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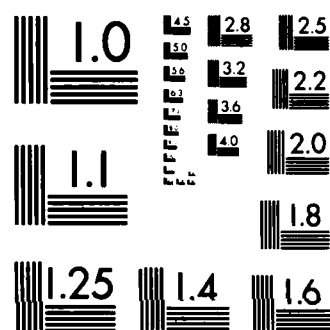
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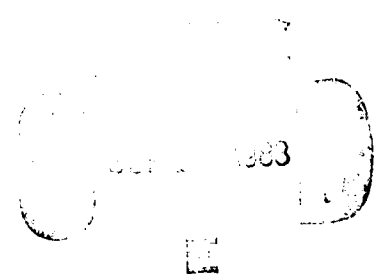
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FIBER COMPOSITE MATERIALS RESEARCH IN THE UK:
ASSESSMENT REPORT

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24 June 1983



UNITED STATES OF AMERICA

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This report examines the status of basic research on fiber composites in the UK. The information is based on interviews at 15 universities, governmental laboratories, and industrial companies.		

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FIBER COMPOSITE MATERIALS RESEARCH IN THE UK: ASSESSMENT REPORT

The UK is doing intensive work on fiber composites. Overall, the level of research activity has been expanding recently; in some respects, the quality of the work is better than in the US. Most of the researchers in composites were trained as physicists and metallurgists. Thus, the approach in research has traditionally given considerable emphasis to the microscopic and physical aspects of material behavior. Since US researchers in composites tend to stress more the mechanics and analytical aspects, it certainly would be mutually beneficial for researchers in the two countries to maintain meaningful interactions.

This report evaluates and analyzes basic research on fiber composites in the UK. The information is based on visits to 15 universities, governmental laboratories, and industrial companies in the UK. Descriptions of the research activities for all the visits are detailed in a series of articles beginning in the April 1983 issue of *European Scientific Notes*.

Status of Research

There is a resurgence of interest in metal matrix composites--research that was last active in the UK during the late 1960s and early 1970s. Some laboratories already have the necessary expertise. If adequate commitment is made in the near future, metal matrix composites research will become fruitful.

Research efforts in glass and ceramic composites as well as carbon-carbon composites are rather limited at this time.

The recent development of the high temperature PEEK (polyetheretherketone)-based composites by Imperial Chemical Industries (ICI) is expected to have long-term impact on the advanced composites technology.

The aligned short fiber composite systems developed earlier by the Propel-

lents, Explosives, and Rocket Motor Establishment in Waltham Abbey have not had much impact beyond laboratory studies. (However, a similar system developed by Messerschmitt-Bölkow-Blohm GmbH is being pushed more vigorously in Germany.)

The UK seems to be more interested than the US in using fabric reinforcement materials and in hybridizing different types of fibers. The UK's knowledge and capability in textile technology could improve its capability in woven fabric composites.

Special Expertise

Table 1 lists 29 universities, governmental laboratories, and industrial companies with experience in composite materials research. The list is rather comprehensive in terms of university research, but may be fairly limited with respect to industrial research activities. I have visited laboratories 1 through 15 on the list. Visits to British Aerospace and Dunlop (16 and 17) were not carried out because it was evident during the course of the contacts that in-depth discussions would not be possible.

Table 2 lists the specializations of the laboratories. The table is categorized according to subject areas. The asterisks indicate institutes with either substantial on-going programs and experience or strong potential for future development.

Observations and Recommendations

There was no difficulty in having meaningful exchanges with researchers at universities and governmental laboratories; however, communicating with industrial research laboratories presented problems. Some researchers were concerned about US restrictions on the flow of information in certain aspects of composite research.

The need for the UK researchers to obtain high temperature fibers (such as SiC), coupled with the vigorous effort of the Japanese in research and marketing, has increased the exchange between

the UK and Japan in metal matrix composites. If US fibers (such as FP) and know-how are not readily available to UK researchers, Japan will take full advantage of the situation.

Future expansion in composite research and development in the UK could be hindered if the training of composite technologists cannot keep pace with the demand.

Some of the finest fundamental work in fiber composites has been done by British researchers. However, they have not been as successful as their American counterparts in applying the research.

Many of the British researchers I spoke to are either familiar with the function of the ONR London or have had contacts with ONR liaison scientists. They were very receptive to my requests for visits. Sound personal contacts are indispensable for meaningful exchange of research ideas.

I recommend that the British literature in fiber composites be followed closely and systematically and that workshops on certain specific areas of interest (damage tolerance, for example) be held jointly as an effective means of interaction.

Table 1

Material Research Laboratories
in the UK

- | | |
|--|---|
| 1. AERE | 17. Dunlop Limited |
| 2. Fulmer Research Laboratories | 18. Brunel Univ. |
| 3. ICI, Welwyn Garden City | 19. Cranfield Institute of Technology |
| 4. Imperial College | 20. Hepworth and Grandage Limited |
| 5. Loughborough Univ. of Technology | 21. ICI, Mond Division |
| 6. National Physical Laboratory (NPL) | 22. National Engineering Laboratory |
| 7. Queen Mary College | 23. Paisley College of Technology |
| 8. Rolls-Royce Limited | 24. Propellents, Explosives, and Rocket Motor Establishment |
| 9. RAE | 25. Plymouth Polytechnic Institute |
| 10. Univ. of Cambridge | 26. Preston Polytechnic Institute |
| 11. Univ. of Liverpool | 27. Univ. of Reading |
| 12. Univ. of Nottingham | 28. Univ. of Salford |
| 13. Univ. of Bath | 29. Univ. of Southampton |
| 14. Univ. of Oxford | |
| 15. Univ. of Surrey | |
| 16. British Aerospace, Warton, Weybridge, Manchester | |

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Table 2

Research Programs

1. Materials

- a. Metal matrix composites
 - (1) Loughborough*: very experienced in fabrication technology
 - (2) Surrey*: emphasizing discontinuous, alumina "Safill" fiber of ICI, aiming at low cost production
 - (3) British Aerospace, Atomic Energy Research Establishment (AERE), and Rolls Royce deserve our attention in the near future
 - (4) Queen Mary College: fiber/matrix interfacial bonding and compatibility
 - (5) Nottingham: fatigue and fracture
- b. Carbon/carbon composites and ceramic composites
 - (1) Dunlop*: carbon/carbon composites
 - (2) AERE: current effort in ceramic composites is very low
- c. Thermoplastic composites
 - (1) ICI*: PEEK-based continuous fiber composites
 - (2) Liverpool, Nottingham, and Surrey: molding technology of short fiber composites, structure-property correlations
- d. Hybrids: Bath, British Aerospace, Imperial College*, Royal Aircraft Establishment (RAE), and Surrey; involving short fiber, continuous fiber, and fabrics

2. Mechanical Properties

- a. Notch sensitivity and damage tolerance
 - (1) AERE* and RAE*: extensive programs in analyses and experiments
 - (2) Bath*: acoustic-emission monitoring techniques
 - (3) British Aerospace, Imperial College, and Ministry of Defense: on-going programs
- b. Fracture and fatigue
 - (1) Liverpool* and Nottingham*: multiaxial static and fatigue loading
 - (2) RAE*: extensive program
 - (3) Cambridge: fracture map approach

- c. Impact
 - (1) Oxford*: high strain rate deformation
 - (2) Liverpool*: energy absorbing materials
 - (3) Surrey: impact of tubes
 - (4) Fulmer: ballistic impact
 - (5) Imperial College: low velocity impact

3. Environmental Degradations

- a. Bath*, Liverpool*, and NPL*: effects on long-term properties due to temperature, moisture, and acid
- b. Nottingham and Surrey: stress corrosion cracking

4. Joining

- a. Imperial College*: mechanical fastener
- b. AERE*: composite-metal bonding

5. Repair and Patching

- a. Fulmer and RAE: wet laminate patching, tolerance of contaminants
- b. British Aerospace*: comprehensive repair program

6. Filament Winding: AERE and Nottingham*

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