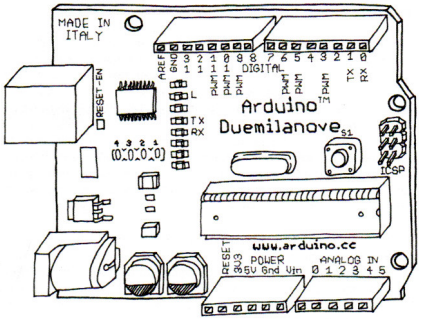
POLAR SCAN

Evaluation
of
Advanced Fiber Reinforced Composites

The Arduino Way



ir Willem H.M. van Dreumel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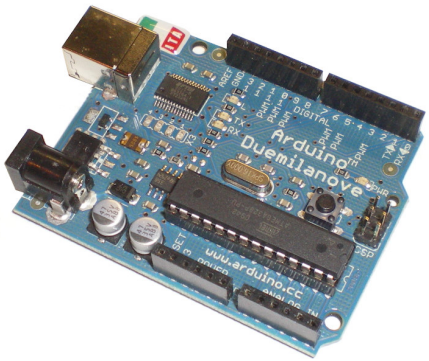
Preface

This book is written for students in materials technology. It shows a method for fingerprinting complex materials like fiber reinforced composites. It makes use of a low cost, simple rotation mechanism, driven by the open platform Arduino board.
Hard and software are described and easy to combine with existing Non Destructive Testing equipment.

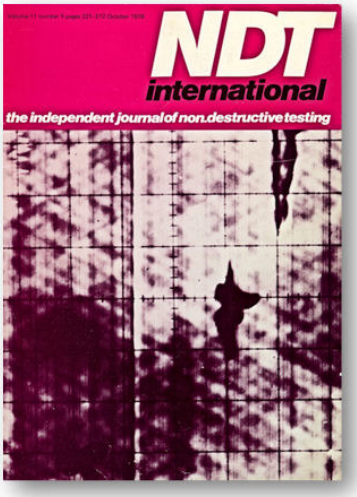
Introduction

The Arduino microcontroller board is cheap (slightly over € 20,-), very well documented and open source.
It facilitates the design of complex equipment.
In this book, an Arduino board is used to realize the hardware for an Ultrasonic Polar Scanner, using two stepper motors, which can be bought on the Internet. Shipping costs usually exceed tee cost of these stepper motors.
To better understand the basics, we go back in time some decennia.



History

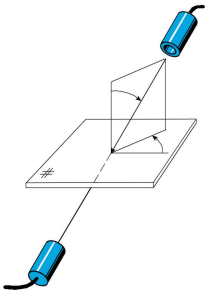
During a period of 18 years, I worked at Delft University in fiber reinforced composites research. One of my fields of interest was ultrasonic inspection techniques and we constructed one of the first c-scanners for composites materials and published the results way back in 1978.

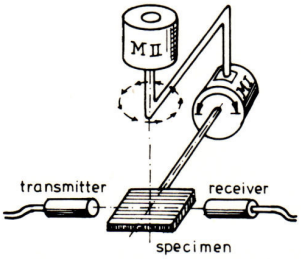


We experienced deviations in c-scans, when the ultrasonic beam was not exactly perpendicular to the specimen under test. To study this phenomenon, the specimen was rotated to check the accuracy of the angle needed to obtain reliable results. To our surprise, the rotation showed a remarkable pattern in the attenuation of the ultrasound signal.

-90 0 +90

This observation gave us the idea that there might be quite some additional information to retrieve, so we extended the rotation along a second ax in search of critical angles.



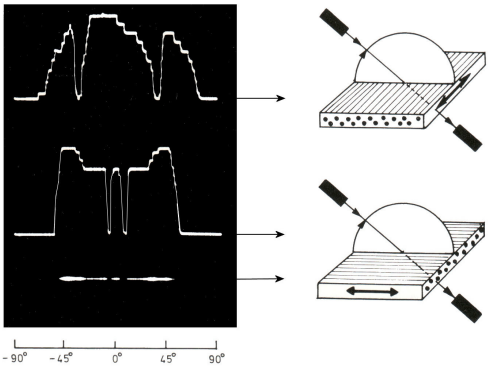


An instrument was build in order to rotate a specimen along two axes, scanning a specimen under all angles of a half sphere. Motor 1 rotates 180 degrees and after finishing, motor 2 makes one step. This is repeated until motor 2 also rotated over 180 degrees. The diagram below shows signal attenuation perpendicular to the fibers of a unidirectional specimen, while the lower diagram shows the pattern parallel to the fibers.

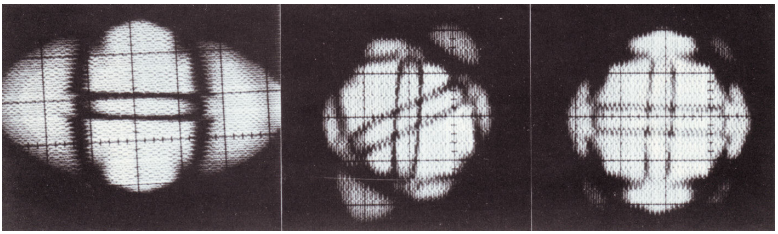
Attenuation

Attenuation

Intensity

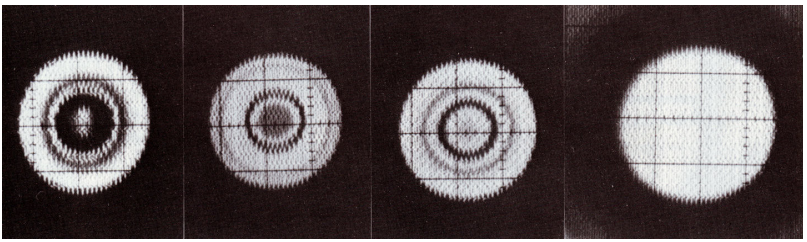


A full Polar Scan of a unidirectional laminate shows a lot of information.



0-0 degrees 0-60 degrees 0 degrees

To help developing a relation between material critical angles (Snell's law), density, Young's modulus and the ultrasonic patterns in general, isotropic materials like metals were scanned as well.



Titanium Aluminum Steel Lead

The difference between isotropic and anisotropic materials is obvious.
In anisotropic materials, the fiber orientation is clearly visible.
These very first results were published in 1983.