October 2016

TTM-05: The Importance of Anti-Vibration Mounts to Avoid Resonance in Fan Systems

1 Introduction

Structure-borne noise in building systems can lead to unwanted and unacceptable noise levels in commercial building applications. With this being the case, it is common practice for anti-vibration mounts (AVM) to be specified in the mounting of capital equipment in air-conditioning applications such as air handling units and chillers. The purpose of these devices is to isolate the vibration of the operating machinery from the building, reducing the structure-borne noise in the building system.

The selection of the AVM is critical, as an incorrectly specified product can be ineffective in its aim to reduce transmission of structure-borne noise, or cause the fan system to operate in resonance, leading to damage of the fan.

In this month's Technical Topic, we will look at the causes of resonance; the selection of AVM and a case study showing the effects of incorrectly selected AVM.

2 Resonance

Resonance occurs when a vibration or external force is applied to a system at its natural frequency (the resonant frequency), which causes the vibration to amplify.[1] A common example of this is the shattering of a crystal wineglass when exposed to a tone of the correct pitch; the wavelength of the sound excites the wineglass at its resonant frequency, causing it to vibrate then shatter. Resonance does not cause vibration; it simply amplifies it.

In fans, the speed of the fan is a source of excitation of vibration, and it follows that with higher speeds there are higher frequencies of system vibration. Given that the fan system has a resonant frequency, operating the fan at a speed corresponding to the resonant frequency will result in excessive vibration, which, over the course of time, can lead to structural damage to the fan.

The strategic design of fan systems is required such that the fan speed, and the vibration caused by the rotational speed, does not cause the system to operate in a region of resonance. ebm-papst fans can be rigidly mounted to solid bases without the need for AVM, and operation from 0-100% speed will not cause the fan to operate at a resonant frequency.

[1] Mobley, R. Keith (1999), Vibration Fundamentals Part III, Resonance and Critical Speed Analysis, Chapter 18 - Introduction, Newnes, Woburn, p. 201.

ebm-papst A&NZ Pty Ltd
ABN 33 115 927 556
10 Oxford Road · Laverton North VIC 3026 · Phone +61 (03) 9360 6400 · Fax +61 (03) 9360 6464
NSW Phone +61 (02) 9827 6400 · NSW Fax +61 (02) 9827 6464 · NZ Phone +64 (09) 525 0245 · NZ Fax +64 (09) 525 0246
sales@ebmpapst.com.au · www.ebmpapst.com.au

3 Selection of anti-vibration mounts

Where AVM are specified, their correct selection is crucial, as the addition of AVM changes the speed at which resonance occurs. The new resonant frequency is governed by the AVM selected, which is generally based on the isolation efficiency required, the spring deflection and fan operating speed range. When selecting AVM for use with fans it is imperative that the fan operating speed in the application is known so that a correct AVM selection can be made.

Figure 1 describes the rigid zone, resonant zone and flexible zone that are present in the operation of an AVM.

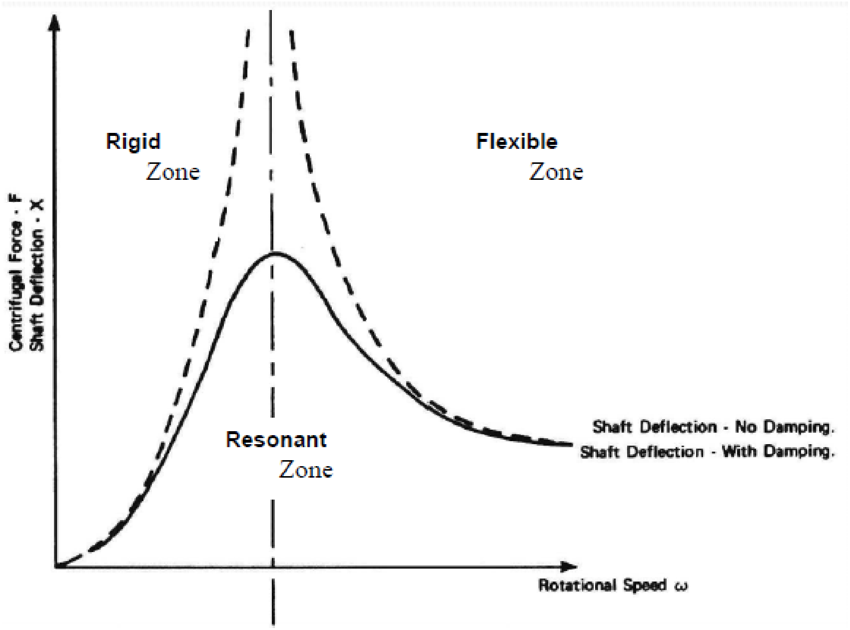

Figure 1: Rigid, flexible & resonant zones, *Fundamentals of Vibration Measurement and Analysis Explained*. Source: www.Lifetime-reliability.com, 25 October 2016.

AVM should be selected based on continuous operation in the flexible zone; it is here that vibration isolation is achieved. In the case of speed-controlled EC fans, it is important to take this into consideration, as operating the speed of the fan varies, and an incorrectly selected AVM could cause the fan to operate in the resonance region as the fan speeds up and slows down.

For fan systems operating at a speed in the rigid zone, there is no vibration isolation and the AVM has no effect.

4 Measuring vibration and vibration levels

The vibration level of the fan system can be measured through the use of a vibration transducer. ANSI/AMCA Standard 204-05 *Balance Quality and Vibration Levels for Fans* defines the suitable measurement locations as axial, vertical and horizontal. In any installation orientation, “measurement shall always be made in a radial direction and perpendicular to the axis of rotation.” In the case of a vertical reading, the measurement needs to be taken perpendicular to the axis of rotation and perpendicular to a horizontal reading. An axial vibration measurement need to be taken parallel to the shaft.   An axial measurement shall always be made parallel to the shaft (rotor) axis of rotation. An example of each vibration measurement point is shown in Figure 2.

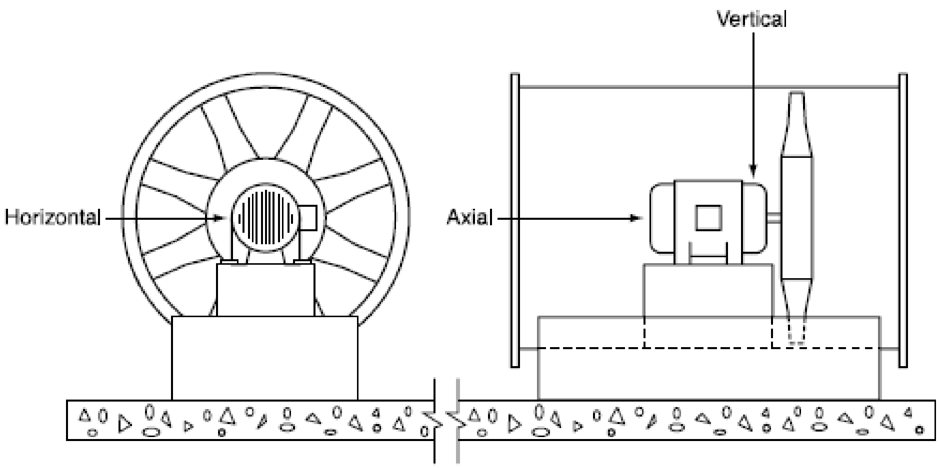

Figure 2: Axial, vertical and horizontal vibration measurement points, *ANSI/AMCA Standard 204-05 Balance Quality and Vibration Levels for Fans*, 21 October 2016.

The measurement of vibration at all three points is recommended to be undertaken across the full speed range to attain a complete picture of the vibration present in the application.

The balancing grade of ebm-papst RadiPac fans is G6.3 and therefore as per the standard ISO 14694 *Industrial fans -- Specifications for balance quality and vibration levels*, fan application BV-3 applies. For flexibly mounted fans, ebm-papst recommends vibration velocity levels of less than 3.5mm/s (RMS), in line with the BV-3 levels. For rigidly mounted fans, ebm-papst recommends vibration velocity levels of less than 2.8mm/s (RMS), in line with the BV-3 levels.

If the vibration levels are exceeded in any measurement orientation, it suggests that the fan is operating in resonance and selection of AVM or minimum fan speed need to be reconsidered.

5 Case study

The following case study from a building in Victoria illustrates the severe consequences of improper mounting of fans, and highlights the importance of selecting the correct AVM. An ebm-papst 630mm RadiPac fan was found to have damaged bearings after only 12 months of operation. Investigation and vibration measurements were undertaken on site to determine the cause.

On site it was found that the fan had been mounted with rubber mounts. The AVM manufacturer confirmed that these mounts have a minimum speed rating of 930rpm. Figure 3 shows on-site vibration measurements with the AVM installed.

The results from vibration testing of the fan using the incorrect AVM showed excessive vibration in the region of 45-50% of full speed, corresponding to 800rpm (purple curve), exceeding the recommended BV-3 level.

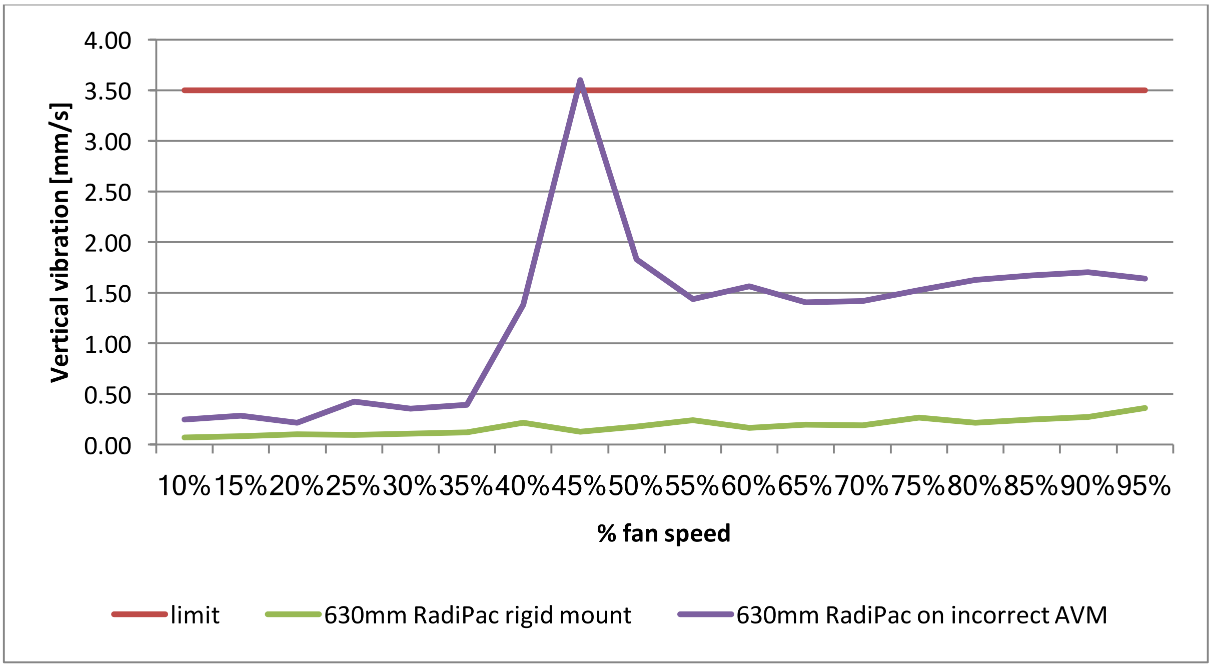

Figure 3: Radial vibration vs fan speed, as measured on site installed in application, before and after removal of AVM.

The same model fan was installed and tested using rigid mounts at the base of an air-handling unit. Vibration of the fan was measured in this instance, and the green comparison curve is shown in Figure 3.

The test results highlight the effect of the AVM used in this application, particularly its similarity in shape to the theoretical curve shown in Figure 1. We can see the rigid zone in effect from stationary to 35% of full speed, a resonance zone of operation between 40% and 50%, and vibration isolation in the flexible zone between 55% and full speed.

The recommendation made to the end user was to limit the fan speed such that it would not operate below 55% of full speed, in accordance with the client's requirements. This way vibration isolation is achieved, and the fan will not operate in the resonant zone. If lower fan speeds are required, the AVM would need to be reselected to allow a lower minimum speed.

6 Conclusion

In closing, the selection of AVM for use with fan systems is a simple process given the operating parameters are understood. Premature fan failure can be avoided through the use of correct AVM and avoiding fan operation at speeds within the resonance zone.

For more information on the correct selection of AVM for your fan installation, or any other inquiries, please contact your ebm-papst A&NZ representative.