6104-85

INTRODUCTION

Vibration is extremely undesirable, but something that we come into contact with every day: steering wheels vibrate and affect our cars, washing machines vibrate when they are on spin, floors of workshops or offices vibrate in close proximity to large machines. The vibrations are annoying and unwelcome. They are also unwelcome because they have a detrimental effect on the elements of the equipment that produces the vibration. They also disturb and affect most things in their vicinity – load bearing structures, machines and personnel.
The solution to this is anti-vibration elements. These elements dampen the vibration, this ability is due to their elasticity and the incompressibilty of the rubber.

NATURAL FREQUENCY

Let's start by considering a system made up of a body of mass M supported by a base and connected to the surface above by a spring (fig. 1a).
Taking away the base the weight of the compoennts will extend the spring (= delta).
The difference in height between the intial and final position is called extension and can be expressed as:

$$\Delta = \frac{M * g}{K}$$

	= extension (m).
M	= mass of the part (Kg).
g	= acceleration of gravity (m/s2).
K	= strength of spring (N/m).

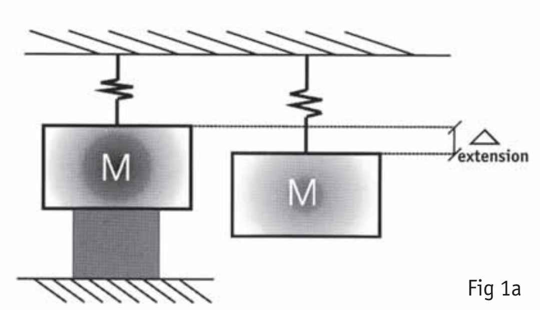

Fig 1a

Now let's consider the same part supported from underneath by an unloaded spring and then subjected to a force F.
As in the previous illustration the spring deforms this time it is compressed (fig.1b).

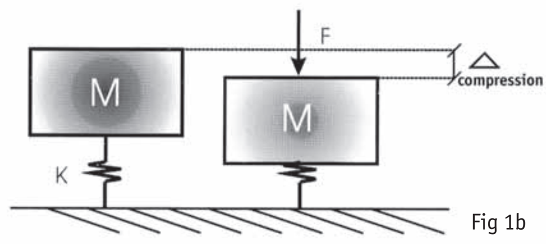

Fig 1b

Let's now suppose that the force F is removed and the system is left to freely osciliate:

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$$

indicates the number of cycles (oscillation) that the system will make in a unit time. This is called the natural frequency and represents the oscilation frequency in the absence of external forces.

RESONANCE

When the system mass, (as shown in fig. 1b) is supported by a sinusoidal force (F=Fsin Ωt) such as might be the case in a motor or other rotating application with angular velocity Ω this results in an equal and opposite action and begins to oscillate at the same frequency:

$$f = \frac{\Omega}{2\pi}$$

The maximum level of oscillation is reached when the frequency coincides with the natural frequency of the system:

$$f = f_0$$

This is the resonant frequency and is normally undesirable in that the level of oscillation compromises the functionality of the system and reduces its operating life. An appropriate choice of anti-vibration element added to the system resolves this by shifting the natural frequency to one outside of the functional range of the machine.

CHOOSING THE CORRECT ANTI-VIBRATION ELEMENT

To avoid any danger its necessary change the frequency in a way that removes it as far as possible from the natural frequency of the system. This can be done by using one or more anti-vibration element between the machine and the external environment. This can resolve problems of natural resonance, eliminate noise caused by vibration.
The cause of vibration needs to be understood taking into account the weight supported, the surroundings the system is in, and contact with corrrosive elements and particles. Then it is necessary to identify the centre of gravity of the machine to be able to isolate it symmetrically by the anti-vibration components.

Tel: 01483 286677 Fax: 01483 286678 Email: info@wixroyd.com Web: www.wixroyd.com

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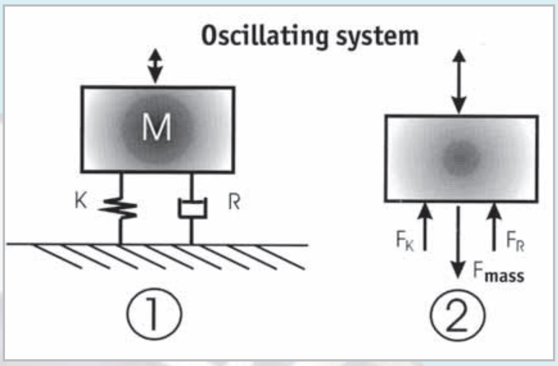
ANTI-VIBRATION ELEMENTS ADDED TO VIBRATING STRUCTURES

The following models represent a simple system:



Taking a body (mass M) subjected to a periodical stress over time, the action of the antivibration parts can be seen as the superimposition of the effect of a spring (K) and a viscous damping which opposes the oscilation in compression or extension.
Useful calculation formulae which are simplified for ease of use but will give realistic results.

The value K characterises the rigidity given by:

$$K = \frac{M * g}{\Delta}$$

The natural system frequency is given by:

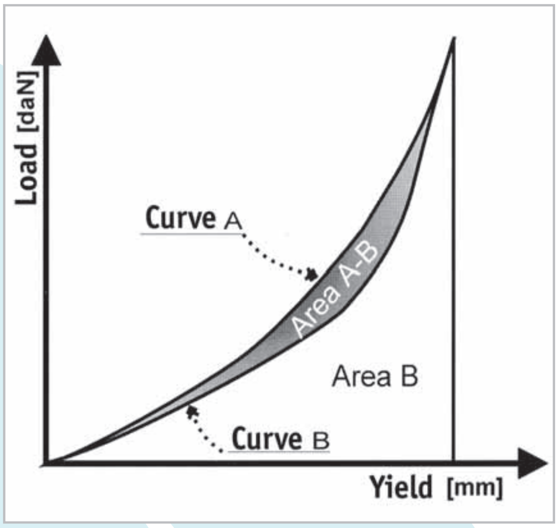
$$f_0 = \frac{1}{2\pi}\sqrt{\frac{g}{\Delta}}$$

With mm as units of measurement we can arrive at a useful approximation in relation to the compression with the natural frequency:

$$f_0 = \frac{15{,}7}{\sqrt{\Delta}}$$

$$(\pi = 3{,}14 \text{ e } \; g = 9{,}81 * 1000\left[\frac{mm}{s^2}\right]),$$

To transfer the formula into cycles/minute mutliply the frequency by 60.
These values are very approximate given the complexity of formula and calculations fundamental to anti-vibration calculations.



To understand we can take the hysteresis cycle of the rubber, indicated by the load curve (curve A) and then unload (curve B) the rubber resumes it's original shape without permanent deformation. This load/unload takes place each cycle up to high frequencies of 70-100 cycles per second (Hertz Hz).
The area under the curve A (area A) represents the work area under a load and the area B (area B) represents the work area under unload. The diference between the the two areas (A-B) shows the dampening function of the anti-vibration elements.
This formula indicates the dampening percentage in each cycle:

$$\frac{(\text{Area A - Area B})}{(\text{Area A})} * 100$$

The higher the dampening the beter the effect of the isolation resulting in major reductions in the amount of vibration.