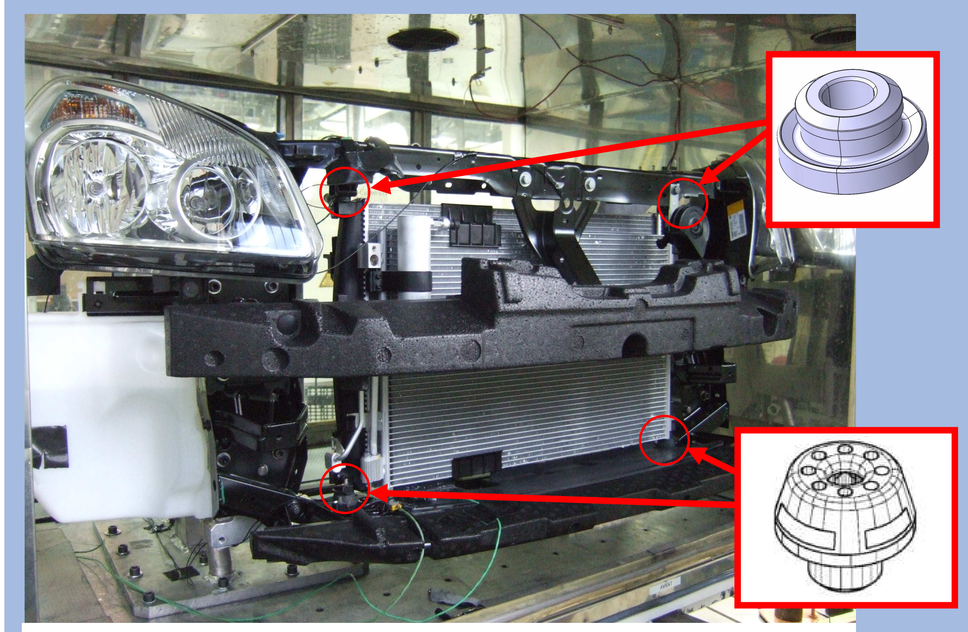
Nonlinear dynamics of on-board structure equipped with elastomer mounts: Application to the vibration insulation of engine cooling module

Benjamin THOMAS[1;2], Pr. Régis DUFOUR[1], Dr. Lionel MANIN[1]

[1]LaMCoS, INSA-Lyon [2]Valeo Engine Cooling, La Verrière

Context of the Thesis – Research motivations

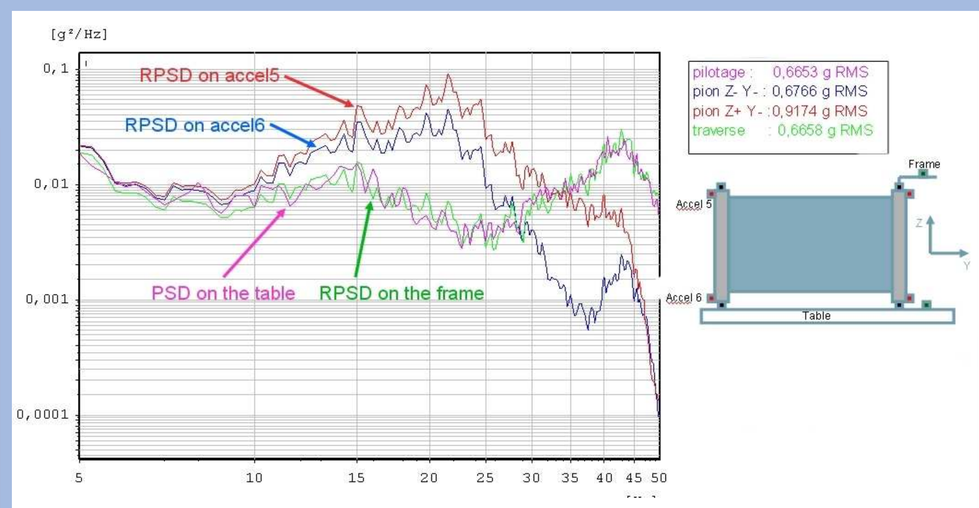


Front End with Engine Cooling Module

Rubbers used are **elastomer** based (EPDM or natural caoutchouc).

They have a **coupled behavior** with a **viscoelastic** part due to the material itself and a **dry friction** part due to their direct environment.

The **characterization** must be realized in both **imposed deflection amplitude and imposed frequency**



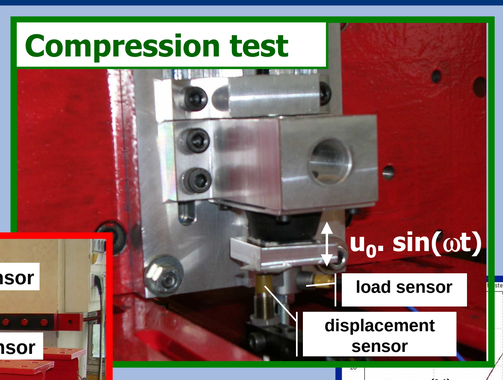
The amplification of Power Spectral Densities due to rubbers behavior must be taken into account in simulation models to obtain reliable calculation and to realize fatigue analysis

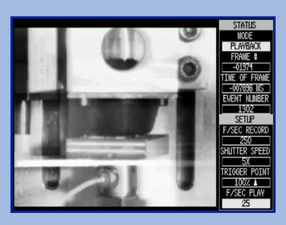
Necessary steps

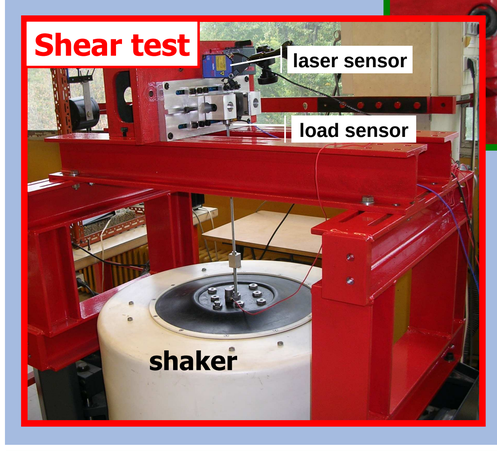
- Choice of a rubber mount behavior model
- Mechanical characterization of mounts
- Model parameters identification
- Model implementation in an industrial FEA software
- Generalization of vibratory solicitations
- New PSD calculation process definition

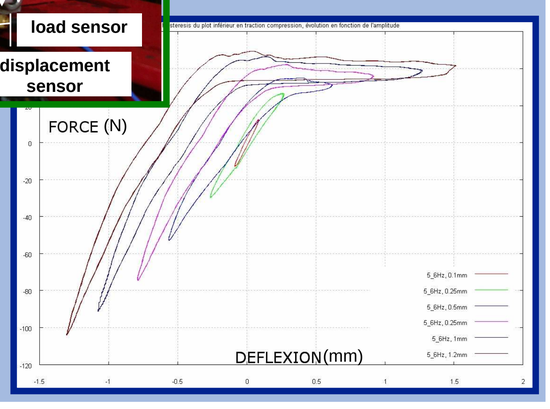
Mechanical characterization of mounts

- **Forced deflection tests**
  - **Controlled amplitude**
  - **Controlled frequency**
  - **Controlled pre-load**



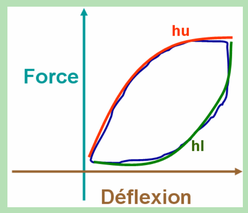






Generalized Dahl's restoring force model

$$\frac{dR}{dt} = \beta \frac{du}{dt} * (h - sign(\frac{du}{dt}) * R)$$



- Model compatible with every type of solicitation and time integration
- Takes into account environment effects
- Simple enveloppe based characterization

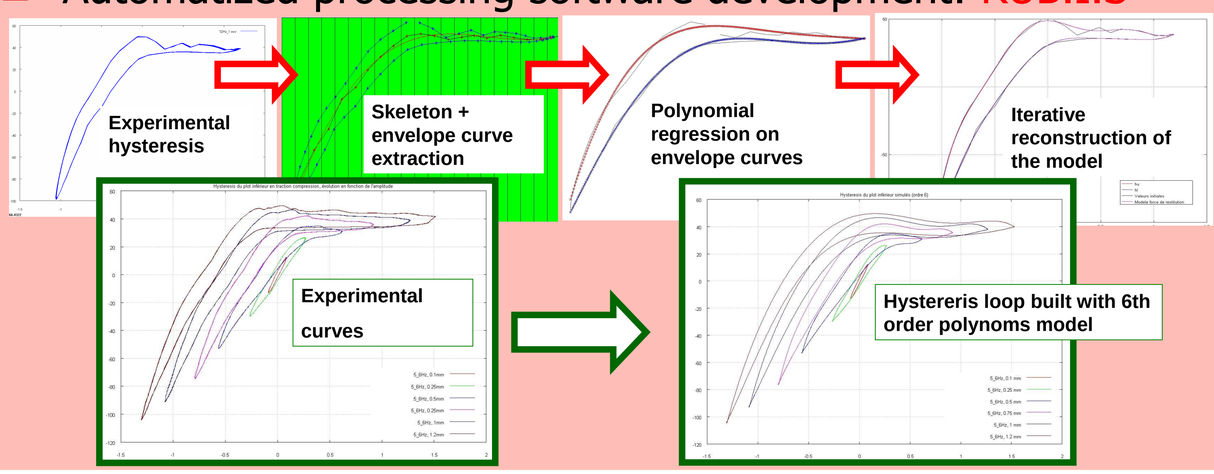
R: restoring force, u:deflection, β:model parameter ,

$$h = 0.5 * ((h_u - h_l) + sign(\frac{du}{dt}) * (h_u + h_l))$$

h_u,h_l: enveloppe curve equation

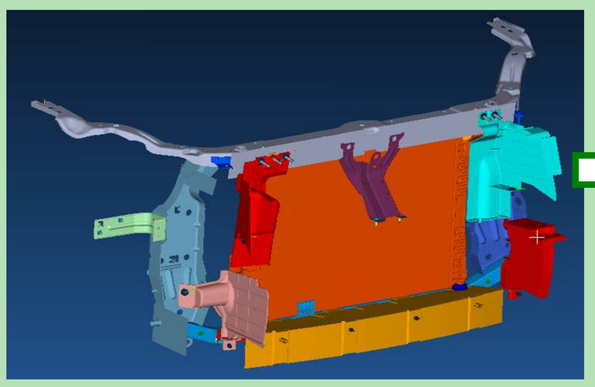
Model parameters identification

- Automatized processing software development: RUB.I.S

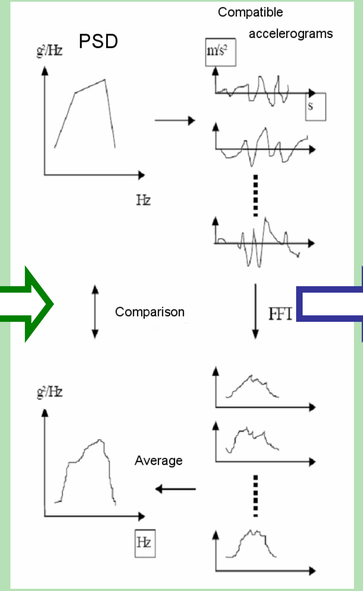


PSD calculation process

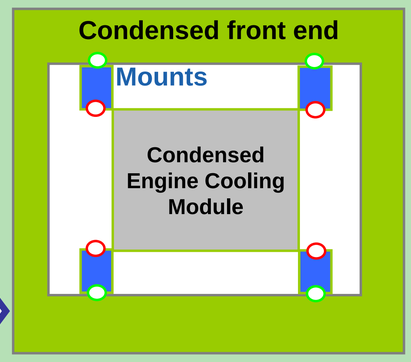
- Usual methods to solve FEA PSD problems are linear because they are based on modal superposition. In our case it is necessary to define a new simulation process in two steps. The first one is a **non linear temporal calculation to integrate rubbers behavior**. The second one is a classical PSD calculation with a new excitation spectrum obtained as a result of the first calculation.



1: Meshing of the front end + cooling module



2: Generation of compatible accelerograms

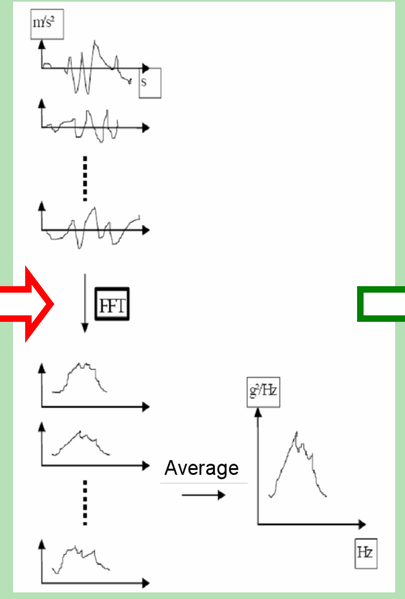


Pilot node with rigid link to spectrum injection nodes

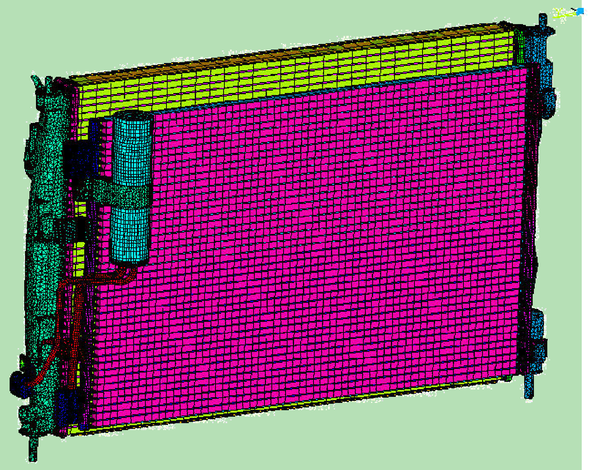
1st calculation

3: Dynamic condensation of the structure

4: Temporal calculation with frequency content estimation on the condensed structure



4: Creation of a new excitation PSD thanks to response accelerograms at rubber nodes



2nd calculation

5: Classical PSD calculation on the cooling module with the new excitation spectrum

lamcos.insa-lyon.fr

LaMCoS, Université de Lyon, CNRS, INSA-Lyon UMR5259, 18-20 rue des Sciences - F69621 Villeurbanne Cedex

Laboratoire de Mécanique des Contacts et des Structures