1. Introduction

Many industrial systems like tooling machines, production machines, handling devices, etc. use a guided longitudinal motion to control a defined axial position. Synchronous power transmission belts are used in a variety of industrial applications as a source of the longitudinal motion or to transmit power efficiently. In both cases the dynamic behaviour of the transmission system is of a great importance for the industrial system and depends on various parameters. Often the axial speed of the belt is predefined and an additional motor belt drive is applied in order to tune the motor for the best use. If the transported mass and its speed are given, there are several position dependent eigenfrequencies in such a dynamic system with variable parameters and also a huge range of excitation frequencies is present. These frequencies are discussed in the series of theoretical and experimental studies below.

2. Theoretical frequency analysis

A system of two synchronous belts is analysed, which assure the longitudinal motion of a tooling system. The first belt serves for the power transmission from the motor to the main belt.

2.1 Analysis of the Transversal Vibrations

The eigenfrequencies of the transversal vibrations of the power transmission belt were determined considering the material properties, the free length of the belt between the pulleys and the tension force by means of Eq. (1), which gives the k-th transversal frequency of the belt. In Fig. 1 the result is shown for the first transversal frequency of the motor belt for different values of the tension force.

\[ \omega_k = \frac{k\pi}{L_3} \sqrt{\frac{k\pi}{L_3}^2 EI + S} \rho A. \]  

(1)

For the transversal oscillations of the belt also parametric instabilities can be found, see [1], [2], which is not analysed here.

![Fig. 1: First transversal frequency for various values of belt tension force](image)

The transversal oscillation frequency of the main belt can be computed using Eq. (1), which is a function of the position of the transported mass and hence the free length of the three parts of the belt.

2.2 Analysis of the Axial Vibrations

In order to determine the eigenfrequencies of the longitudinal vibrations of the transmission system a mechanical model consisting of the motor belt, main belt, guide rollers and moving mass was derived which results in a mechanical model with three masses, see Fig. 2.

Three eigenfrequencies of the system were calculated depending on the position of the moving mass considering a constant material property of the belt. The calculated eigenfrequencies are shown in Fig. 3 together with the other computed eigenfrequencies.
3. Experimental frequency analysis

In order to verify the theoretical assumptions a series of experimental tests were conducted to determine the axial and transversal frequencies of the analysed system. The frequencies of axial vibrations were determined for various positions and various constant velocities of the moving mass, see Fig. 4 and Fig. 5. The main excitation of the system comes from the distance between two consecutive teeth of the belts which can be included in a waterfall diagram where the variable and constant frequencies can be seen for various axial speed values. A good correlation with the theoretical results was observed.

4. Conclusion

Belt drives show a variety of different eigenfrequencies which are usually excited due to various axial speeds and the variable free length of the belts. Transient conditions prevent typical resonances and result in higher vibration amplitudes for specific system parameters.

5. Acknowledgements

The support of the authors E.C. Cojocaru, H.J. Holl and A. Brandl by the ACCM – Austrian Center of Competence in Mechatronics is gratefully acknowledged.

6. References