The virtual machine : a signal generator based on realistic dynamic behavior

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Abstract

Condition monitoring of rotating machines is largely based on signal processing techniques involving different approaches in time, cyclic or angular domains with various numerical tools. Generally speaking authors extract simple models from literature analysis in order to generate some test signals dedicated to the demonstration of effectiveness and efficiency of the proposed method. Most of the time, the signal of interest is a vibration signal and this analytic signal is constructed by a convolution of an impulse excitation through a transfer function and some added perturbations or noise. The transfer function generally describes a single DoF with a resonance frequency including damping coefficient. Impulse excitation is generated by some assumptions on a shock when fault enters in a contact zone in gears or bearings. This analytic signal simulation suffers from strong assumptions, strong drawbacks and lacks in order to describe more realistic dynamic behaviors in rotating machines. Some of them may be listed in the following:

- There is no direct link between geometry, in particular fault geometry, and excitation characteristics (impulse duration, amplitude, ...),
- These signals are related to a 1D model where excitation and sensor are placed in the same direction,
- There is no way to investigate other signals or physical quantities in order to understand the meaning of indicators extracted from signal analyses,
- It is very difficult to compare signal analyses on a reference basis,
- Cyclic and time descriptions are generally merged in a time description, assuming a constant rotation speed of the machine,
- Sensor transfer function or model describing sensor and signal acquisition are not included in the signal generation process.

The present paper presents a "simple" model which includes realistic structural parts, fixed or in rotation, linked together with mechanical components like bearings or gears (see Fig. 1). These linking elements are described as restitution forces between structural parts with light but realistic models related to technological parameters. For sake of illustration, load sharing over roller elements in bearings will be held as instance of coupling between constant radial load applied on the shaft and torque variations on the rotating shaft. Various external excitations may also be added as resistive torque fluctuations or external forces located in realistic positions. As this model keeps the rotating DoF of at least one shaft, the angle-time

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function is known during simulation, allowing the description of cyclic and time phenomena in a precise and simultaneous way. Some symptomatic results will be presented showing for instance some modulation effects on vibration signals which are linked to mechanical couplings between shafts. Non stationary operating conditions in speed will be also illustrated as strong perspectives for realistic signal generation of different natures. The software will be available online as p-code and m files for Matlab ©.