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Joint UNIDO/Arab School of Science and Technology Workshop on Composites and Advanced Materials: Development and Technology
Damascus, 16-22 February 1992

Report

Prepared by the Department for Industrial Promotion, Consultations and Technology in cooperation with the Department of Industrial Operations

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INTRODUCTION

1. The Joint UNIDO/Arab School of Science and Technology Workshop on Composites and Advanced Materials: Development and Technology was held at Damascus, Syrian Arab Republic, from 16 to 22 February 1992.

2. The main objective of the Workshop was to provide scientists and engineers from Arab countries who are active in the field of materials science and technology and who have experience in the processing and application of composites and advanced materials, with information on trends in technology and technical cooperation possibilities.

CONCLUSIONS AND RECOMMENDATIONS

3. On the basis of the joint work carried out by the participants, the Workshop concluded that efforts should be made to support industrialization and socio-economic development in Arab countries by introducing new materials science and engineering disciplines. In that connection, the participants recommended as follows:

(a) Awareness should be built up in developing countries by monitoring, assessing and disseminating information in the field of materials and engineering;

(b) Workshops and seminars in selected materials should be organized, with special attention to materials based on local resources;

(c) UNIDO should promote the establishment of an Arab centre for multidisciplinary materials research in order to strengthen the capacities of developing countries in materials science and engineering and to foster regional cooperation in this field. Preparatory work has been undertaken by both the Arab School of Science and Technology and UNIDO for the establishment of such a centre.

I. ORGANIZATION OF THE WORKSHOP

4. The Workshop was attended by individuals and experts from the Commonwealth of Independent States, Germany, Italy, Jordan, the Syrian Arab Republic and the United Kingdom of Great Britain and Northern Ireland and from the United Nations Industrial Development Organization (UNIDO). The list of participants is attached as annex I.

5. Opening the Workshop, A. H. Said, Secretary-General of the Arab School of Science and Technology, welcomed the participants to the Syrian Arab Republic and to the School. He spoke of the importance of advanced materials, particularly composites, and described their role in supporting the development of advanced technologies.

6. The Secretary-General of the School pointed out that the Workshop was the first of a series of workshops on materials that would be sponsored by the School. It would offer a comprehensive review of the latest developments and state-of-the-art technology in the field, with special reference to the needs

of Arab countries. He hoped that the Workshop would allow an exchange of experience and would strengthen technical capacities in the field of advanced materials.

7. An Industrial Development Officer from the Department for Industrial Promotion, Consultations and Technology, UNIDO, addressed the participants on behalf of UNIDO and thanked the Secretary-General for having invited the organization to contribute to this event, which was one of the areas of cooperation mentioned in the Memorandum of Understanding between UNIDO and the School. He outlined the overall approach of UNIDO to the promotion of new technologies in supporting the industrialization process in developing countries, and he stressed the importance of new materials in this process. He also hoped that the Workshop would promote the role of composites and advanced materials in the industrial development of the Arab countries.

8. Omar Farouk Bizri, Director of Research of Scientific Studies and Research Centre in the Syrian Arab Republic, was elected Chairman of the Workshop.

9. A technical programme that would constitute an agenda for the Workshop was introduced and adopted (annex II).

II. PRESENTATION OF THE PAPERS

10. Over the week-long course of the Workshop, papers were presented on international trends in materials science and engineering; the design, development and manufacture of composites; and the application of composite materials. Special reference was made to the linkages between education, research and the production of advanced materials to suit the specific needs and capacities of the Arab region. The papers were collected and issued by the School as a separate document and distributed to the participants. They are listed in annex III.

III. SUMMARY OF THE DISCUSSIONS

11. In recent years, the science of materials had become a high-technology sector, with serious implications for innovation, competitiveness, economic growth, employment, the global division of labour, trade patterns and the environment.

12. Materials science and engineering integrated the structure-synthesis/processing/properties-performance continuum and provided, therefore, an interdisciplinary, unified approach across all classes of materials. That had opened huge potential for the improvement of traditional materials as well as for the design of new materials tailored to specific end-uses.

13. For industries and, indeed, entire economies to survive in the 1990s and beyond, they needed to build a critical mass of materials science and engineering capabilities at the company level. Developing countries in general and in the Arab region in particular were beginning to address the problem of building up interdisciplinary materials science and engineering competence in their institutions in order to utilize and upgrade existing resources and/or develop new materials for use at different stages of the production cycle.

14. The main objective of the Workshop was to describe the state of the art in composite materials and to provide a group of scientists and engineers working on materials-related subjects with a basis for understanding some of the relevant issues. This objective was achieved through a series of presentations that covered the basic characteristics and properties of composites, their potential for use and their design implications. A great deal of information was also made available to the participants in panel discussions, which focused on the potential for non-polymeric composites and the feasibility of a composites industry in developing countries.

15. Aspects of the design, development, manufacture and application of composite materials were discussed and a number of practical problems were addressed. Because composite materials were anisotropic, most complex hardware products made of composites experienced design difficulties due to the poorer "secondary" or matrix dominated properties. One of the main problems was caused by an increase in the effective three-thickness expansion coefficient due to the laminating of graphite/epoxy composites. This problem had an impact on the design of thermally stable structures.

16. Faulty design could lead to the catastrophic failure of a structure. An analysis of the failure mechanism often showed that a design developed for structures using isotropic materials was not suitable for structures using anisotropic materials.

17. Designing with composites also demanded a more thorough educational background. The design process should adhere to the following guidelines:

(a) The material and the structure must be designed simultaneously;

(b) The impact of the characteristically poor secondary (transverse) properties on the design must be rigorously appraised;

(c) A strong interdisciplinary team effort was essential as there was an intimate connection between design, analysis, testing, quality assurance and manufacture;

(d) Opportunities for exploiting advanced composites must be sought, such that advantages other than weight advantages were realized (the low thermal distortion of graphite/epoxy structures was a good example).

18. The widespread use of polymer matrix composite materials had been facilitated by the development of several specific technologies for the processing of parts with different geometries using different raw materials. However, the understanding of the fundamental engineering principles associated with each technology was still a challenge for researchers in the field of high-performance composite materials.

19. The greatest drawback of these materials, however, was their difficulty of manufacture: that might seem something of contradiction, in so far as thermoplastic polymers were well known for their ease of processing into complex shapes by injection moulding, thermoforming, blow moulding etc. The main manufacturing difficulties presented by thermoplastic composites did not have to do with forming a final shape, although there were some serious problems to be overcome, but rather with incorporating the fibres into a matrix of thermoplastic to obtain adequate hardness.

20. Composite materials were different from homogeneous materials: they were anisotropic, i.e. their behaviour parallel to the fibres differed from their behaviour perpendicular to the fibres. This anisotropy was advantageous, because stiffness and strength could be designed into the composite structure in the direction in which they were needed. However, it required different analytical approaches and necessitated re-training designers, since classical engineering curricula did not usually cover the properties of anisotropic materials.

21. A considerable amount of effort was required to study the properties of these new materials and, especially, their modes of failure. As failure did not appear to be caused by the propagation of a single through-crack, different, non-destructive methods must be developed to evaluate the integrated effect of damage in composites.

22. Fibre-reinforced polymeric composites were used in structural applications in which high strength and light weight were critical. In such applications the composites were expected to be exposed to a wide range of temperatures, to mechanical fatigue and to extreme environmental conditions, such as freezing and thawing at high humidity or in aggressive, solvent-rich atmospheres. The investigation of penetrant sorption, induced plasticization and the environmental sensitivity of polymer matrices was hence of primary importance for the application of high-performance composites to extreme conditions.

23. Two opposing views were expressed on the viability and role of a composites industry in the Syrian Arab Republic. A developing country should choose between two strategies: it could immediately embrace the highest technology, in which case competition from other developing countries would be minimized, or it could concentrate on establishing a lower technology base, adding state-of-the-art materials and processing to that base. In the field of composites, that would mean choosing between high-tech carbon fibres, which were driven by the aerospace industry, and glass fibres, which dominated the general industrial field. The high-tech approach might be hampered, however, by strategic limitations on the accessibility of materials and technology.

24. The less sophisticated approach - establishing a glass-fibre-based composites industry - would allow the Syrian Arab Republic to compete and sell into the region. That could improve the competitiveness of its products further along the product chain or could improve other aspects of the industry and infrastructure. (Examples would be composite pipes, storage vessels, bus bodies and railway trucks.) The country could also move "upstream" and establish a facility for the production of glass fibres, given its abundance of raw materials.

25. It was proposed that an Arab centre for multidisciplinary materials research should be established to meet the needs of developing countries in the Arab region. The regional character of such a centre would concentrate limited financial and human resources and promote regional cooperation in the field of materials science and engineering, which had been the subject of extensive development efforts in the industrialized countries and had in many cases reached maturity. The proposed centre would strongly interact with local industries and would positively affect the development of human resources.

26. The aim of such a centre would be to assist developing countries to address materials science and engineering issues, and, through concrete and practical measures, to build up related technological capabilities in the region. The centre would also facilitate the links between countries in the field and foster regional cooperation, through the exchange of experience, information, research and development, and training.

27. The proposal was put forward during the UNIDO presentation on new materials. The establishment of a centre could be implemented as a UNIDO project, to ensure its interaction and complementarity to other UNIDO programmes and projects in the area. In the ensuing discussion, the participants expressed a great deal of interest in the proposal and emphasized the need for the project and the role UNIDO played in the industrialization process in developing countries.

Annex I

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Annex II

TECHNICAL PROGRAMME

1. An Introduction to Composite Materials

   Plastics
   Composite Materials
   The Structural Properties of GRP
   Designing with Composite Materials

2. Composite science fundamentals

   Thermosetting Resins
   Thermoplastic Resins
   Fibres

3. Composite Technology

   Fabrication and Processing of Polymeric Composites
   Non-Polymeric Composites

4. Environmental Resistance of Polymeric Composites

   Physical Characterization of Composites
   Environmental Effects on Thermosetting and Thermoplastic Matrices for Advanced Composite Materials
   Quality Assurance (NDT) of Composite Materials

5. Design with Composites

   Lamination Theory and Failure Theories
   Principles of Designing with Composites
   Joining of Composites
   Repair of Composites Structures
   Fracture Analysis
   Composite Damage Tolerance

Annex III

LIST OF PAPERS PRESENTED AT THE WORKSHOP

"An introduction to composite materials", by Ian H. Marshall

"Thermosetting resins", by Paul J. Hogg

"Thermoplastic resins", by Paul J. Hogg

"Fibers", by Paul J. Hogg

"Fabrication and processing of polymeric composites", by L. Nicolais and others

"Non polymeric composites", by Karl Schulte

"Physical characterisation of composites", by Paul J. Hogg

"Environmental effects on thermosetting and thermoplastic matrices for advanced composite materials", by L. Nicolais

"Quality assurance (NDT) of composite materials", by Karl Schulte

"Lamination theory and failure theories", by Keith T. Kedward

"Principles of designing with composites", by Keith T. Kedward

"Joining of composites", by Keith T. Kedward

"Repair of composites structures", by Keith T. Kedward

"Fracture analysis", by Karl Schulte

"Composite damage tolerance", by Keith T. Kedward

"The dependence of physical properties of binary metallic composites on their components concentration ratio", by S. Sh. Soulayman

"A mixed formulation for torsion of multi-hole composite sections", by R. A. Daoud