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ON THE INFLUENCE OF MECHANICAL AND PROCESSING CHARACTERIZATION ON THE VIBRO-ACOUSTIC RESPONSE OF LCM AND PREIMPREGNATED COMPOSITE LAMINATES

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1.1 Introduction. **Motivation**

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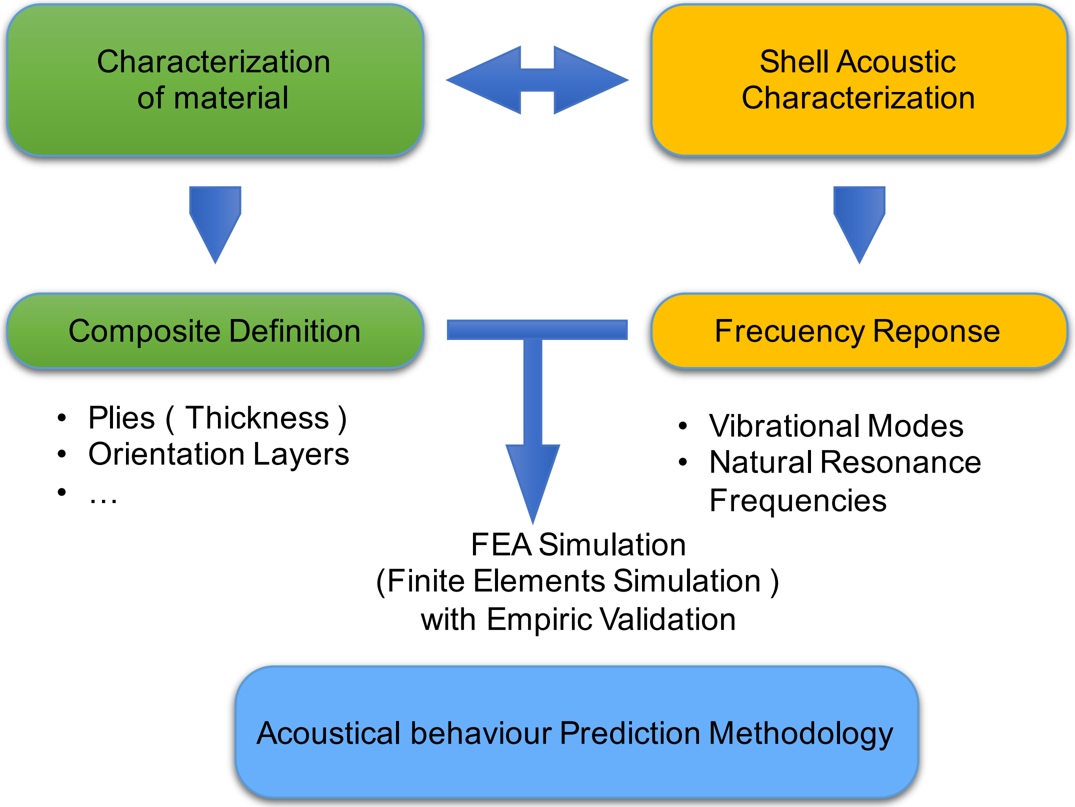
- Characterization of instrument **material composite**, and therefore **modifying its mechanical properties, allows modulation frequencies generated by its vibrational modes.** This fact gives us the possibility of intervening in the frequencies produced.

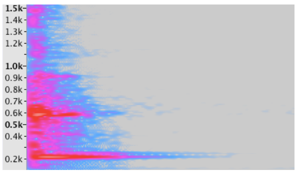
Ply	Material	Thickness (mm)	α_1 / α_2 (°)
0	Polyurethane	0.15	0
1	CFRE	0.34	0 / 90
2	CFRE	0.34	0 / 90
3	CFRE	0.34	0 / 90
4	CFRE	0.34	0 / 90

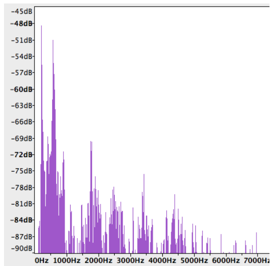


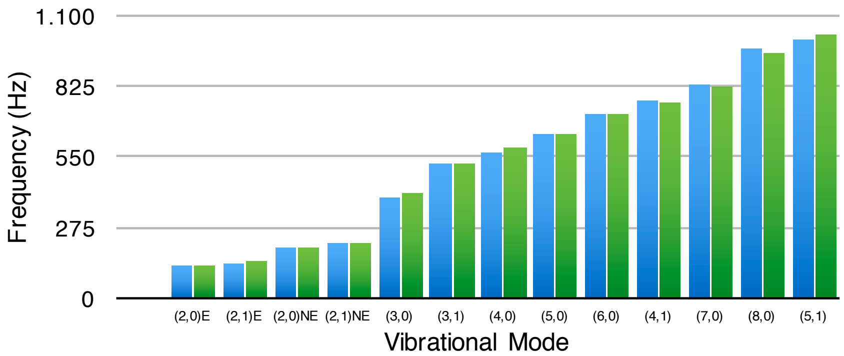
- The **experimental and simulated data** with Finite Element Analysis allows one **to correlate** the **vibro-acoustic response** of the preimpregnated composite laminate with the **mechanical characterization**

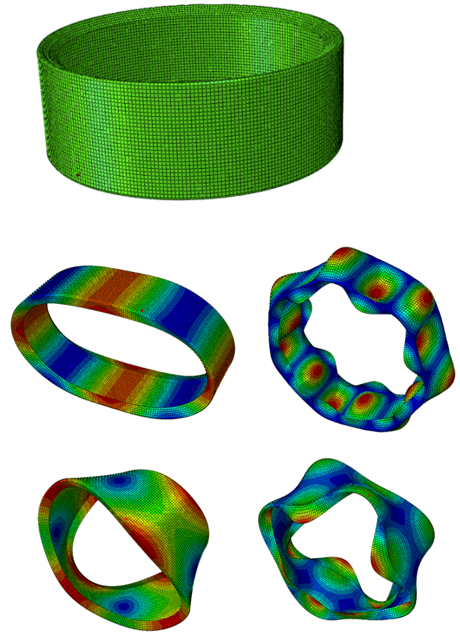
FEA SIMULATION

EXPERIMENTAL









Getting frequencies by spectral analysis.

Getting frequencies by Vibroacoustic simulation

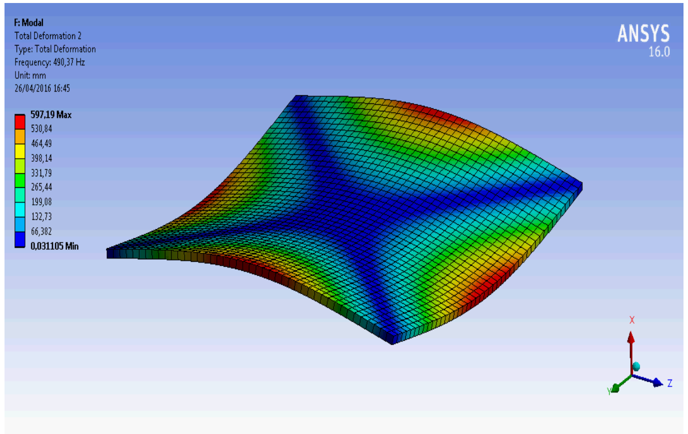
Great variability of material characterization depending on the composite processing

1.2 Mechanical modelling. Acoustic response due to material characterization

- The **frequencies produced** by a rectangular plate [3] can be **expressed in terms of its geometry and its elastic** and material properties as:

Vibrational Mode (m,n)

$$f(m,n) = 0{,}453 C_L t \left[\left(\frac{m+1}{a} \right)^2 + \left(\frac{n+1}{b} \right)^2 \right] \quad where \quad C_L = \sqrt{E/\rho(1-v^2)}$$



- The **elastic properties** of the composite laminate **can be obtained theoreticaly** from the matrix and fiber data as:

$$E_c = E_f V_f + E_m(1 - V_f)\,; \quad \rho_c = \rho_f V_f + \rho_m(1 - V_f)$$

- **Or experimentaly** by two different approaches:
  - according to **ISO 527-4:1997 standard for tensile test** [6]
  - using a **dynamic method** based on its acoustic resonance. [7]

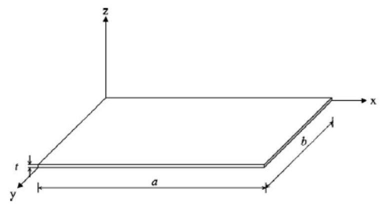


Fig. 1. Schematic representation of the specimen.

1.2 Mechanical modelling. Dynamic method based on its acoustic Response.
Determining Dynamic Young Modulus

Frequency Obtained by Resonance for a mode (m,n)

Mass

Length (a)

Young modulus

$$E = \frac{48}{\pi^2}\left(\frac{f}{\lambda(\nu)}\right)^2 \frac{ma^3(1-\nu^2)}{bt^3},$$

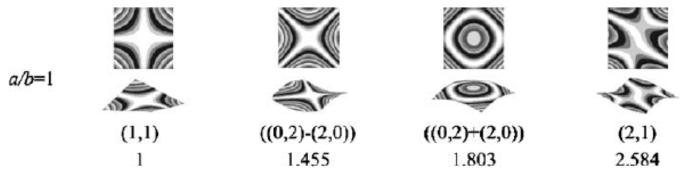
Poisson Ratio

Thickness

Length (b)

Frecuency Factor for a Poisson Ratio (v) & mode (m,n)

VIBRATIONAL MODES FOR A SQUARE PLATE



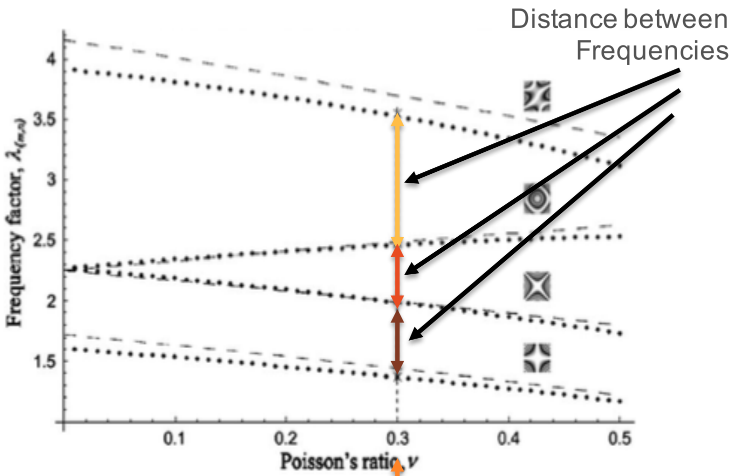


Fig. 3. Variation in the frequency factors with ν for $a/b = 1.0$; (- -) Warburton [28], (×) Leissa [29], (●) FEM.

Mode (2,1) 191 Hz

Mode (0,2)+(0,2) 143 Hz

Mode (0,2)-(0,2) 130 Hz

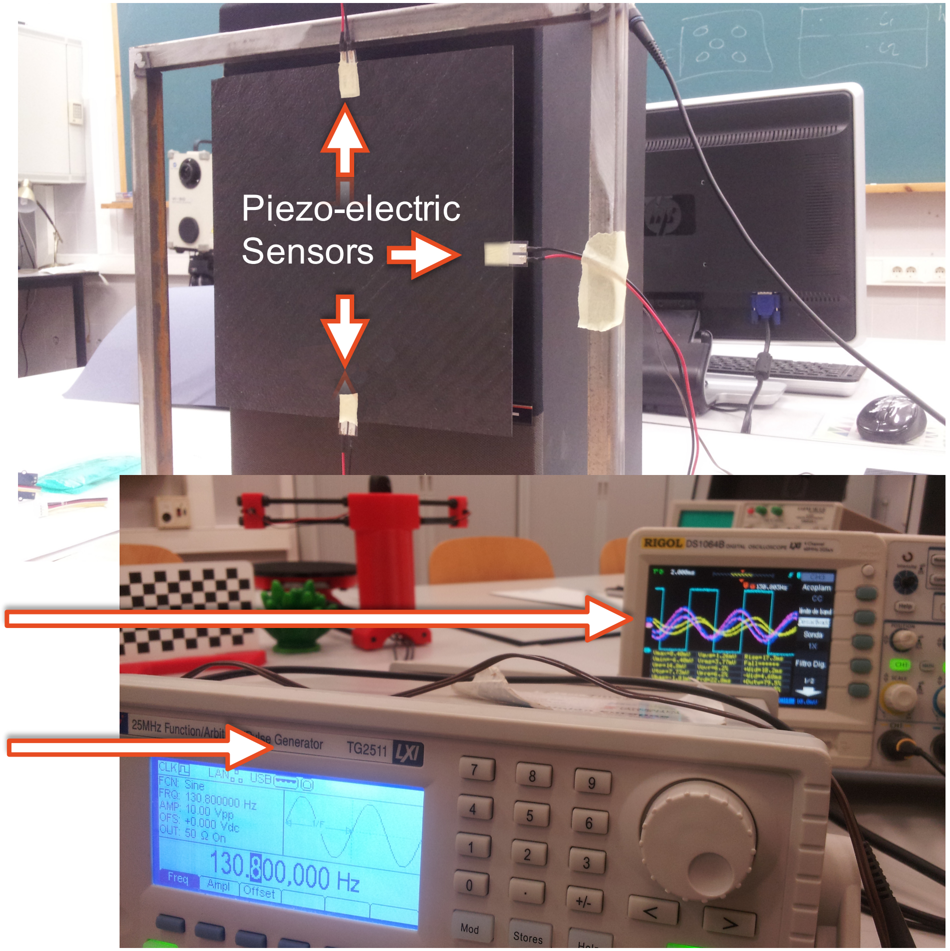
Mode 1,1 110 Hz

Poisson Ratio Value

1.2 **Mechanical modelling. Dynamic method** based on its acoustic Response.
Determining Dynamic Young Modulus

Standard Tensile Test

Dynamic method



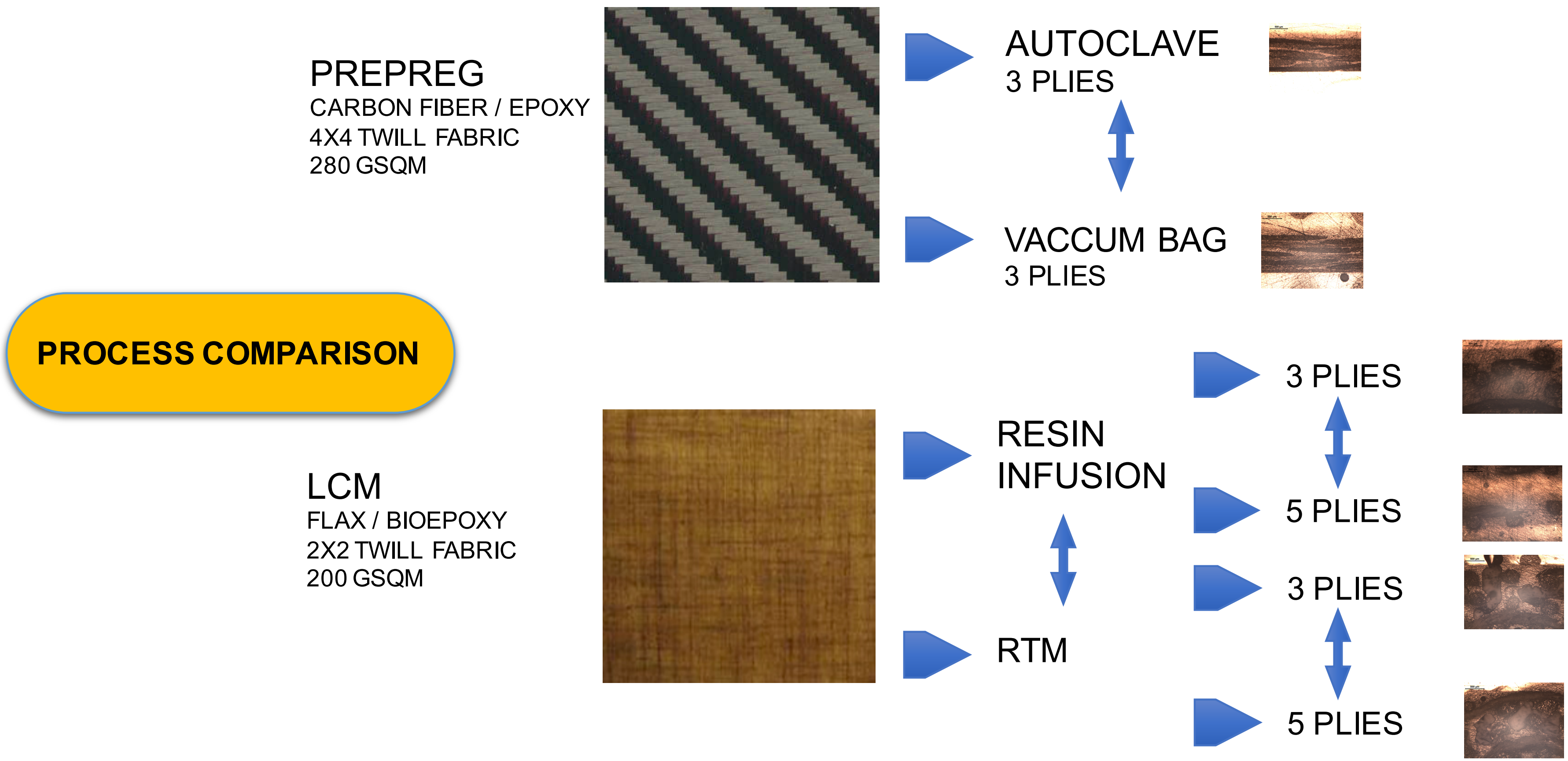
Oscilloscope

Wave Generator

1.3. **On the influence of** mechanical and **processing characterization on the vibro-acoustic response**

Study cases

Objective: Theoretical and empirical comparison of the mechanical and acoustic properties of different samples of composite materials produced by different processes



1.3. On the influence of mechanical and **processing characterization on the vibro-acoustic response**
Study cases

- A proper **manufacturing study is essential to be developed** in order to establish appropriate material properties through its processing. The preliminary results show the **vibro-acoustic analysis of a drum shell built in autoclave carbon fiber reinforced epoxy**. A set of experiments conducted in different prototypes, **illustrates variations in the frequencies produced** by their vibrational modes depending on composite design definition. Preliminary results are **on working** but not conclusions yet

	E_{th} (Gpa)	E_{ISO} (Gpa)	$\frac{E_{Iso}}{E_{th}}\%$	E_{dyn} (Gpa)	$\frac{E_{dyn}}{E_{th}}\%$	ρ_{th} (kg/m^3)	ρ_e (kg/m^3)	$\frac{\rho_e}{\rho_{th}}\%$	f_{th} (Hz)	f_e (Hz)	$\frac{f_e}{f_{th}}\%$
Prepeg Auto.	55,75	55,9	0,27%	56,6	1,60%	1480,00	1450	-2,03%	366,9	370,0	0,85%
Prepeg. Vac.	53,66	41	-23,59%	42,4	-20,92%	1469,20	1350	-8,11%	373,8	354,0	-5,30%
RTM 3 plies	7,44	5,56	-25,24%	6,08	-18,25%	1207,37	1121,1	-7,15%	448,54	412,73	-7,98%
RTM 5 plies	9,55	7,18	-24,81%	8,24	-13,71%	1232,29	1234,4	0,17%	490,92	438,68	-10,64%
RI 3 plies	8,95	4,76	-46,79%	4,98	-44,33%	1225,17	988,2	-19,34%	357,06	308,78	-13,52%
RI 5 plies	9,55	4,38	-54,13%	5,02	-47,43%	1232,29	951,6	-22,78%	514,11	417,57	-18,78%