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Modeling of shaft bow using finite element of curved beam.

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Abstract

This project deals with shaft finite element modeling using curved beam model. The objective is to evaluate the potential of replacing the current model of bowing, that neglects the inertia effects of the rotating shaft, for a more representative one, that includes such dynamic effects. The parameters used in the simulation will be the same as the built test bench, for comparison purposes. Depending on the results obtained in this project, the rotor-bearing model can be refined to achieve higher accuracy.

Key words:

Timoshenko beam, bowing shaft, finite elements.

Introduction

The bow shaft in rotary machines, as well as the imbalance, has been the subject of research in many studies. The system dynamic response changes when the bow effect is considered, resulting in several important phenomena, especially when added to imbalance forces present in the rotor. Most of the published papers represent the bow through fictitious forces acting on the shaft, causing bowing. These equivalent forces are determined from the displacement nodes of the finite element due to bow, and are dependent of the rotor angular velocity and phase relative to the inertial reference. When the rotor-bearing system rotates, elastic forces due shaft strain tends to restore it to the original bowed configuration [(1)].

However, it is known from dynamic mechanical systems that different dynamic effects can result if rotating distributed masses are replaced by equivalent forces, such as occurs in bowed shafts.

In this project, the bow shaft is modeled using finite element [(2)] combined with curved beam. With this model, the rotating inertia forces are not neglected in the dynamic system response.

Results and Discussion

Initially the static case was study, where the displacement of the beam is given by:

$$[K]\,\{V\} = \{F\}$$

$[K]$ = stiffness matrix.

$\{V\}$ = displacements vector.

$\{F\}$ = external effort vector.

The bowing shaft is modeled like elastic force, according Hooke's law:

$$\{Fb\} = \ [K]\,\{\delta\}$$

$\{Fb\}$= bow force vector.

$\{\delta\}$ = displacements of bowing vector.

The bow curve is modeling using a second-degree polynomial (parabolic function).

Therefore, the red curve y(x) is given by:

$$y(x) = ax^2 + bx + c$$

y(x) = bow amplitude.

x = shaft position.

a, b, c = coefficients of the function.

Entering with the inputs: bow amplitude and external force in the middle of the shaft, the following results are in figure 1:

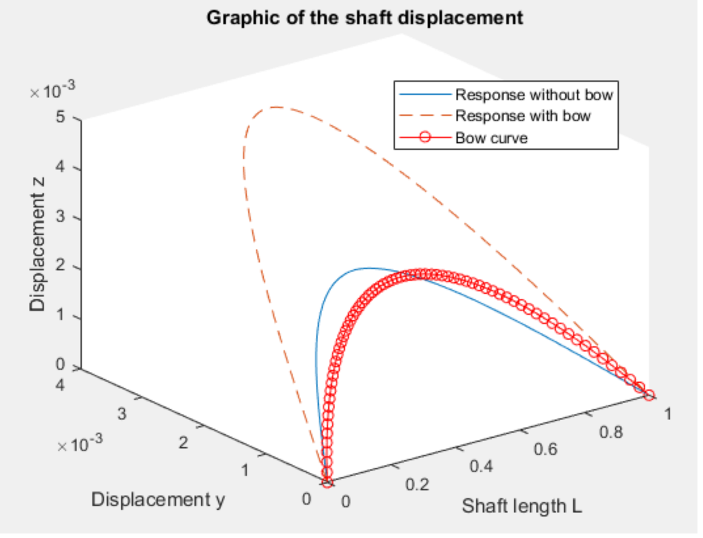

Figure 1 – Displacements of the Timoshenko beam and bow curve.

Conclusions

The resultant shaft displacement was a overlapping of the effects between the external effort and the residual bowing shaft.

The next steps of this project are to study how the bowing shaft interferes in the dynamics models and improve the approach of the bow curve.

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