RESONANCE -The Hidden Threat

Text: Adash Ltd.

You have done proper balancing (twice for sure), you have done alignment, you have checked the mountings and your machine is still vibrating like an old washing machine for no obvious reason... The reason is probably resonance.



MECHANICAL RESONANCE is the tendency of a mechanical system to respond at a greater amplitude when the frequency of its oscillations matches the system's natural vibration frequency than it does at other frequencies.

For every mechanical object, there are natural frequencies at which that object vibrates more easily and harder than at other frequencies.

You can see this in everyday life. For example, there might be something in your car that does not vibrate very much, but if you make a small change in engine RPM, you can hear much stronger vibrations.

This is an example of where the engine RPM is near the natural frequency of the thing that is vibrating.

It is very dangerous to operate machines near their natural frequencies because even a small unbalance can generate extremely high vibrations. This can destroy the machine very easily.

We usually encounter the resonance problem on the machine foundation. When the machine speed is near the natural frequency, then we measure high vibrations without a visible reason. The maintenance team usually carries out all the standard procedures like balancing, alignment and bearing mounting checks but vibrations still remain high. The resonance problem is the reason.

Now I would like to describe to you how to use the bump test measurement. It is the perfect measurement for situations where you suspect a resonance problem. We used a steel beam for this simple demonstration. Imagine that it is a machine foundation.

We used a standard 100 mV/g accelerometer and a hammer.

The Adash VA4Pro and VA5Pro vibration analyzers contain a super easy bump test mode. There is no need for any settings. Just place the sensor on the object to be measured and hit it with a hammer.

Let's look at the final graph. [1]

High peaks on the spectrum represent natural frequencies, in our case 100 Hz and 280 Hz. There will be a resonance problem if the machine speed is near these two frequencies.

We can move the natural frequency to solve the problem by reinforcing the construction in order to change the natural frequency. For example, we could add another pillar in the middle and the natural frequencies will decrease. [2]

A fixed pillar would be welded to the machine foundation in

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Graph 1: initial spectrum



Graph 2: changed spectrum

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Figure 1. Every mechanical object has its mode shapes.

Figure 2. The length of each arrow is proportional to the g value at that point.



Figure 4. Second natural frequency.

the real world and natural frequencies would not only be reduced but also re-tuned.

Every mechanical object has its mode shapes. I will explain it on this simple free beam (Figure 1).

The first mode shape is this: we can see two nodes and three anti nodes. The next mode shapes have more nodes and more anti nodes. But for now, we will only consider the first one, whose natural frequency is the lowest natural frequency from the measured graph. We marked several points on our steel beam and measured the amplitude on each mark.

The length of each arrow is proportional to the g value at that point. Now you can see the first mode shape, which we have got from real measurements (Figure 2). For simple objects you can calculate the mode shapes, but for a complicated construction it is not possible, you have to measure it.

We analyzed the frame by hitting it with hammer. When the machine is operating, you can also measure the vibration levels at every point. In this case the frame is not excited by the hammer but by operational speed. The vibration levels will not be the same on all points of



the machine. Measure all of them and draw the arrows again, you will get the first operational deflection shape of the machine. For finding the next operational deflection shapes, you have to know the spectrum of vibration on each point. Knowing the machine shapes is important for machine understanding.

The ADASH analyzers contain the ADS mode. It enables you to measure these shapes very simply and then illustratively animate the results.

In the next example I show you why it is important to know the mode shapes which are the cause of the vibration problem. We used the shaker and the rubber cord. The first natural frequency is 10 Hz and you can see the first mode shape (Figure 3).

If I need to decrease the vibration level, then I can add the pillar to many places and it will work.

But sometimes the second mode shape could be the problem rather than the first. Now you can see the second natural frequency (Figure 4).

The location of the pillar is now much more important. If I add it in the middle, then the vibration remains unchanged.

Back to our first example with the steel beam. Initial overall vibration was 6.34 g. We added a pillar in the middle and the main natural frequency on 100 Hz decreased approximately 4 times. But the second natural frequency on 280 Hz decreased only about 2 times and now is influencing our frame almost as much as the first frequency. The overall vibration is now 3.19 g.

Then we moved the pillar from the middle to 1/3 of the way between the end pillars. The new natural frequencies look like this. [3]

You can see that the first frequency remained the same, but the second was more reduced.

Overall vibration decreased to 2.56 g.



Graph 3: final spectrum

