Modeling of plasticity in spectral methods for fatigue damage estimation of random vibrations

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Many mechanical structures are subjected to random vibrations due to external forces (forces, acceleration,...). The best fatigue design should allow improving the safety of structures and reducing manufacturing cost and design. We present here, a spectral method for estimating the fatigue damage to the polycyclic and low cycle fatigue domains.
The fatigue phenomenon is usually studied in time domain because loads are quasi-static and so there are no dynamic response of the structure. Within the framework of random vibration, mechanical structures have a dynamic response. This implies some problems for the calculation of stress for fatigue analysis:
- Convolution integral (problem of computing time)
- Random aspect of vibrations (consideration of random processes)
- Potential local plasticity (nonlinear behaviour – material non-linearity)

A solution to these problems is to study the fatigue phenomenon in the spectral domain. In the frequency domain, random vibrations are represented by the PSD (Power Spectral Density). Spectral methods are currently applicable in polycyclic fatigue domain for stationary ergodic Gaussian vibrations. They are based on a frequency calculation in stress. Spectral methods are limited by assumptions such as material behaviour or geometrical linearities. The method developed in this work allows plasticity modelization in confined areas for damage calculus. Another advantage of the method relies on its strain formulation which allows fatigue law computation (Manson-Coffin-Basquin). This modification enables to extend application domain of spectral methods to policyclic and low cycle fatigue domains.

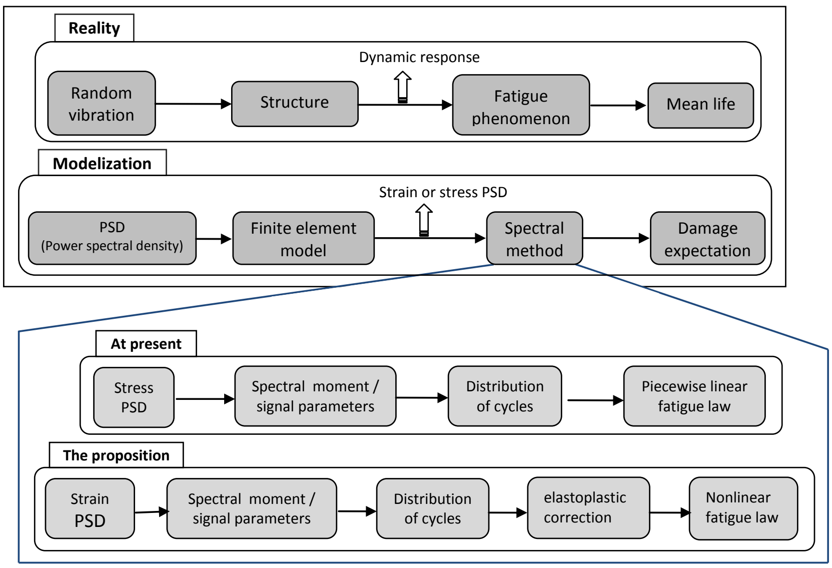

Fig1 : Description of vibration's fatigue process and spectral methods

To validate the method, we performed several correlations between experimental, numerical analysis and Monte-Carlo simulations. Random vibration used are a narrow band with a uniaxial strain state, a narrow band with a multiaxial strain state, a white noise with a multiaxial strain state.

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