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Optimization of non-collocated active spatial vibration absorbers

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Mechanical vibration is one of the common problems in many engineering applications. Passive and active absorbers are proven tools for their suppression. The disadvantage of simple passive absorbers is that they are limited to a narrow frequency band close to the natural frequency of the absorber. Moreover, due to the inherent damping and frictional forces in their elastic components, vibration suppression cannot be ideal. Improved results can be achieved if the mechanical properties of the absorber can be tuned ans significantly better performance can be achieved if the absorber is actively controlled. A typical example of an active vibration absorber is the delayed resonator (DR) concept proposed in the 1990s by N. Olgac and his co-workers [1]. It is based on the use of time-delayed feedback, which can be taken from position, velocity, acceleration, or a combination of these. Proper adjustment of the delayed feedback compensates for damping and changes in the stiffness of the mechanical part. Such an absorber has the properties of an ideal one.

The active vibration absorber is usually designed for a collocated absorption, where the location of the absorber is identical to the point whose vibration is to be suppressed. In the non-collocated case, the two locations differ from each other and finding the optimal absorber parameters is a more challenging task. The use of the DR concept for simple unidirectional non-collocated absorption is described in [2].

In most applications, absorbers are designed as single degree-of-freedom (DOF) systems absorbing vibration in one given direction, which is the most problematic in terms of vibration of the primary structure. Multiple such absorbers can be used simultaneously in different directions to suppress the spatial vibration of the flexible primary structure, Fig. 1. An interesting concept is to replace such a system of many single DOF absorbers by a single absorber with many DOFs [3], [4].

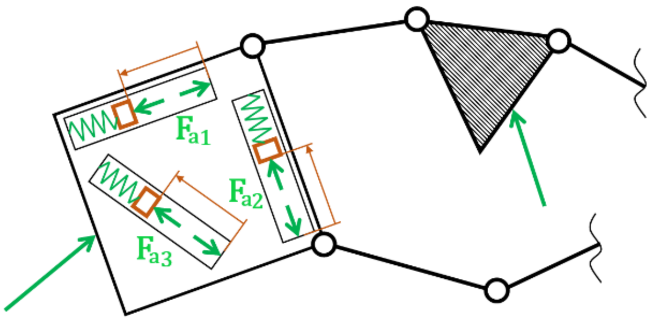

Fig. 1. Scheme of the set of single DOF absorbers attached to the primary mass

An important parameter of the absorber to optimise is its mass. It affects the amplitude of its oscillation and also the time required to reach steady state, i.e. to suppress the vibrations of the primary mass. As the mass of the absorber increases, its performance improves, but its energy requirements also increase. In the spatial case when using multiple single DOF absorbers, a separate mass for each direction is required. This clearly shows the advantage of using a single multi DOF absorber with only one mass.

In collocated absorption, the position of the absorber is determined, but in the non-collocated case, the coordinates of the absorber location on the primary mass are important optimization parameters that must be determined considering the excitation force, the position of the reference point and the mode to be suppressed.

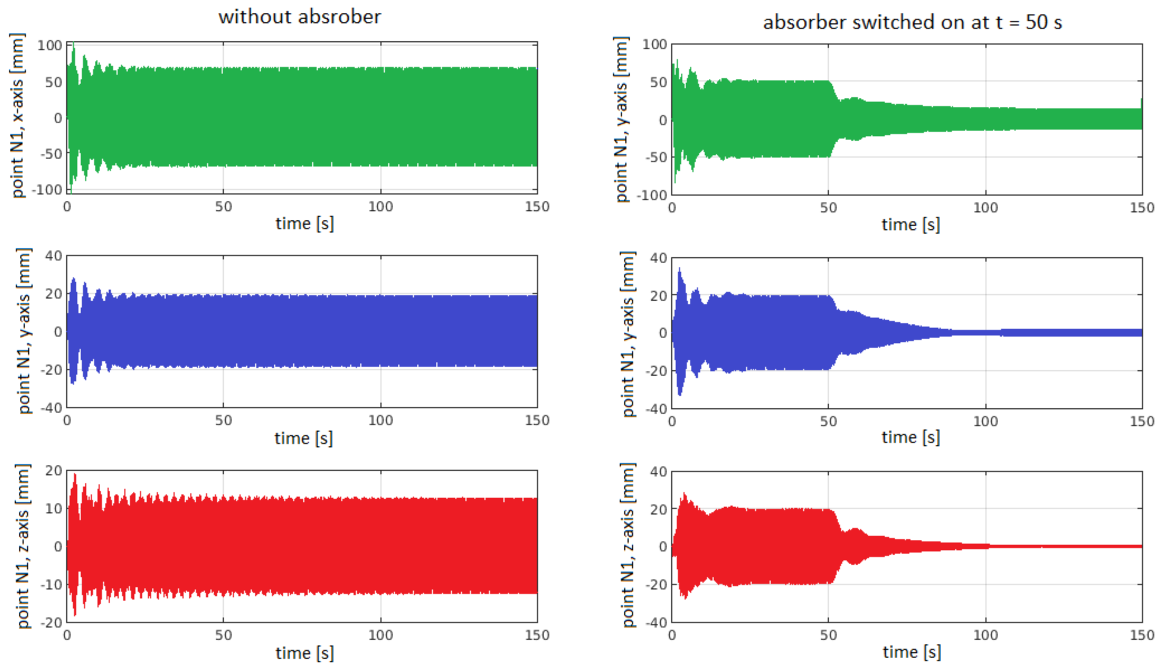

Fig. 2. Time response of the reference point to excitation by spatial periodic force without absorber (left) and with non-collocated absorber (right)

Fig. 2 shows the time response in the *x*, *y*, *z* directions of the reference point on a flexible frame when excited by a periodic force. In the left part of the figure is the waveform without absorber, in the right part with a non-collocated active multi DOF absorber switched on at time t = 50 s. It is seen that the use of the non-collocated absorber provides a significant reduction of vibration at the reference point.

Acknowledgement

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References

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