Power Industry

Technical bulletin

T&D noise solutions

AMORIM CORK COMPOSITES

Vibration and Noise Control in T&D

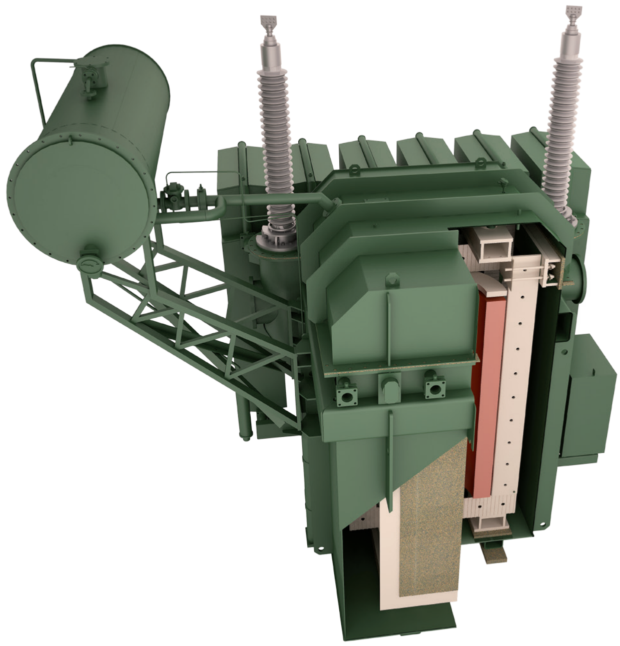
T&D industry trends and requirements have created high demand for low noise equipment with a good long-term performance. Amorim Cork Composites, as a worldwide supplier to the T&D Industry, has invested in R&D, established its VC (Vibration Control) product range and successfully implemented noise reduction solutions through vibration control.

It is very often said that "just putting some rubber" to isolate structures creates an inefficient or even a vibration isolation problem, that fails to take into account the characteristics of the overall system; such as media environment and temperature, material stiffness adjusted to the application load, surface area, material transmissibility, as well as pad design techniques, such as shape factor conformity - which is fundamental to ensure the selection of a good anti-vibration material and consequent noise reduction.

Through its experience in T&D applications, Amorim Cork Composites has implemented a priority 4-step system approach (fig.1) in analysis and treatment of "noisy" equipment. Our 4-step approach focuses on the need to control vibration before it reaches the tank structure (i.e. intervening closer to the source of the vibration), thereby preventing structural vibrations on the tank from being transformed into airborne noise through the amplitude vibration of the tank walls, acting as "speakers".

Typical noise reduction gains (cumulative gains) can also be observed in fig.1 when designing with ACC methodology (values based on project statistics).

fig.1



The noise paradigm

As T&D equipment becomes larger and more powerful, due to electrical grid complexity and natural energy sources, general tank construction relies on rigidity and stiffness to reduce the amplitude of vibrations that reach the tank wall, which are then released as airborne noise.

Whilst the increase of stiffness of the tank is achieved through the use of U-beams and profiles, this also increases the actual natural frequency (f_n) of the tank structure narrowing the gap between the disturbing frequency derived from the active part. The closeness of these two frequencies leads to an amplification in transmissibility and a consequent increase in noise.

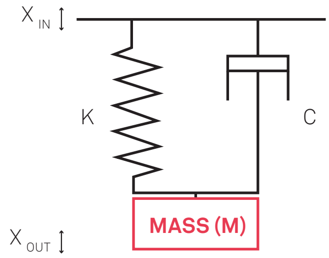
Though optimal mechanical construction is imperative for the equipment's functional characteristics, noise level restrictions now form part of utilities requirements due to demand from end consumers.

Vibration control basics

Natural Frequency

All anti-vibration pads/materials, components and systems have a natural frequency (f_n). In case of the anti-vibration pad, the natural frequency, f_n, is dependent upon the stiffness of the pad material, K, and the mass of the load that it is supporting (M).

In elastomeric materials the f_n is not only defined by the actual material but also by its thickness and shape (see shape factor). ACC has defined the natural frequency in various thicknesses under dynamic conditions for its materials.

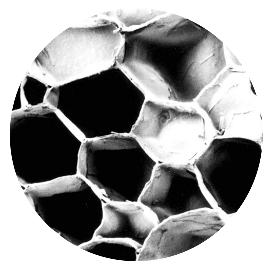


$$f_n = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$$

Damping

Damping is the dissipation of energy, usually by releasing it in the form of low-grade heat. The loss factor (η) quantifies the level of damping of a material. It is the ratio of energy dissipated from the system to the energy stored in the system for every cycle. The damping ratio (ζ) can be obtained from the loss factor, using the following expression $\eta = 2\zeta$.

Due to cork's closed cell structure, filled with air, cork has a higher loss factor than rubber, essential to the damping function and consequent dissipation of energy. Our specific polymer formulations and the inclusion of cork, with unique compressibility and recovery characteristics, absorbs energy, yielding high material loss factors.



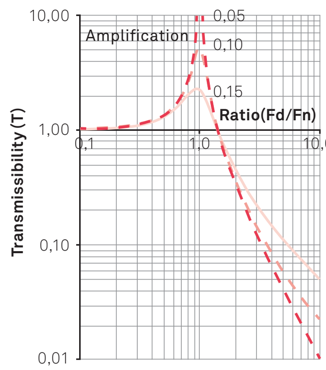
$$\eta \approx 2\,C/C_c \approx 2\zeta$$

Vibration Isolation

The performance of an isolation system is determined by the transmissibility of the system, the ratio of the Energy going into the system to the Energy coming out of the system. Vibration control design aims to place the system's disturbing frequency in the isolation region.

The amount of damping in the isolation system will determine the height of peak transmissibility (f_n) for the system. As damping increases, this peak value will decrease.

Amorim Vibration Control Materials exhibit significant material loss factors resulting in a lower amplification at resonance ($f_d = f_n$), giving them operational effectiveness over a broad range of frequencies.

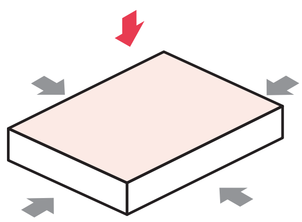


$$T = |A_{out}/A_{in}| = \sqrt{\frac{1+\left(2\zeta\, f_d/f_n\right)^2}{\left[1-\left(f_d/f_n\right)^2\right]^2+\left[2\zeta\, f_d/f_n\right]^2}}$$

Shape Factor

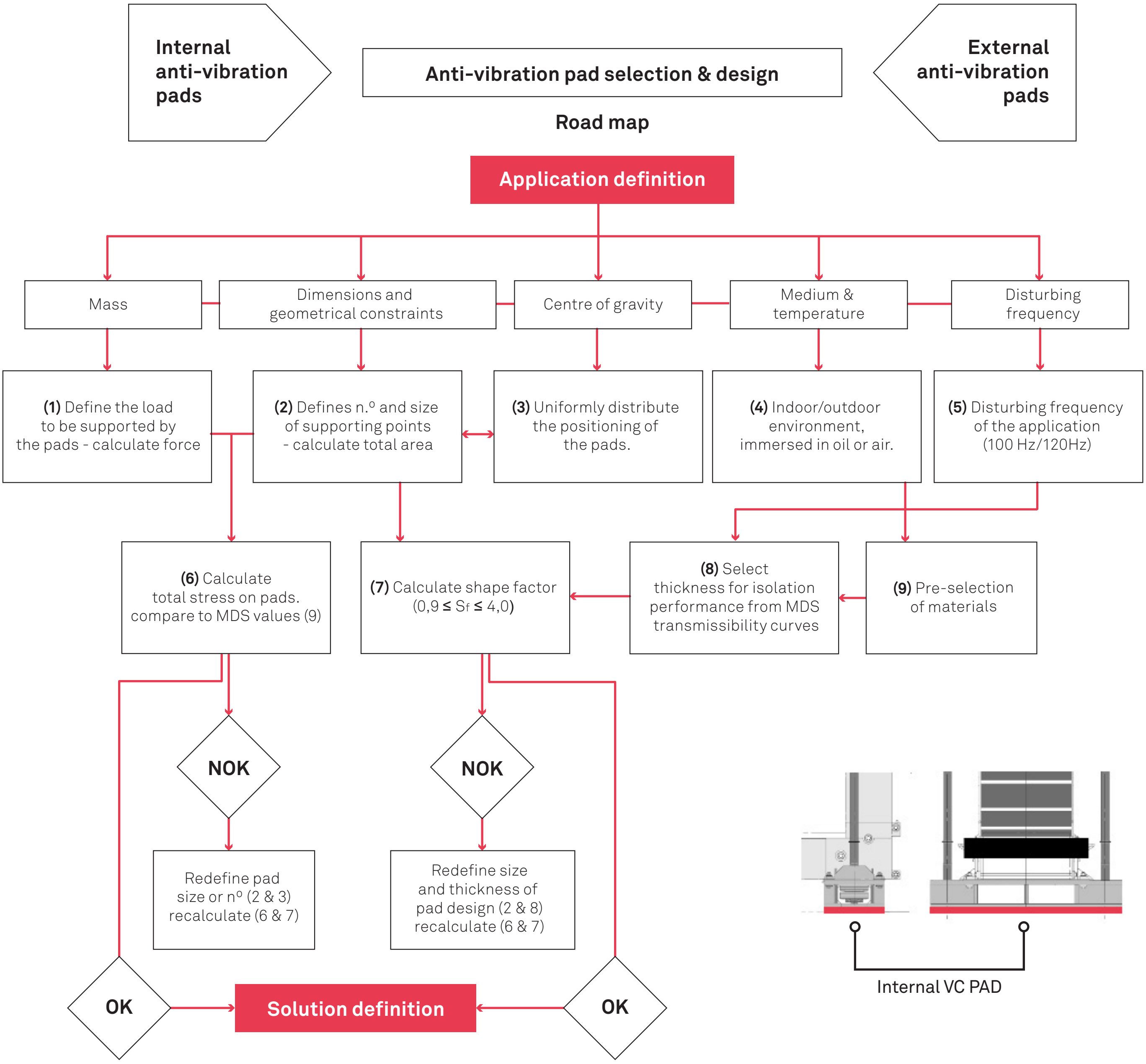
S_f is the geometric measure for the shape of an anti-vibration pad, defined by the ratio of the loaded area to the area of the sum of the perimeter surfaces. The correct design of the shape factor is important to achieve the correct stiffness.

While rubbers are considered incompressible, and require space to displace the compressed volume, cork rubber displaces much less volume due to cork's internal compression (lower Poisson ratio), allowing for a wider S_f tolerance, which in turn affects the robustness of the design.



Loaded area
Perimeter surface area

Design structure



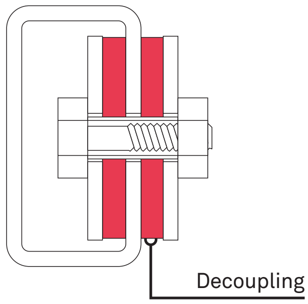
Internal VC PAD

Careful analysis of the system is crucial; extraordinary loadings should be taken in to account, such as oil mass, loads introduced through anchoring or significant connections that may impact the overall seating stress on the anti-vibration pad.

As rule of thumb whenever possible design for the lower end of the material stress range, to account for load variations and long term creep effects. Detailed information is available in our Data Sheets.

Design structure

Decoupling active part design — Road map



Core clamping mechanism

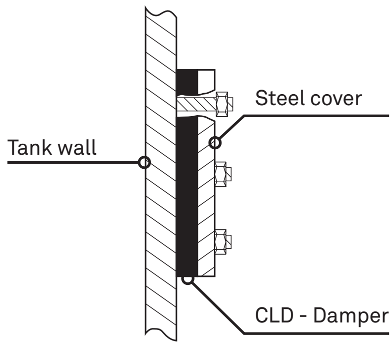
Identify all connection points between active part and tank

Evaluate loading on connections due to transport or assembly.

Redesign and implement decoupling material, eliminating steel/steel connections

Due to the fact that each manufacturer has a unique design and clamping requirements, which is then replicated throughout its product range, every design needs to be uniquely evaluated. The importance of adequate decoupling at the clamping points, significantly enhances the effectiveness of the interior vibration pads, preventing flanking paths from the active part to the tank structure. Amorim VC2100 is used for the decoupling function.

Structural damping design — Road map



Compressed layer damper (CLD)

Identity all tank wall areas with highest vibration amplitude/noise

Define CLD area in function of mechanical constraints, in approximately 50% of the wall area

Design clamping mechanism to compress the CLD nominally at 10%

Structural damping provides a means of converting mechanical energy (vibrations) in to low-grade heat, if correctly implemented it can significantly reduce noise.

Thickness of the CLD is defined by the tank wall. In an optimized design the CLD thickness should be similar to the tank wall thickness. If the wall is too thin it will have minimal effect, or no effect at all. It should be implemented in the interior wall. Amorim VC2100 is the selected material for the CLD

In equipment with a shunt wall, the current shunt wall can serve as the compressing element of the CLD against the interior tank wall. This construction will also reduce the vibrations that are passed on by the shunt wall to the tank structure, due to the loss currents from the active part.

ACC.794 | NOV 2017 | EN

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