General information on vibration technology

Demands on the design and operation of modern machinery and equipment continue to escalate. The technical capabilities of today's machines in terms of machining speed, dynamic load changes and achievable precision, as well as the key features of the geometry and the properties of the materials used have grown steadily over recent years. However, this also increases the need to reduce the transmitted vibrations and structure-borne noise. This concerns both the vibrations generated by machinery and equipment (source isolation), for example in metal-working machines, as well as machines being subject to vibrations (receiver isolation), e.g. in measuring machines. The importance of industrial safety regulations to protect people, buildings and the environment also continues to grow.

DEFINITION OF TERMS

Damping is the physical property of an isolator to remove energy of a vibrating system. This limits the vibrations to an acceptable level and converts mechanical energy into heat.

Isolation means the decoupling of disturbance forces and vibrations. This effect always works in both directions, that is from the machine to the environment as well as in the opposite direction.

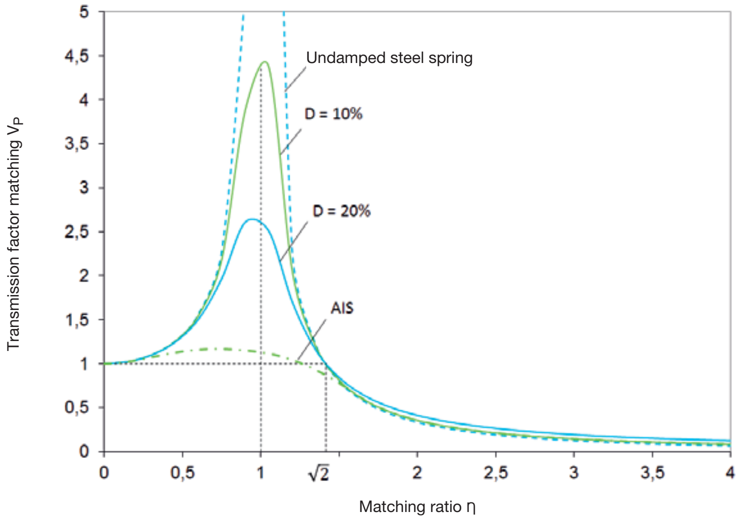
Source isolation is the vibration-isolated mounting of a machine in order to reduce its pulse or sinusoidal vibration forces. This protects objects in the environment such as adjacent machines, the building and people from the disturbing forces. The special task here is to keep the movement of the now elastically mounted machine within its operational limits.

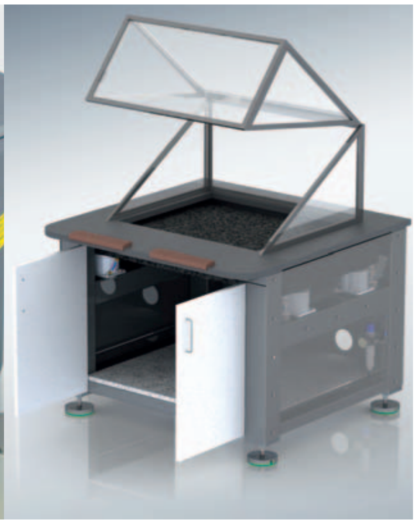
In the case of **receiver isolation** it is necessary to protect vibration-sensitive equipment (e.g. measuring machines) from disturbing ground vibrations. The production or characterization of ever smaller components, down to structures consisting of a few atoms or molecules, make heavy demands on facilities and their vibration isolation.

Passive vibration isolators exhibit upon excitation an amplification of the vibration amplitude in the range of the natural frequency. This resonance amplification is dependent on the damping characteristics of the isolators.

Active vibration isolators generate a counter-force phase-shifted by 180° through a suitable control; the isolators act as actuators. The resonance amplification in the natural frequency range of the isolators is minimized. An optimum isolating effect is achieved with frequencies above the resonance range.

Vibration control matching





Isolation of periodically excited vibrations
The effect of vibration isolation depends mainly on the ratio of the disturbance frequency or excitation frequency to the natural frequency of the isolator (matching ratio), and its damping ratio. With source isolation the excitation frequency is the machine speed or stroke rates, with receiver isolation it is the disturbing ground vibrations. Generally it can be said that the lower the natural frequency of the isolator the better the efficiency of the isolator, i.e., the larger the ratio of disturbing frequency is compared to the natural frequency. The resulting graph shows that an isolating effect only occurs when the value of the matching ratio is greater than $\sqrt{2}$. At smaller values an amplification (resonance magnification) of the disturbing force may also occur.

Transmission factor V_S of the vibration isolation without damping:

$$V_S = 1 - \frac{\eta^2 - 2}{\eta^2 - 1}$$

The transmission factor V_P taking into account the damping ratio D is:

$$V_P = \sqrt{\frac{1 + 4D^2\eta^2}{(1-\eta^2)^2 + 4D^2\eta^2}}$$

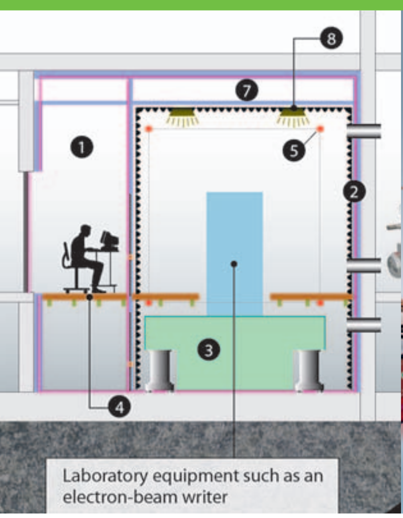
f_{dist} Disturbing or exciting frequency

f_0 Natural frequency of the isolator

$\eta = \frac{f_{dist}}{f_0}$ Matching ratio

Usually a matching ratio of between 3 and 4 is desirable, whereby 3 is considered the technical lower limit and 4 the economic upper limit. A matching ratio larger than 4 cannot normally be justified from the economic perspective because the material expense would increase above average compared to the degree of isolation.

ISOLATION OF SHOCK



Essential characteristics of shock are its duration, its distribution and its intensity.

With **shock isolation**, the dynamic disturbing pulse, consisting of a high power peak over a short period of time, generated e.g. by pressing, stamping or hammering, is changed to a longer lasting pulse with smaller forces.

Unlike intermittently induced vibrations, the isolated system oscillates at its natural frequency, not at the disturbing frequency, for example, the number of strokes. This can be compared with a tuning fork, which always produces a sound of a constant pitch.

Efficiency of shock isolation

$$J_S = 1 - \frac{f_{iso}}{f_{fix}}$$

f_{fix} Natural frequency of the system on its rigid-base foundation.

f_{iso} Natural frequency of the isolated system