FIELD BALANCING OF A GENERATOR USING A MODEL-BASED METHOD

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ABSTRACT

In general, in rotormachinery, each shaft of a machine-train has two or more main cross-sections that are planned to mount balance weights. These are defined as *main balancing planes* and are located in pre-defined axial positions: e.g. at the ends of the main body of the rotor of turbines, generators and electric motors, that allow the balance weights to be mounted at a significant radial distance from the axis of the shaft. This maximises the dynamic effects of the balance weights.

Often some further balance planes located in the middle part of the rotor, that is in axial positions that are inside the machine case, can be used for balancing actions carried out by the manufacturer, in special laboratories, at the end of the production cycle of the rotating machine in order to reduce the residual imbalance of the shaft. These planes are not accessible for in field maintenance actions.

In general, the main balancing planes can be accessible only after an in field disassembly of some parts of the machine case. This often requires long and costly maintenance actions as well as an accurate evaluation of magnitude and angular position of the balance weights since the case must be reassembled before any machine restarting. However, the axial position of these balance planes may not be optimal to balance flexible rotors in some particular ranges of the rotating speed. This depends on the shape of the normal modes associated with the flexural critical speeds of the shaft that are contained in the speed range of interest.

Sometimes, in field balancing actions are necessary to be carried out during the life of large rotating machines. Often, in order to reduce length and costs of the maintenance actions the balance weights must mounted on easily accessible cross-sections of the shaft. That is *"unusual" balancing planes* must be used.

In order to limit the number of trial shots the influence coefficients associated with unusual balancing planes can be evaluated with methods based on a mathematical model of the fully assembled rotating machine. The choice of unusual balance planes can be optimised on the basis of the results of a sensitivity analysis that shows the dependence of the influence coefficients on the axial position of the balance planes. This analysis can be carried out for different values of the shaft rotating speed. This approach allows the best choice of unusual balancing planes to be carried out accordingly with any technical restriction.

Moreover, this model-based method allows the prediction of the shaft radial vibrations induced by the balance weights in a large number of cross-sections where no sensor can be mounted. These results can be very important for diagnostic purposes.

This paper shows the results obtained with a model-based technique within the analysis of the dynamic behaviour of the generator of a power unit (Figure 1) that required an in field balancing to be carried out. High synchronous vibration levels induced by a significant residual imbalance (Figure 2) had to be reduced at the machine operating speed (3000 rpm) without causing undesired high additional vibrations when passing through the first flexural critical speed of the shaft and a local natural frequency of a support mounted near the generator exciter. The dependence of the theoretical influence coefficients on the axial position of the balance planes has been investigated.

The results provided by a sensitivity analysis carried out by means of a model-based method are shown and discussed (Figure 3).

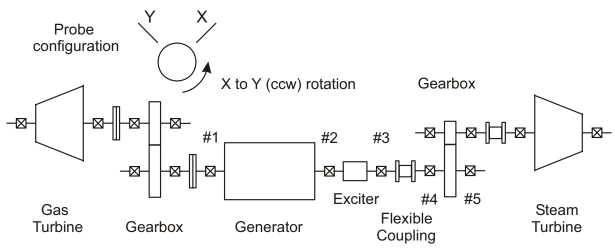

Figure 1. Machine-train diagram and bearing numbers.

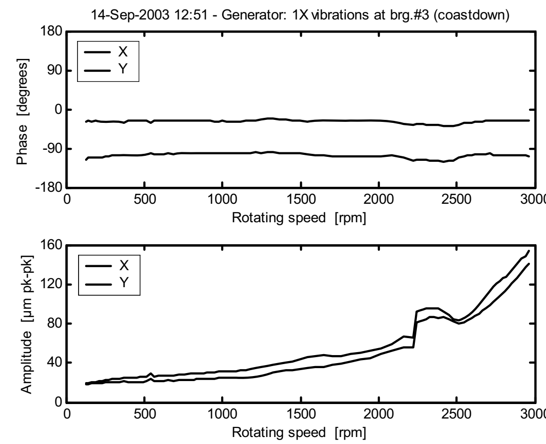

Figure 2. Bode plot of the 1X transient vibrations measured at bearing #3 before the balancing actions.

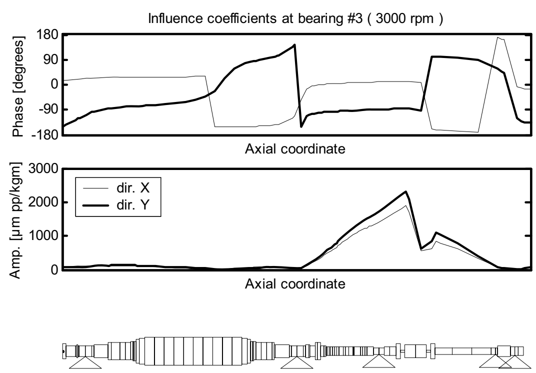

Figure 3. Magnitude and phase of the influence coefficients associated with the shaft vibrations at bearing #3, in the Y direction, evaluated considering balance planes located at different axial positions. Analysis carried out at 3000 rpm.

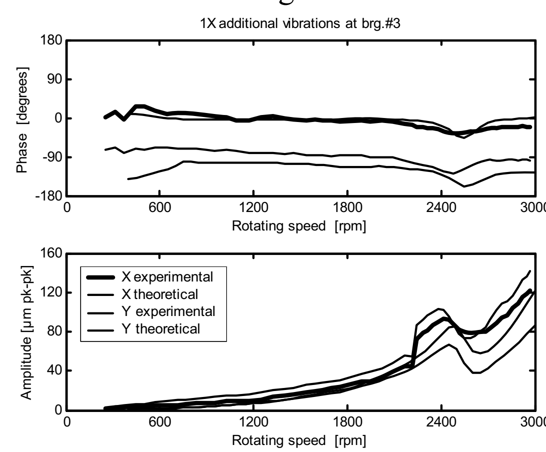

Figure 4. Comparison between predicted and experimental 1X transient vibrations caused by the balance weight mounted on a cross-section near the exciter.

Comparisons between theoretical and experimental influence coefficients are shown along with the comparison between predicted and experimental vibrations.

Since the machine dynamic behaviour was influenced by the generator thermal state magnitude and angular position of the balance weights had to be optimised to compensate the effects caused by a partial thermal bow that affected a large portion of the generator rotor in the region near the exciter. The successful results of this further optimisation of the in field balancing are shown in the paper.

The model-based investigation method used for the analysis described in this paper gave interesting results that can be used for in field balancing actions as well as to optimise the choice of pre-defined main balance planes carried out during the shaft design stage.

Keywords: rotor balancing, shaft vibrations, model-based methods, vibration predictions, case history.