Frequency Regulation of the Clamping Plate in Dynamical Tests

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Abstract. Clamping plates used for fixing testing facilities or tested specimens during the dynamical test are in industrial practice suspended by pneumatic, steel or rubber spring. Those suspension systems cannot enable efficient change of natural frequencies during various operating conditions of the testing process. Insufficient natural frequency regulation may lead to unpredictable vibrations of clamping plates and, thus, improper testing results. Therefore, the paper describes a method and its application in the industrial practice of tuning the pneumatic suspension relatively quickly that generates a sufficient change of clamping plate natural frequency.

Keywords: Clamping Plate, Dynamical Testing, Pneumatic Suspension, Pneumatic Springs, Vibroisolation

1 Introduction

In industrial practice, the dynamic testing process is often realised through fixing testing facilities or testing specimens to clamping plates. To minimise transmission of dynamic loads originating from operation vibrations, clamping plates are suspended by pneumatic springs. Those suspension systems enable limited possibilities for setting the natural frequencies according to the current conditions of testing [1], [2]. Improper setting of the system's natural frequency may lead to unpredictable tilting or turning of clamping plates. The described situation may negatively affect the method as well as the results of testing [3], [4], [5]. Therefore, the paper describes the method and its application for a more accurate setting of natural frequencies according to various operating conditions.

2 Materials and Methods

Natural frequencies regulation for minimisation of undesirable tilting and turning of the clamping plate is designed by pressure regulation of pneumatic spring suspension in three sections. In each section, pneumatic springs are connected parallelly, which enables, together with proper pressure regulation, relatively quick stiffness change.

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According to Fig. 1, by changing the stiffness in one of the sections, the elasticity centre of the dynamical system may be shifted to the suitable position. Thus, the tilting or turning of the clamping plate may be suppressed [6], [7].

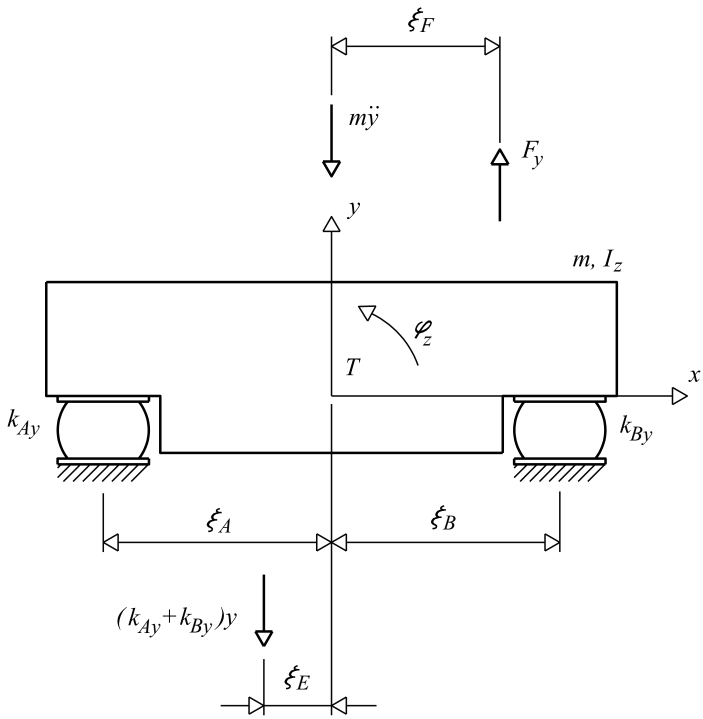

Fig. 1. Mechanical model - the shifting of the elasticity centre.

Fig. 1 describes the simplified mechanical model of the suspended clamping plate serviced in the supra-resonance frequency area. The clamping plate, with a mass m and a moment of inertia I_z to z-axis, is excited by a harmonic force:

$$F_y(t) = F_{y0}\sin\omega t \tag{1}$$

The harmonic force acts at a distance of ξ_F to the origin of the local coordinate system ξ, η, ζ.

The demanded position of the elasticity centre ξ_E may be calculated as:

$$\xi_E = \frac{k_{Ay}\xi_A + k_{By}\xi_B}{k_{Ay}+k_{By}} \tag{2}$$

For a specific example of the suspended clamping plate from industrial practice, amplitude-frequency characteristics of the dynamical system may be shown (see Fig. 2).

The clamping plate with a mass of $50\mathrm{T}$ was serviced in the supra-resonance frequency area with the dominant exciting force frequency of $11\mathrm{Hz}$. Fig. 2 shows the amplitude q_0 of clamping plate depending on the stiffness ratio k_{Ay}/k_{By}.

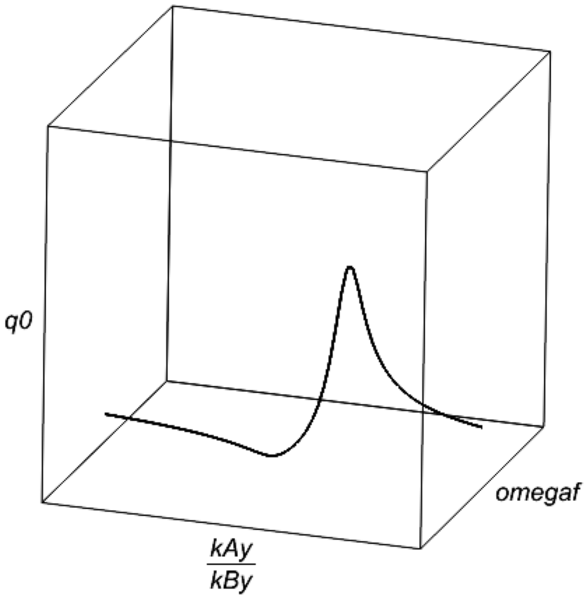

Fig. 2. Amplitude-frequency characteristics – tilting angle φ_z.

3 Results and Discussion

The clamping plate was installed in the automotive industry and was realised according to mentioned principles. The clamping plate was suspended by a set of parallelly connected pneumatic springs divided into three sections. These three sections disposed of separate regulation of pressure in pneumatic springs.

Fig. 3 shows realised pneumatic vibroisolation with natural frequency regulation of the clamping plate.

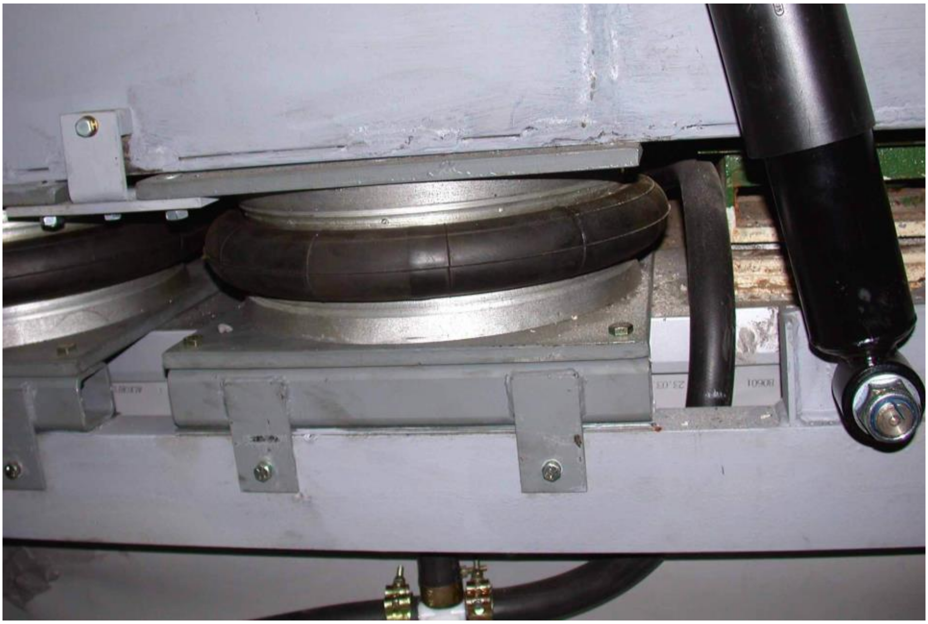

Fig. 3. Pneumatic vibroisolation with natural frequency regulation.

During the testing process, the operating deflection shapes of the clamping frame were measured. The result is visible in Fig. 4. Tilting of the clamping plate was sufficiently suppressed.

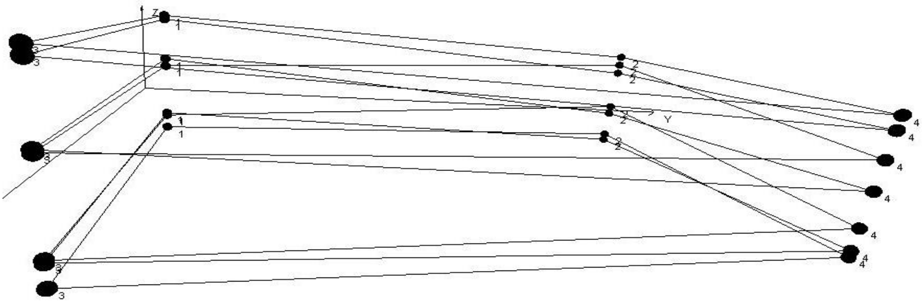

Fig. 4. Operating deflection shapes of the clamping plate.

4 Conclusions

The paper described the possibility of natural frequency regulation in pneumatically suspended clamping plates and, thus, the reduction of tilting and turning effects by various operating conditions.

The solution, based on parallelly connected pneumatic springs divided into three separately regulated sections, was verified in the automotive industry. Results of the clamping plate operating deflection shapes showed sufficient minimisation of tilting during the testing process.

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