COUPLED VIBRATIONS OF A MOVING STRIP AND A ROTOR ON A PREDEFORMED SHAFT

Long Abstract

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Introduction

The suitable and accurate simulation of the vibrations in a coiling process is important to predict the vibrations during standard operation and for special operation conditions. In the present production process an axially moving material is coiled on a rotating drum. The elasticity of the axial moving material and the shaft of the rotor lead to coupled oscillations of the variable mass system. Predeformation or misalignment can be caused by production tolerances or errors in the maintenance.

To maintain a proper long time process the speed of the strip has to be controlled and the strip tension force has to be kept as constant as possible. Bending vibrations of the rotor and the transversal oscillations of the strip are coupled. Simulations are performed for a rotor on a predeformed shaft and the computation results are shown. A controller is introduced to keep a production speed and to reduce the vibrations of the strip and the rotor.

1. Mechanical Model

The mechanical model under consideration basically consists of a shaft, a rotor and an axially moving strip. This mechanical system can be divided into two substructures, which can be computed with a semi-analytic procedure [2], which is not applied in the present contribution as there is only a small number of degrees of freedom present. The equations of motion are derived using the extended equations of Lagrange [5]. Some parameters are variable in the system, like the radius of the rotor, the mass of the system and the bending stiffness of the rotor. In order to keep the axial speed of the coiled material constant, the proper torque at the rotor has to be computed. Longitudinal elasticity of the strip is considered using the axial stiffness, however no longitudinal vibrations of the moving strip are considered as the longitudinal stiffness of the strip is high when compared with the bending stiffness of the shaft. For the longitudinal and transversal oscillations a Ritz-approximation for the moving strip is introduced. For the boundary conditions at the inlet of the strip the tension force is given so that the speed of the strip is computed. The effects of various parameters of such a system is analysed in [4] and the eccentricity as a source of vibrations is studied in [1]. The predeformed shaft of the rotor is introduced in the equations of motion and analysed in this analysis. For a convergent time integration the Runge-Kutta procedure is used. In order to maintain a constant speed the torque applied at the shaft is controlled. The application of this procedure to an industrial process and the simulation results are reported in [3].

2. Computed Results

The computed results are shown for given geometry and machine parameters as a reference example. For two given bending predeformations in the middle of the shaft of 0.1 and 0.2 mm Fig. 1 shows the torque at the coiling drum to maintain a constant speed at the entrance into the system. It is assumed that the radius varies linear with the rotation angle and the corresponding amplitude of the transversal oscillations of the strip is shown in Fig. 2. Additional more enhanced control strategies are possible to reduce the vibrations of the rotor.

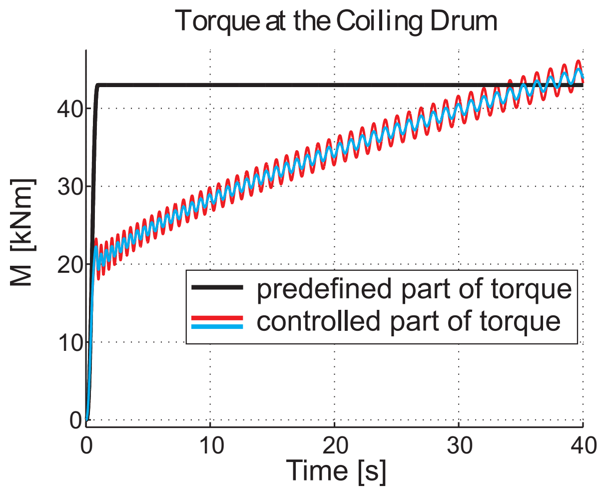

Figure 1. Torque at the rotor for a constant axial speed.

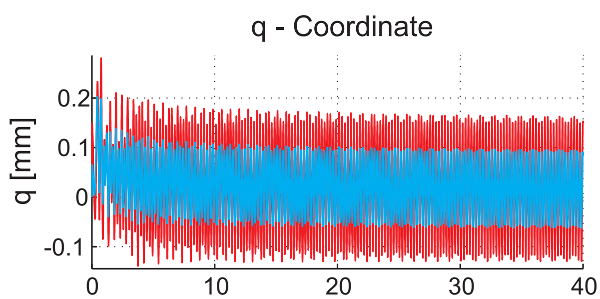

Figure 2. Torque at the rotor for a constant axial speed.

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