITEC G, FAX: 0483 301563

12-13 March 1991

Bonding and Repair of Composites II

Zurich, Switzerland

Contact: Kay Royle, Conference Coordinator, Rapra Technology Limited, Shawbury, Shrewsbury, Shropshire SY4 4NR, ENGLAND; Telephone: 0939-250383, FAX: 0939-251118

8-10 April 1991

AIAA/ASME/ASCE/AHS/ASC 32nd Structures, Structural Dynamics and Materials (SDM) Conference

Baltimore, MD

Contact: Ron Kollmansberger, 16761 Via Del Campo Court, San Diego, CA; Telephone: 619-592-2423

21-25 April 1991

(ICES '91) International Conference on Computational Engineering Science

Patras, Greece

Contact: ICES' 91 Secretariat, c/o Professor S. N. Atluri, Computational Mechanics Center, Georgia Institute of Technology, Atlanta, Georgia 30332-0356;

23-24 April 1991

Symposium on Constraint Effects in Fracture

Indianapolis, IN

Contact: Symposium Chairman E. M. Hackett, David Taylor Research Center, Code 2814, Annapolis, MD 21402; Telephone: 301-267-3755

Summer 1991

American Society of Composites 6th Technical Conference

Telephone: 513-255-9080

15-19 July 1991

The Eighth International Conference on Composite Materials (ICCM/VIII)

Honolulu, Hawaii

Contact: Profs. Stephen W. Tsai and George S. Springer, Department of Aeronautics and Astronautics, Stanford, University, Stanford, CA 94305; Telephone: 415-725-3305, FAX: 415-725-3377

7-9 October 1991

22nd Midwestern Mechanics Conference

Rolla, MO

Contact: Professor Romesh C. Batra, Department of Mechanical and Aerospace Engineering and Engineering Mechanics, University of Missouri-Rolla, Rolla, MO 65401-0249; Telephone: 314-341-4589

27 October - 1 November 1991

IUTAM Symposium on Local Mechanics Concepts for Composite Materials Systems

Blacksburg, VA

Contact: J. N. Reddy, Department of Engineering Science and Mechanics, Virginia Tech, Blacksburg, VA 24061-0219, USA; Telephone: 703-231-6744 FAX: 703-231-4574

1-6 December 1991

ASME Winter Annual Meeting

Atlanta, GA

Contact: ASME, 345 East 47th St., New York, NY 10017; Telephone: 212-705-7722

Summer 1992

6th US-Japan Conference on Composite Materials

San Diego, CA

Contact: Kenneth L. Reifsnider or M. W. Hyer, Department of Engineering Science and Mechanics, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0219; Telephone: 703-231-5077 or 703-231-5372, FAX: 703-231-4574

Summer 1992

American Society of Composites 7th Technical Conference

Telephone: 513-255-9080

8-13 November 1992

ASME Winter Annual Meeting

Anaheim, MI

Contact: ASME, 345 East 47th St., New York, NY 10017; Telephone: 212-705-7722

28 November–3 December 1993

ASME Winter Annual Meeting

New Orleans, LA

Contact: ASME, 345 East 47th St., New York, NY 10017;

Telephone: 212-705-7722

13–18 November 1994

ASME Winter Annual Meeting

Chicago, IL

Contact: ASME, 345 East 47th St., New York, NY 10017;

Telephone: 212-705-7722

12–17 November 1995

ASME Winter Annual Meeting

San Francisco, CA

Contact: ASME, 345 East 47th St., New York, NY 10017;

Telephone: 212-705-7722

17–22 November 1996

ASME Winter Annual Meeting

Atlanta, GA

Contact: ASME, 345 East 47th St., New York, NY 10017;

Telephone: 212-705-7722

Send items for this calendar to:

*Prof. M. W. Hyer, Department of Engineering Science and
Mechanics*

Virginia Polytechnic Institute and State University

Blacksburg, VA 24061-0219

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FAX: (703)231-4574

Guest Commentary

Composites in Primary Aircraft Structures

Progress in the introduction of composite materials (for example, carbon fiber reinforced plastics) into engineering applications has been paced primarily by two key factors. They are our understanding of fundamental material characteristics and our ability to transfer this understanding into cost-effective structures. In high performance applications, such as commercial transport aircraft, composite materials are applied today in only secondary structures. These lightly loaded structures include control surfaces and vertical stabilizers. While these applications are significant, the big payoff for composites is in the primary wing and fuselage structures. Structural weight savings could be greater than 30%. Major advances in both our fundamental understanding of composites and in cost-effective structural concepts are required to achieve this benefit in future aircraft.

NASA initiated the Advanced Composites Technology Program in 1989 to address the key technical issues related to the application of composites in primary aircraft structures for subsonic transports. This is a joint government, industry, and university program with planned funding of about \$150M over the next 5 years. The program has all of the essential ingredients of composite materials and structures research such as matrix resin technology and structural mechanics. However, innovative structural concepts are emphasized. They include structural concepts that take advantage of composite properties and that have the potential for cost-effective fabrication techniques. For example, woven textile structural forms offer one approach to cost effective structures. Such a process might use carbon fibers already coated with the matrix resin and woven into a structural part of near-net shape with the fibers in the proper orientation for structural load conditions. This could be a three-dimensional fiber structure to take care of out-of-plane loads—a serious shortcoming of planar composites. Composite cure could be done within structural forming tooling designed to provide the finished part shape. Several approaches of this type have the potential of achieving cost-effective aircraft structures. They will be included in the concept evaluation part of this program.

Supersonic transport aircraft offer another opportunity for the use of composites in primary aircraft structures. NASA is in the early phase of exploring the potential of an advanced supersonic transport aircraft with the aircraft industry. These exploratory studies emphasize overall economic feasibility including aircraft configurations, market potential, and environmental concerns. Systems studies have shown aircraft structural weight fraction to be a very strong economic driver and the potential benefits of

composite structures look very attractive. Like the subsonic transport aircraft, cost-effective structural concepts will be a primary driver for composite applications in supersonic aircraft. Plans are being prepared to scope the technology program that would be required to develop an advanced supersonic transport operating in the Mach 2–3 range. They include both composite materials and structures technologies. Airframe operating temperatures of a supersonic transport (200 to 450°F [93 to 232°C]) will place a new demand on resin-matrix composites. Temperature and time dependent properties will be dominant for the 60 000 h life requirement. Most likely, a new resin-matrix composite will be required. Building the fundamental understanding and the required database in a new resin-matrix composite will be a very demanding task. Research directed toward meeting these materials requirements should be initiated in the near future.

Changes in composite structural configurations and in composite material requirements as outlined present new challenges for the technical community. These new composite structures with their multiple load paths may require new analysis methods. Failure modes may not be dominated by delamination. In some applications, thermal considerations may dominate structural designs. Time and temperature dependent properties will be of greater concern and significant advances in matrix-resins are required. Developing an integrated technology base is essential in order to realize the potential benefits of composites in engineering applications like subsonic and supersonic aircraft. Also, the development of this technology base is important to our continued technical leadership.

By Charles P. Blankenship

Mr. Blankenship graduated from Virginia Polytechnic Institute and State University with B.S. and M.S. degrees in Metallurgical Engineering. After a 3-year tour in the U.S. Air Force, he began his career with NASA at the Lewis Research Center in Cleveland, OH. From 1964 to 1980, he conducted and managed research in high-temperature materials for propulsion and power systems. In 1980, he was appointed Chief of the Materials Division at the NASA Langley Research Center in Hampton, VA. In this position, he managed the Center's research in the development of aircraft and spacecraft structural materials. He has been in his present position as Director for Structures at Langley since 1983. In this capacity, he manages the Center's research program in materials, structures, and acoustics.

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