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Optimization for vibration analysis in rotating machines

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1. Problematic

A not stable mechanical movement transmission between systems produces equilibrium losses, such as a rotor of motors that are coupled in rotating machines, such as turbines, some pumps, and some compressors

2. Proposed solutions

Active Magnetic Bearings (AMB) propose a good support to enhance the vibration reduction in the operation of rotating machines, which is improved when the main control of the rotating system correlates the effect of AMB with its own vibration measurement.

2. Proposed solutions, mathematical analysis

A mathematical analysis was developed for this target, because of the correlation between vibrations and AMB:

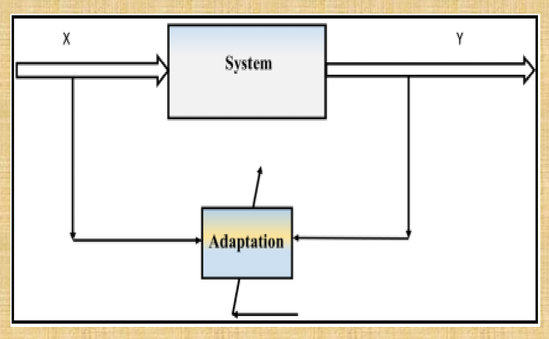


Figure 1. Adaptive scheme.

$$y(t)=\gamma(x(t)),u(t),\theta) \quad (1)$$

$$\frac{\partial y}{\partial x} = (\mathrm{Y}-\mathrm{r}\theta)^{\mathrm{T}}\mathrm{W}^{-1}(\mathrm{Y}-\mathrm{r}\theta) \quad (2)$$

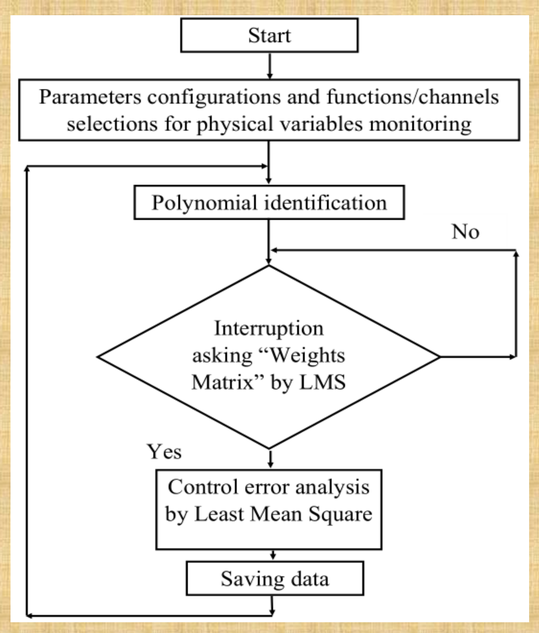
$$\theta = (r^{\mathrm{T}}W^{\mathrm{T}}r)^{-1}r^{\mathrm{T}}W^{-1}\mathrm{Y} \quad (3)$$

$$\widehat{\mathrm{Y}} = \mathrm{X}\theta \quad (4)$$

$$\mathrm{W}(\mathrm{n}+1) = \mathrm{W}(\mathrm{n}) + \mu\widehat{\mathrm{X}}(n)E(n) \quad (5)$$

2. Proposed solutions, algorithmic analysis

After the mathematical analysis, it was prepared an algorithm based in Least Mean Square due to find the best weight matrix for the main control system.



3. Results, setup

In figure 2 is showed the setup for the experiments

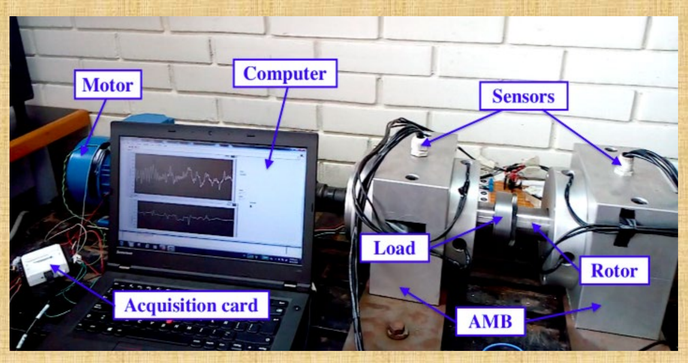


Figure 2: Setup configuration

3. Results, vibration surface

Vibration surface of the AMB holders

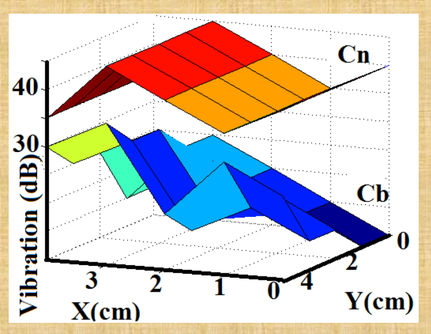


Figure 3: Vibration surface of the AMB holders

3. Results, vibration in time domain

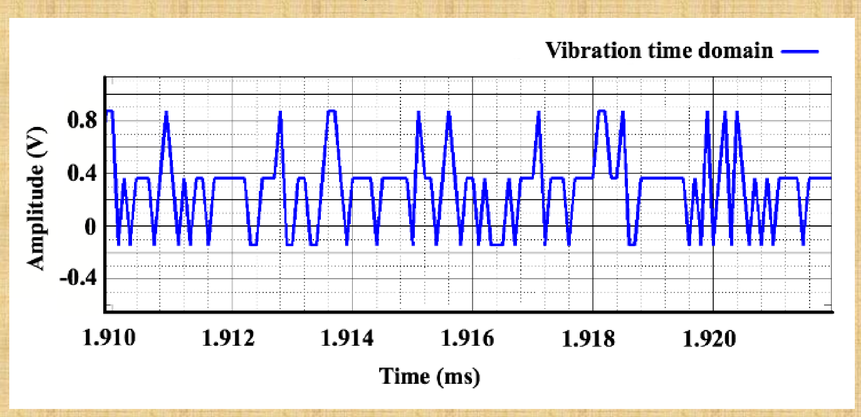


Figure 4: Vibration surface of the AMB in time domain

3. Results, in frequency domain

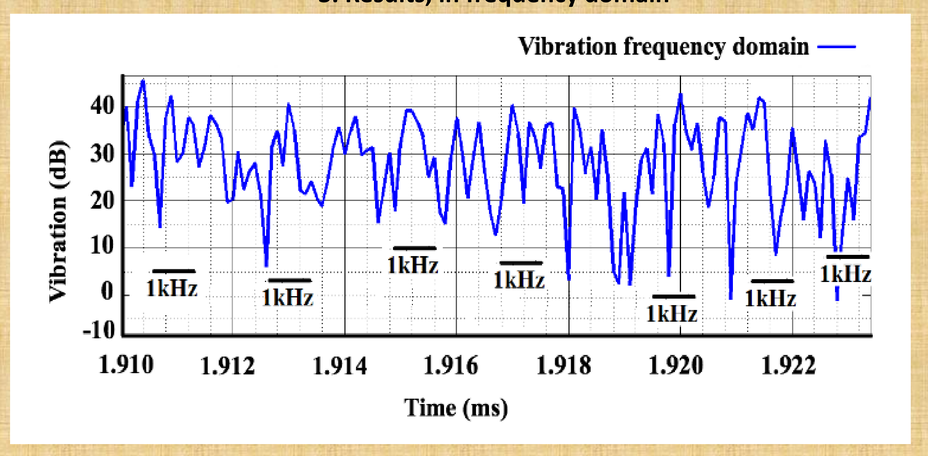


Figure 5: Vibration surface of the AMB in frequency domain

3. Results, under control system

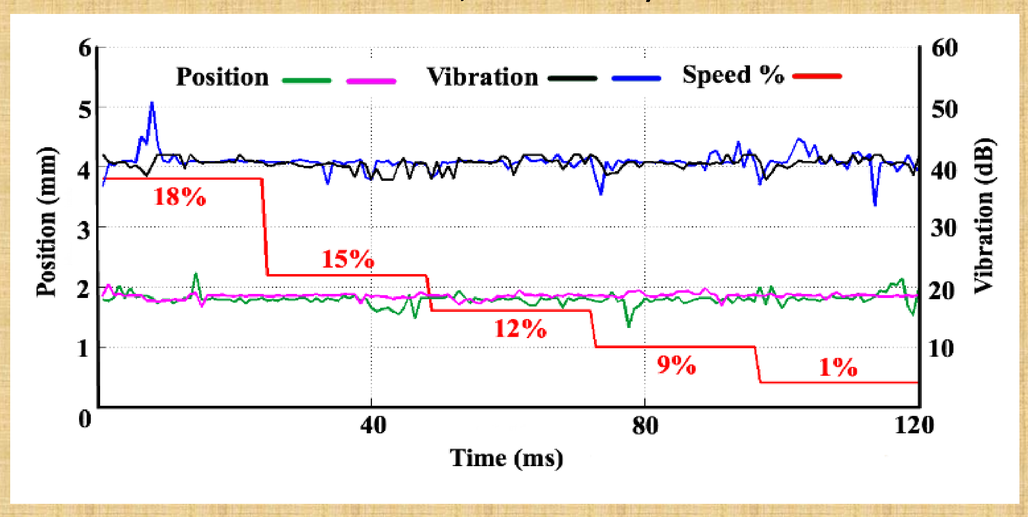


Figure 6: Vibration surface of the AMB under control position correlating its vibration

4. Conclussions

It was achieved a good performance in control position for a rotating machine that was based in Active Magnetic Bearing, it because the analysis of the vibration (that was produced as the consequence of reaction forces disequilibrium over the controlled system: motor/rotor/rotating machine) was introduced as the part of the main rotor position control algorithm.

It was possible to design a robust and faster control algorithm that was based in Model Predictive Control, owing to a surface analysis of the position control variables (including vibration). That analysis was supported by sensors based in nanostructures to correlate vibration measurement in fixed reaction points to look for better equilibrium of the system in parallel to the position control. It means, this type of algorithms need faster and robust sensors that are in researching stage nowadays, due to systems tend to be more integrated, whereby geometrical characteristics in internal design of sensors/actuators. These geometrical characteristics help to integrate the main mathematical model of the main control algorithm.

It is suggested to correlate the implicit vibration control that was achieved with a sound consequence, due to rotating machines produce sound more than 40dB in operating work. Therefore, as it is estimated the mathematical model of transmitted vibration, this support can help to estimate an adaptive sound signal to attenuate produced sound around the rotating machine.

5. Acknoledgements

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