PARTICULAR CASE STUDY OF DYNAMIC ABSORBER


Abstract: The paper presents a theoretical study on a crankshaft with five reduced masses having a dynamic absorber attached. The dynamic absorber is used for the reduction of the amplitude of the torsion vibrations of crankshafts. This paper does not present experimental results; these results will be presented in another paper, upon the completion of the experiment.

Key words: dynamic absorber, torsion vibrations, mass

1. INTRODUCTION

The paper presents a study on the effect of the dynamic absorber on the torsion vibrations produced in a mechanical system composed of reduced masses \( m_1, m_2, m_3, m_4 \) and \( m_5 \) subjected to a harmonic \( x \).

The dynamic absorber has the specific dimensions of \( L \), \( l \) and mass \( m \) is attached to the reduced mass \( m_5 \).

The necessary and sufficient condition for the most dangerous order \( x \) harmonica to be prevented from creating vibratory torsion movements is for the proper pulse of the dynamic absorber to equal to the pulses of the order \( x \) harmonica.

The paper contains the theoretical background and it does not contain experimental data. The experimental results will be presented in another paper, pending the experiment will have been completed.

2. MECHANICAL SYSTEM

This study presents a system with five reduced masses noted \( m_1, m_2, m_3, m_4, m_5 \) (Fig. 1.) which are connected through the reduced crankshaft and presenting the elastic constants \( c_{12}, c_{23}, c_{34}, c_{45}, c_{56} \).

3. EQUIVALENT SYSTEM

The dynamic absorber is replaced by a mechanical system of a reduced mass \( m_5 \) and the reduced crankshaft with an elastic constant of \( c_{12} \) (Fig. 2.) that is restricted to be dynamically equivalent to the dynamic absorber to be applied on the reduced mass \( m_5 \) and having the same momentum as the dynamic absorber.

Fig. 1. Mechanical system

Fig. 2. Equivalent mechanical system

\[ \begin{align*}
\Omega^2 &- \frac{c_{12}}{m_5} A_1 + \frac{c_{12}}{m_5} A_2 = 0 \\
\frac{c_{12}}{m_2} A_1 + &\left( \frac{c_{12}}{m_2} \frac{c_{12}}{m_3} \right) A_2 + \frac{c_{12}}{m_2} A_3 = 0 \\
\frac{c_{12}}{m_3} A_2 + &\left( \frac{c_{12}}{m_3} \frac{c_{12}}{m_4} + \frac{c_{12}}{m_4} \right) A_3 + \frac{c_{12}}{m_3} A_4 + \frac{c_{12}}{m_3} A_5 = -\frac{P}{m_2} \\
\frac{c_{12}}{m_4} A_3 + &\left( \frac{c_{12}}{m_4} \frac{c_{12}}{m_5} \right) A_4 + \frac{c_{12}}{m_4} A_5 = 0
\end{align*} \]

4. SOLUTION OF THE DIFFERENTIAL EQUATION

The expressions at the elongations \( a_i \) (i=1–6) for the torsion vibrations executed by the five reduced masses according to the amplitude \( A_i \) (i=1–6) of the same torsion vibrations are the following:

\[ a_i = A_i \cos (\Omega t + \phi) \quad i=1-6 \] (2)

The expressions (2) and the second time derivatives for the torsional vibration amplitudes are introduced in the differential equation system, and by simplification with the trigonometrical function \( \cos (\Omega t + \phi) \) we obtain the algebraic equation system (Bălcău & Arghir, 2009).

The system is:

\[ \begin{align*}
\left( \Omega^2 - \frac{c_{12}}{m_5} \right) A_1 + \frac{c_{12}}{m_5} A_2 = 0 \\
\frac{c_{12}}{m_2} A_1 + &\left( \frac{c_{12}}{m_2} \frac{c_{12}}{m_3} \right) A_2 + \frac{c_{12}}{m_2} A_3 = 0 \\
\frac{c_{12}}{m_3} A_2 + &\left( \frac{c_{12}}{m_3} \frac{c_{12}}{m_4} + \frac{c_{12}}{m_4} \right) A_3 + \frac{c_{12}}{m_3} A_4 + \frac{c_{12}}{m_3} A_5 = -\frac{P}{m_2} \\
\frac{c_{12}}{m_4} A_3 + &\left( \frac{c_{12}}{m_4} \frac{c_{12}}{m_5} \right) A_4 + \frac{c_{12}}{m_4} A_5 = 0
\end{align*} \]
\[ \frac{c_{ii}}{m_i} A_i + \left( \Omega^2 \frac{c_{ii}}{m_i} - \frac{c_{ii}}{m_j} \right) A_j + \frac{c_{ii}}{m_i} A_i = 0 \]  
\[ \frac{c_{ii}}{m_6} A_i + \left( \Omega^2 \frac{c_{ii}}{m_6} - \frac{c_{ii}}{m_4} \right) A_6 = 0 \]  
\[ (3) \]

The amplitudes of the torsion vibrations executed by the five reduced masses \( A_i \) (i=1~6) are provided by the expressions:
\[ A_i = \frac{A_1}{A_1} \]  
\[ \frac{A_1}{A_1} \]  
\[ (4) \]

therefore this is the solution of the equations system, where the determinants \( \Delta_i \) and \( \Delta_6 \) are obtained using the Cramer method used (Haddow & Shaw, 2002).

For the mechanical system formed of reduced mass \( m_i \) and the reduced crankshaft with the elastic constant \( c_{ii} \) to be dynamically equivalent with the dynamic absorber it is necessary and sufficient for the relations to be fulfilled (Bălăcu & Ripianu, 2008):
\[ m_s = m \left( \frac{L+1}{r^2} \right) \]  
\[ c_{ii} = m \left[ \frac{(L+1)^2}{r^2} - \frac{L}{1} \right] \]  
\[ (5) \]

Results that:
\[ \begin{align*}
\frac{c_{ii}}{m_4} = \frac{L}{1} \omega_4^2, \\
\frac{c_{ii}}{m_6} = \frac{m_4}{m_6} \frac{L}{1} \omega_6^2
\end{align*} \]  
\[ (6) \]

If the dynamic absorber is dimensioned in such a way that
\[ \frac{L}{1} = \omega^2 \]  
\[ (7) \]

and taking into account the conditions (3) that have to be met by the reduced mechanic system formed of the reduced mass \( m_i \) and the reduced crankshaft with the elastic constant \( c_{ii} \) to be dynamically equivalent with the dynamic absorber (Ripianu & Crăciun, 1999), the expressions of the six determinants \( \Delta_1, \Delta_2, \Delta_3, \Delta_4, \Delta_5, \Delta_6 \) become:
\[ \Delta_1 = -\frac{P}{m_3} \omega_{ii} \omega_{vi} \left( x^2 \omega_{ii}^2 - \omega_{iv}^2 \right) \]  
\[ + \frac{m_3 + m_6}{m_3} \omega_{ii} \omega_{vi} \left( x^2 - \frac{L}{1} \right) \omega_6^2 \]  
\[ (8) \]

then this device does not introduce a new resonance phenomena, irrespective of the order of the harmonica induced inside the mechanical system which caused the forced vibrations.

5. CONCLUSIONS


Bălăcu, M. & Ripianu, A. (2008), Case study of the mechanical system composed of four reduced masses that is subjected to a single harmonic \( \omega \) to which we attached one dynamic absorber, over upon the other mass then the given two harmonic \( \omega \), Acta Technica Napocensis, series Applied Mathematics and Mechanics, nr.51, vol.IV, pp. 99-106, ISSN 1221-5872.
