

**OBLIQUE INSONIFICATION ULTRASONIC NDE OF
COMPOSITE MATERIALS FOR SPACE APPLICATIONS**

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Leaky Lamb Wave NDE of Composites Background

- Phenomenon discovered in 1983*
- Very good agreement between theoretical analysis and experimental data
- An efficient setup was developed for data acquisition
- An inversion algorithm was developed to allow determination of the elastic constants
- Method was applied to NDE of defects imaging and characterization

* Bar-Cohen & Chimenti

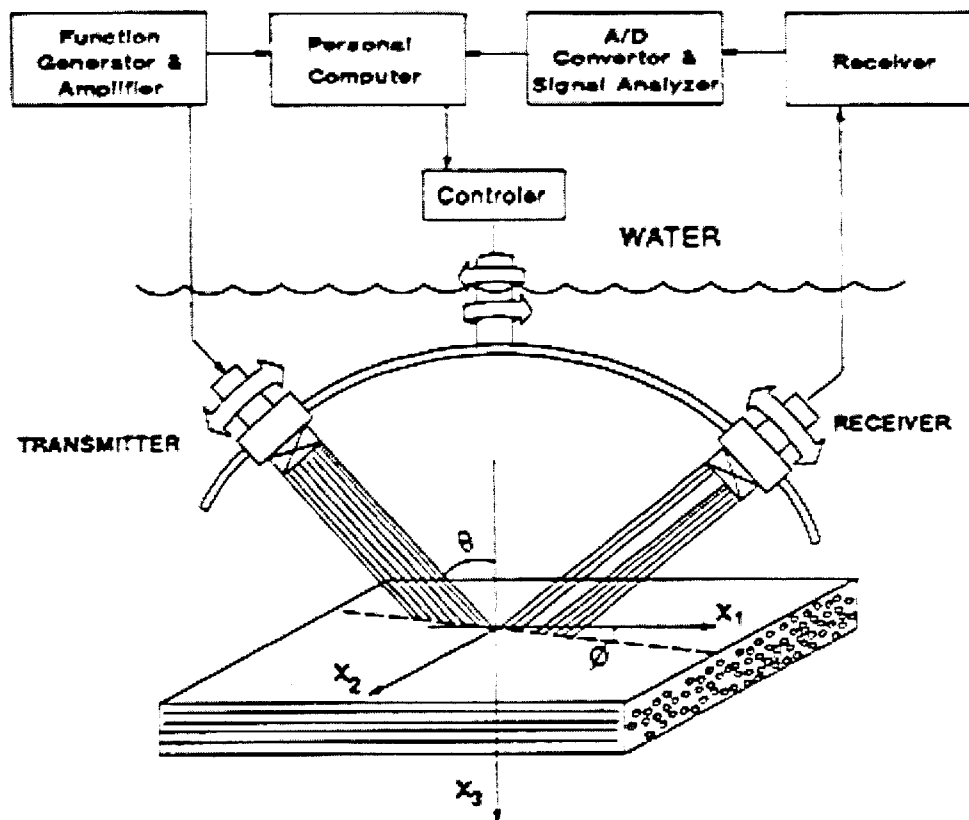


Application of LLW Data inversion of Elastic Properties: Fire Damage Assessment

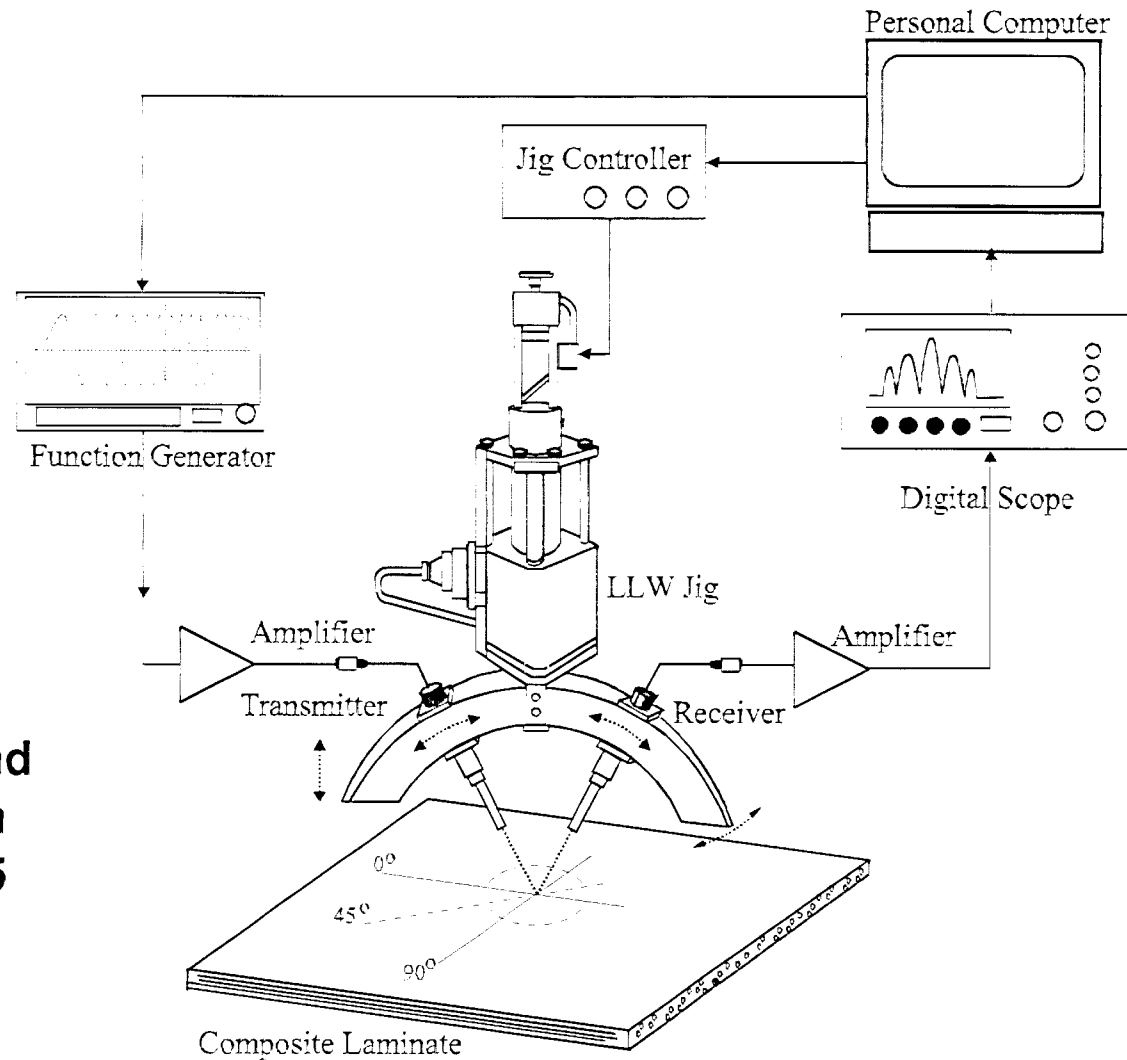
- Fire damage to composites is causing initially material degradation and as the damage becomes more severe, physical flaws appear.
- Repair of aerospace structures exposed to thermal damage or removal of all the infected sections.
- Practical NDE methods are unable to indicate thermal infection unless physical damage already occurred (cracking, delaminations, etc.)



Leaky Lamb Waves (LLW) Experimental Setup



LLW SCANNER AND TEST SYSTEM



The LLW scanner is computer controlled and the dispersion data can be obtained at about 45 seconds

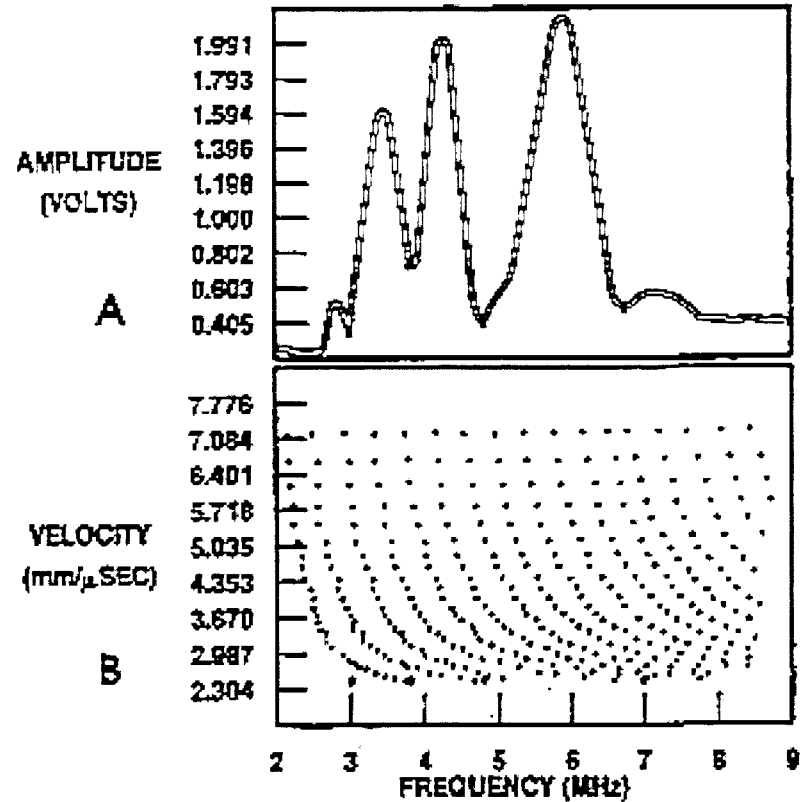


LLW DISPERSION DATA

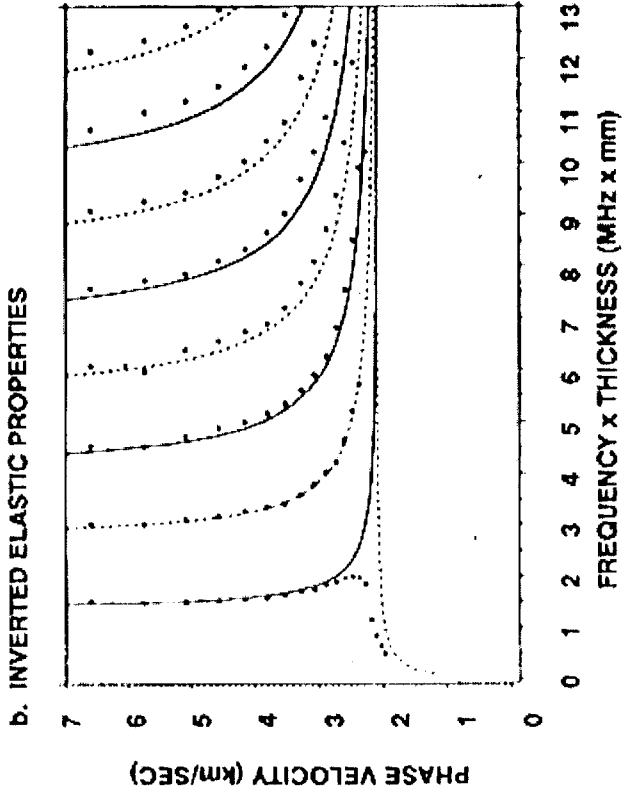
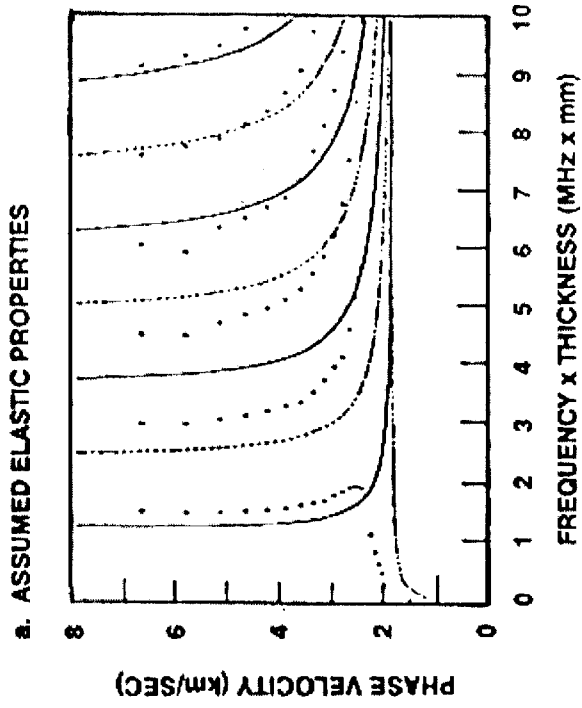
Data Acquisition Process - Computer Display

Spectra at a given angle being acquired first and modes are searched by the computer

Dispersion curve is formed as an accumulation of all the acquired modes

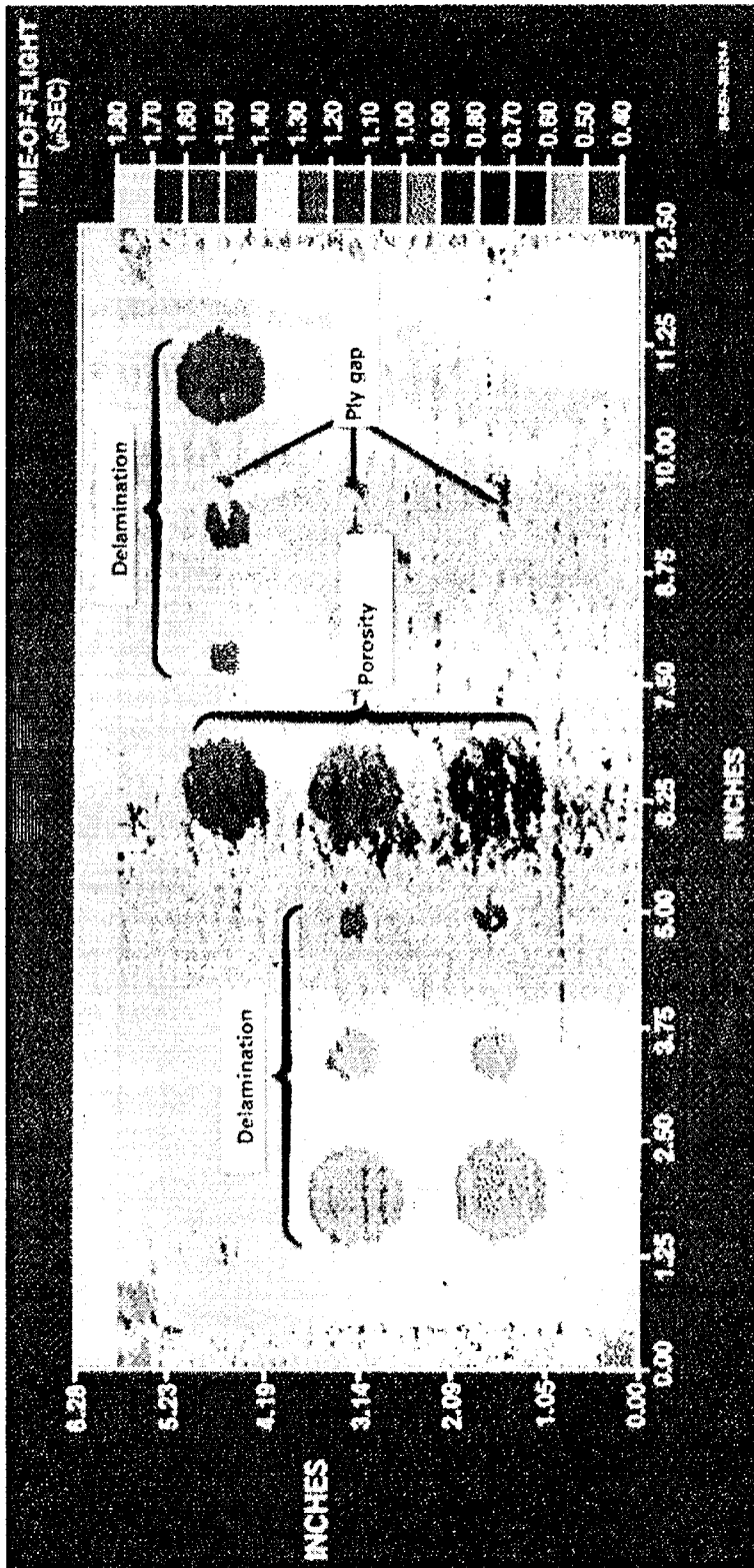


LEAKY LAMB WAVE (LLW) DISPERSION CURVE [0]₈ Gr/Ep Laminate along the fibers



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LLW C-scan of $[0]_8$ Gr/Ep Laminate



JPL

APPLICATIONS OF POLAR BACKSCATTERING

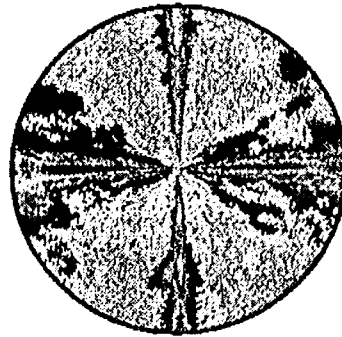


90° cracks

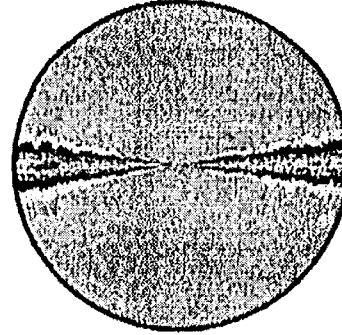


45° cracks

$[0, 90]_{2S}$



$[0]_B$

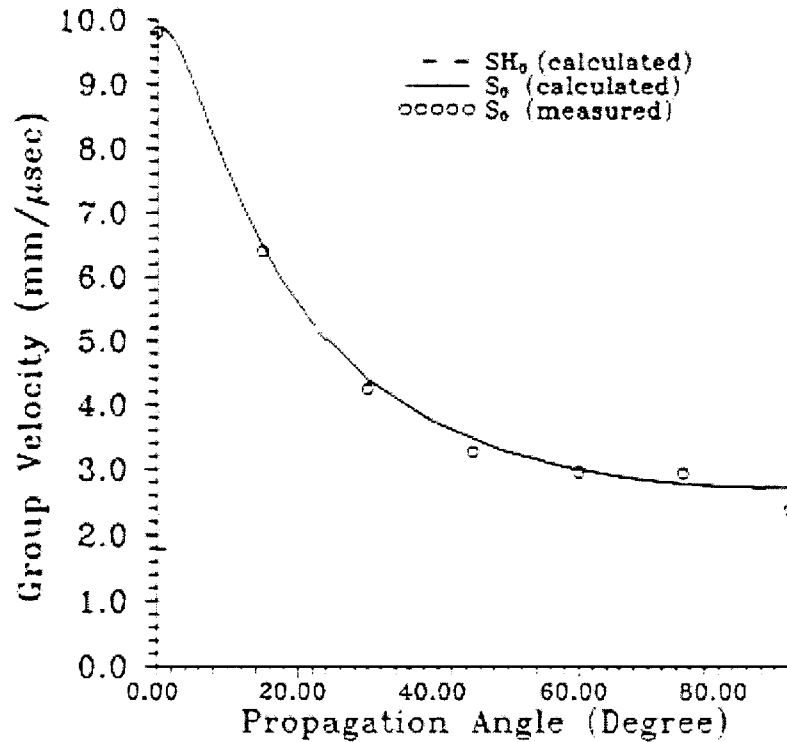


Preferred scattering characteristics of discontinuities allows to perform unique imaging of their configuration

Imaging of fiber orientation



Measured & calculated group velocity for the extentional mode s_0 propagating at 0° to 90° with the fibers in a unidirectional Gr/Ep 3.175-mm thick plate.





Concluding Remarks

- LLW measurements allow assessment of the matrix dominated properties.
 - At high frequencies the model requires analysis of the influence of the individual layers.
 - Low frequency analysis can provide global laminate properties.
 - LLW data inversion can be used to gauge the material degradation due to manufacturing (e.g., porosity, excessive resin) and service (e.g., fire) causes.
- All five constants of a composite laminate can be determined using pitch-catch pulse experiments.