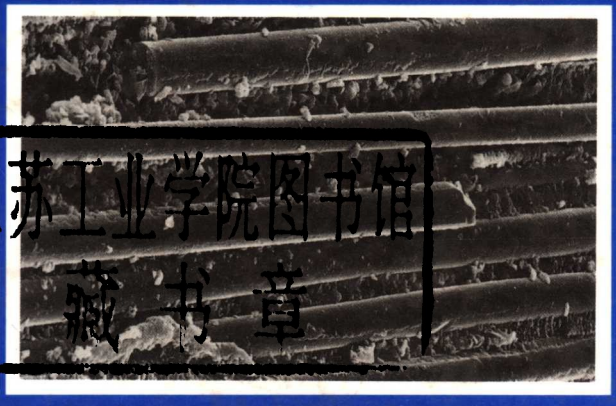
AMME-ASMECCANICA
CENTRO MATERIALI COMPOSITI

UNIVERSITA' DI CASSINO

UNIVERSITA' DI NAPOLI

# Advancing with Composites '94

MAY 3 - 5, 1994
Milano - Italia





## VOLUME 1

# MATERIALS AND TECHNOLOGIES

**EDITOR:** I. Crivelli Visconti

**Supported by**

**ASSOCOMAPLAST**
ITALIAN PLASTICS AND RUBBER PROCESSING MACHINERY AND MOULDS MANUFACTURES ASSOCIATION

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THIRD EDITION OF

# "ADVANCING WITH COMPOSITES"

## PREFACE

The third edition of the International Conference "ADVANCING WITH COMPOSITES" is taking place during the most crucial stage of the development of the global economical crisis, when planning of production and business in innovative fields is of basic importance.

For this reason the date and the location of 1994 "ADVANCING WITH COMPOSITES", during the Plast '94 Exhibition in Milan, characterise the special feature of the event, being the occasion of multiple meetings between producers and utilizers of advanced materials.

The Conference is organised on several technical Sessions, with special Key-note presentations, made by recognised experts, that will show the latest developments of particular aspects of composite technologies, properties and applications.

Particular attention has been devoted to the choice of the four principal topics: MATERIALS, TECHNOLOGIES, DESIGN and APPLICATIONS, so that fruitful indications can be gathered from the presentations in order to plan future research and industrial activities.

**VOLUME 1 - MATERIALS AND TECHNOLOGIES**

## CONTENTS

# NONDESTRUCTIVE TESTING OF COMPOSITES - INFORMATION TECHNOLOGY PROBLEMS

I. MATISS
Latvian Academy of Sciences

Abstract. Problems arising in application of nondestructive testing techniques for quality evaluation of composite materials are highlighted. Solution of these problems by means of information technology, particularly expert systems is recommended. Concepts of the expert system as well as basic principles of its architecture are presented

## INTRODUCTION

Every process connected with a creation of materialized qualities (designing, manufacturing, repairing, reconstruction, etc.) begins with a choice of proper material, corresponding to certain properties in accordance with a designated purpose of the material. Information on materials properties can be obtained in different way, mostly from handbooks, production certificates, data basis, and testing outcomes. A reliability and accuracy of the data are the main considerations taken into account choosing the information source, for example sampling tests, nondestructive testing (NDT), means of technical diagnostics etc. NDT seems most promising for materials properties study due to its feasibility of direct approach to the material under examination.

More than 30 years experience of the Institute of Polymer Mechanics has shown that success in application of NDT for evaluation of composite materials (CM) properties in great scale depends on optimal choice of the physical technique, on skill of the operator and sometimes on supposed insignificant factors which would be classified as the state of the art. Analysis of all these features show that a number of recommendations leading to reliability and accuracy increase, mainly information technology constitution, need not radical sophistication of

testing equipment and measurement procedures.These information technology aids can be defined as additional software for gaining the following targets: choosing the most relevant testing technique; assistance to establish correlationship between measured parameters and properties of material under study; data processing of test results in order to facilitate the decision making process for vague and ambiguous solutions. Explanation of these recommendations, guidance promoting better understanding of the measurement process by NDT techniques, simplifying of orientation in various testing methods and summarizing all these features in the version of software design as an expert system, available for operators of different qualification are the subjects of the proposed presentation.

## 1. COMPOSITE MATERIAL AS A TEST OBJECT

The main factor attracting attention for the understanding of testing peculiarities of CM is their treatment as a test object.If to take into account that CM are applied for high responsible structure design, high requirements are put down to the quality control service. In order to characterize CM as a test object it is useful to analyze parameters under study as well as main specific features influencing the course of inspection procedure. The main peculiarities of CM as a test object are the following.

1. Inhomogeneity of properties can be studied by means of physical field penetrating the test piece in different directions (sensors with guided physical field vector must be applied).

2. In order to study viscoelastic properties all informative parameters used for quality evaluation must have complex character, for example, complex wave velocity, complex impedance, complex dielectric permittivity, etc.

3. Relaxation and creep phenomena can be taken into consideration by means of dynamic testing techniques, providing feasibility of different excitation speed of physical field or variable frequency for harmonic excitation.

The final conclusion on CM as a test piece for NDT can be summed up in the following way: testing experience of CM is much more complicated in comparison with conventional materials; testing experience transfer from the field of conventional materials to advanced

materials must be carried out with a certain extent of precaution. For example, it is well known that for materials structure study by ultrasonic technique the wave length must be comparable with a smallest structure element (for some reinforcement fibers or fillers the diameter is less than 6–8 $\mu$m . Therefore the operational frequency is going up to 20–30 MHz. The wave attenuation for CM at such frequency is very significant which makes inspection problematic.

## 2. DIRECT AND INDIRECT MEASUREMENT

The factor causing main misunderstanding and dealing with the first step in solving materials study problem is a choice of relevant – most informative testing method. Variety of materials properties facing materials science specialists involved in testing are exceedingly different, much more than testing techniques, if the search for optimal testing equipment to carry out on the basis of accepted classification, for example [1]. However, it does not mean that some materials examination tasks are not solvable. According classification principles every apparatus design has to be restricted within certain technical specifications, determined by the physical background and fundamental circuit arrangement. These specifications define so called direct application area which in some cases is strictly limited and for people not familiar in details of this particular measurement branch does not state very much about the information potential of the apparatus. For example, ultrasonic equipment usually is applied for wave velocity and attenuation factor measurement, electrical impedance meter for the resistance and reactance measurement, etc . It is impossible to design general purpose measuring apparatus even within an application range of one, single NDT method. In other words, there are contradictions between widening the range of application on the one hand and the achievement of high measurement characteristics, compact and reliable configuration of the apparatus on the other hand.

The existence of correlationship among physical parameters itself and other structural, technological and service characteristics enables to apply testing equipment for indirect evaluation of properties and therefore significantly to widen the possibilities and information capacity of testing techniques. For example, ultrasonic parameters correlate with reinforcement ratio, viscoelastic properties, aging and other structural

characteristics of composite materials; dielectric parameters (permittivity and loss factor) are sensitive to moisture absorption of polymers and composites; thermal parameters (conductivity, capacity) correlate with damage accumulation and porosity, etc.

Summarizing up the above mentioned assumptions about direct and indirect application of NDT equipment the functional diagrams illustrates the main difference between two approaches (see Fig.1). For direct application the conclusion on test object's quality has to be compiled on the strength of measuring apparatus readings. For indirect application

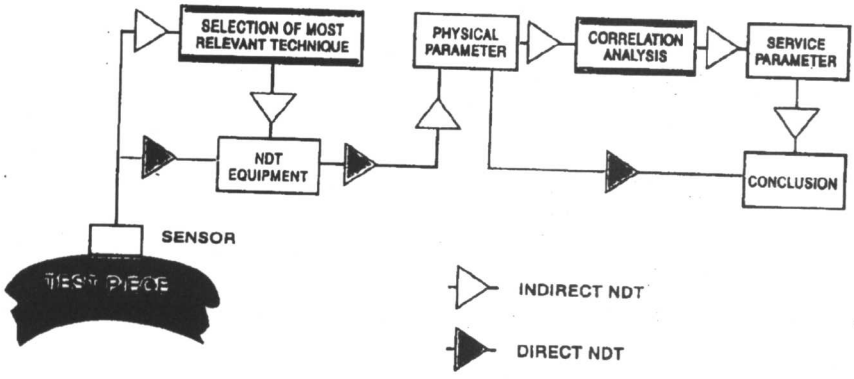


Fig.1. Enumeration of main procedures for direct & indirect application of NDT

additional stages of quality evaluation in comparison with direct application are:

- selection of the most relevant technique for a particular task not always being in accord with NDT equipment assortment;
- correlationship determination between readings of the selected apparatus and service parameters used for quality evaluation of the test piece under study.

Success in solving the first task as mentioned above depends on expert's erudition, accumulated experience in solving similar tasks, extent of knowledge on physics of the testing process. Helpful assistance in choosing relevant testing technique would offer expert systems [2].

For solving the second task the routine approach comprises involvement of a parallel testing technique (usually sampling tests) with higher accuracy and reliability. Correlationship establishment or