



Characterization of the viscoelastic materials up to 10 000 Hz without using time-temperature superposition

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Outline :

1 Design before MAIAS for testing shims

Design

Data post-processing

Results for shims

Results for silicon

2 Design for MAIAS for testing silicon

Design

Data post-processing

Test with shaker for validation

Results for silicon

3 Conclusion and perspectives

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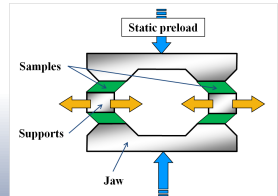
3 Conclusion and perspectives

Background

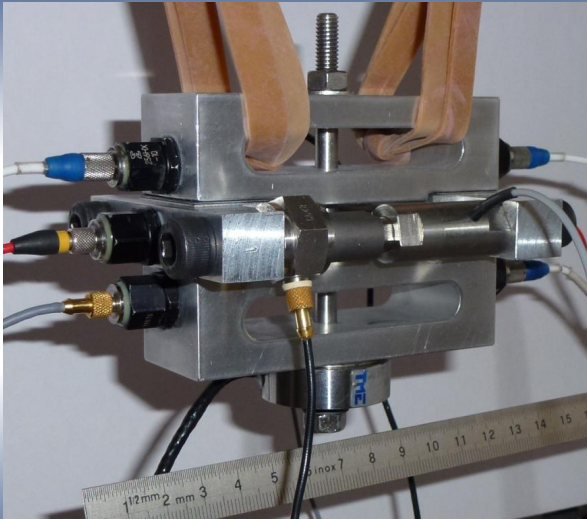
Shims are used in brake systems to damp squeal noises ($f > 1000\text{Hz}$). Shims are viscoelastic materials composed of layers of steel, rubber and glue. The time-temperature superposition principle is not proved to hold for shims.

Requirements for a shear stiffness analyser

- ① Uniform static preload.
- ② Dynamic shear excitation, $f \in [0, 1..10]\text{kHz}$ without using time-temperature superposition principle.
- ③ Stress and strain measurements.
- ④ Avoiding vibrations from outside to get a high signal to noise ratio.



Design

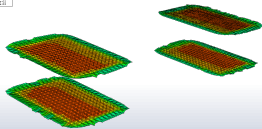


- 1 static force sensor.
- 2 piezoelectric actuators
- 2 dynamic force sensors.
- 6 accelerometers, one per sample face.

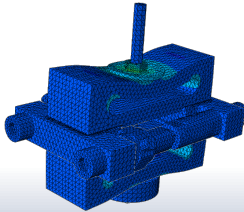
Design

Jaws shape ensure the uniformity of the static preload over the samples surfaces.
A 4MPa static preload on samples is obtained with a 5000N preload on the bolt.

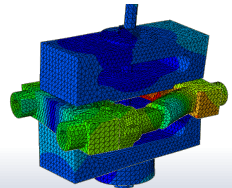
The first eigen mode interfering with measurement occurs at $f \simeq 3500\text{Hz}$. It involves the deformation of the dynamic force sensors.



Static pressure on samples



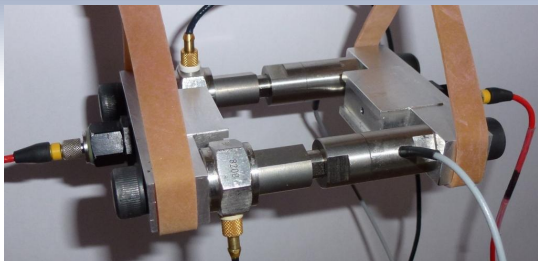
Static deformation



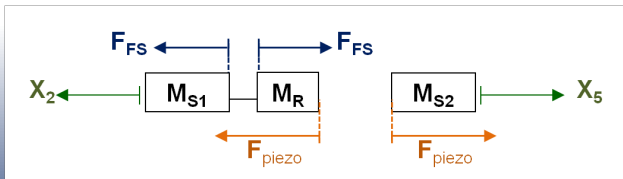
First eigen mode

Data post-processing

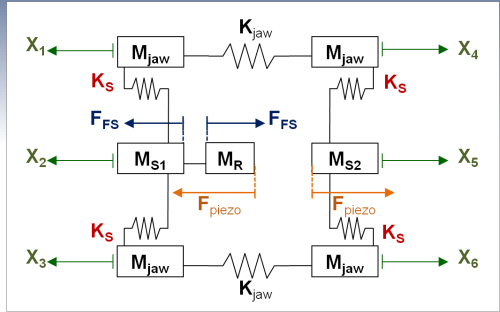
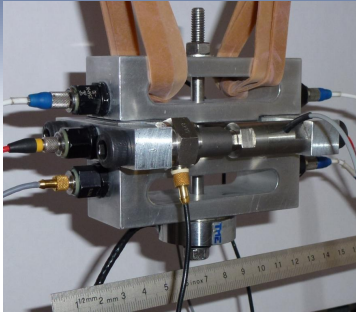
A sinusoidally moving mass of 100g with a displacement amplitude of $1\mu\text{m}$ leads to an inertia force of 4N at 1000Hz and of 100N at 5000Hz.



$$\begin{cases} M_{S1} + M_R + M_{S2} = 290\text{g} \\ M_{S1} = 120\text{g} \\ M_R = 37\text{g} \\ M_{S2} = 133\text{g} \end{cases}$$



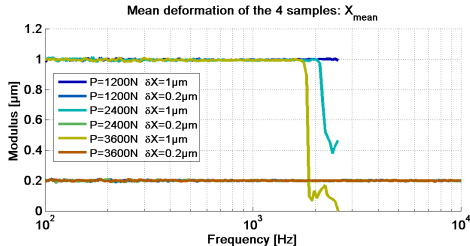
Data post-processing



$$K_S = \frac{\omega^2((M_{S1} - M_R)X_2 + M_{S2}X_5) - 2F_{FS}}{2X_2 + 2X_5 - X_1 - X_3 - X_4 - X_6} \quad (1)$$

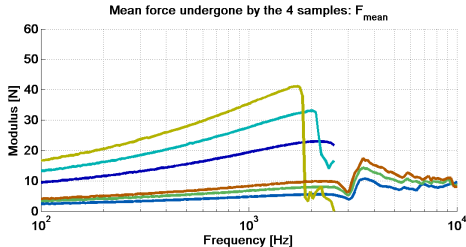
No influence of parameters M_{jaw} and K_{jaw} .

Results for shims



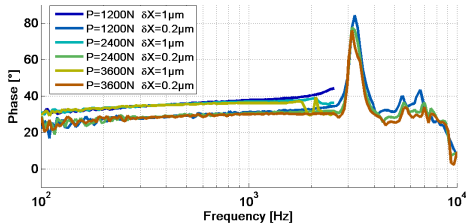
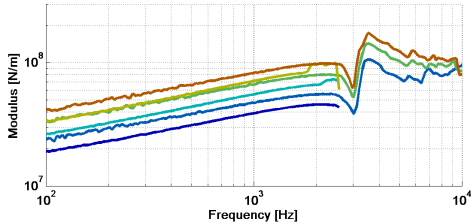
- 3 preloads : 1200, 2400 and 3600N
- 2 deformation : 0.2 and $1\mu\text{m}$

The displacement is controlled except for high amplitude and high frequency because of a lack of power.



Results for shims

Mean shear stiffness of the 4 samples: K_S

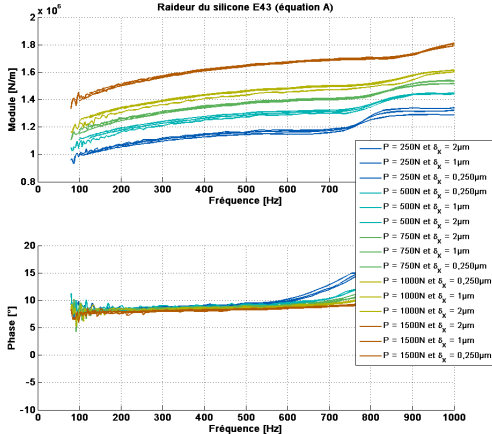


Shim behavior :

- increasing preload :
increasing modulus,
same phase
- increasing deformation :
decreasing modulus,
increasing phase

Because of the first eigen mode around 3 500 Hz, results are accurate only up to 2 000 Hz.

Results for silicon



The first eigen mode depends on the stiffness of samples. Silicon is much more flexible than shims.

The first eigen mode occurs around 800 Hz when characterizing silicon. Results are accurate only up to 600 Hz.

Thus, this test bench is not suitable for silicon characterization.

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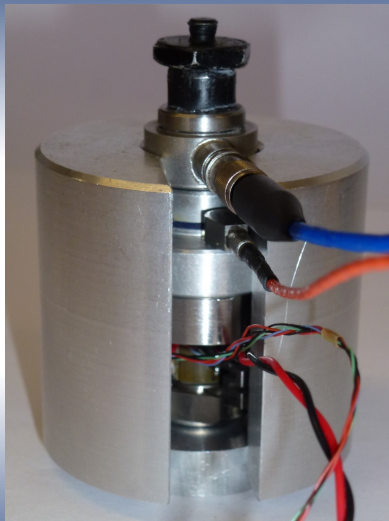
New requirement :

Allow both compression and shear characterization

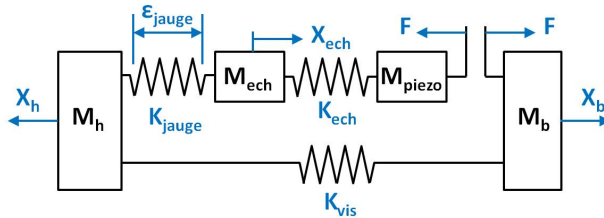
Compression sample

Shear sample

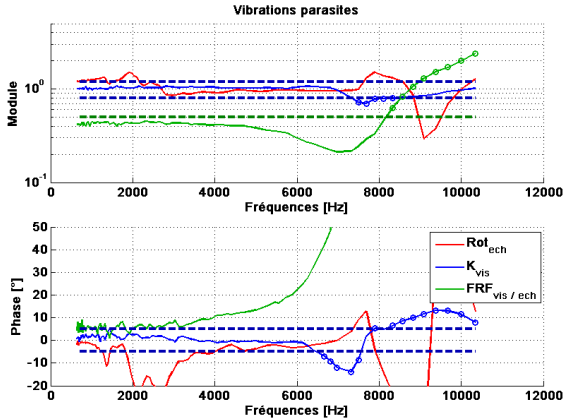
Design



Data post-processing



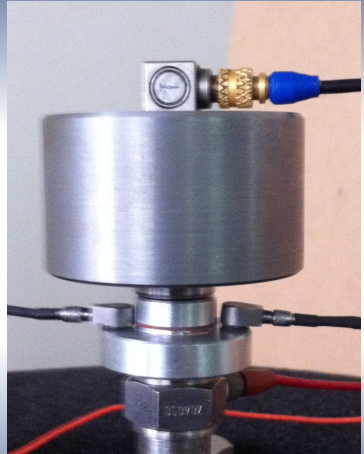
Data post-processing



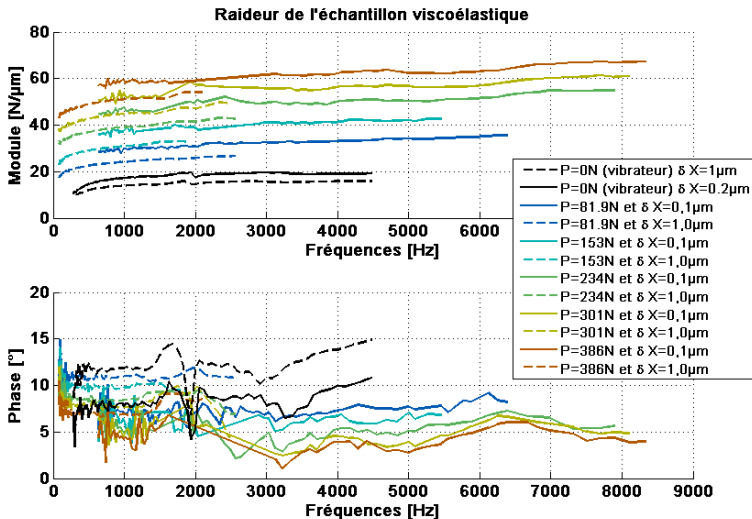
3 indicators :

- the accelerometers of the sample must move in phase (red curve)
- the stiffness of the screw must stay constant with zero phase (blue curve)
- the deformation of the screw must be lower than the deformation of the sample (green curve)

Test with shaker for validation



Results for silicon



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Conclusion and perspectives

Achieved goals :

- No need of time-temperature superposition principle.
- Shim characterization in squeal conditions.
- Silicon characterization up to 8 000 Hz.
- Good agreement with others test (Shaker).

It remains to :

- Test shims in compression on the second test bench design.
- Compare results with the ones of LRCCP.
- Improve the test protocol to make it easier to use.

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