



Machining

What Is Vibration Analysis? A Calculated Approach to Chatter

Vanessa Jo Roberts | Feb 21, 2020

Vibration is a byproduct of the rotating tools common in milling. But excessive vibration leads to chatter, which causes wear on tools and machines—and worse can result in poor-quality parts and excessive cycle times. Here's an overview of the elements involved in vibration analysis to eliminate chatter.

If you work in manufacturing, you know about vibration—mainly that excessive vibration is not good for the milling machines on the shop floor or the parts being produced. In fact, machinists spend a lot of time attempting to eliminate chatter caused by vibration.

“Chatter may cause fast wear of tools and poor surface quality of the workpieces at high cutting speed, and it will happen on different process parameters,” notes research published in *The International Journal of Advanced Manufacturing Technology*.

Typically, machinists turn to trial-and-error tactics, spending anywhere from half to an entire work shift to determine the ideal setup for a job on a CNC milling machine.

To achieve the optimal setup and eliminate chatter—that increasingly louder screech that indicates an unsmooth cut—machinists might reduce speed, adjust feed rates, try varying axial and radial depths of cut, and even replace tools.

Why? To determine how to produce a part at the optimal operating level because that not only extends tool life, it ultimately lets a business produce more high-quality parts more quickly.

When the tool setup on a CNC machine is running in a stable manner, it's akin to running a hot knife through butter: swift, quiet and clean.

In limited instances right now, machining teams try to measure and analyze the frequency of vibration between the workpiece and the cutting tool, and to track the data across setups and machines. The time savings can be significant, but unlike the use of *vibration analysis for planning preventive and predictive maintenance of industrial machinery*, it's fairly uncommon in machining and, most specifically, milling.

Read more: Good Vibrations: How to Optimize Your Machine Setups to Minimize Chatter

What is Vibration Analysis, and Why Does It Matter on the Shop Floor?

Clearly, eliminating vibration can lead to more effective and efficient milling operations. That means a business's machinists can produce more good parts, reduce scrap rates and drive up profitability.

That's where vibration analysis comes in. Vibration analysis is essentially the gathering of information about vibration that can enable the identification of optimal, stable speeds and feeds when machining parts.

"Vibration analysis can be our ears for deciphering the language of machines, and can help us determine where to focus resources," according to an *article on Manufacturing.net*.

It's rather like measuring the health of your milling assembly, which is the unique response of the machine spindle, the toolholder and the milling cutter. The greater the vibration and chatter, the sicker your milling assembly and the more dire the need for adjustment in speed and feed to perfect your parts and to protect your setup from failure.

There are a few ways that vibration can drive up costs for a business. First, there's the potential for spindle failure. *Repairing spindles* can run from a few hundred dollars to several thousand, and replacing them can run into the tens of thousands. In many cases, this can pale in comparison to the cost of a machine that's not producing parts. Plus, ultimately machines running subpar wear out more quickly than those that run chatter-free.

"Monitoring the condition of cutting tools in any machining operation is very important to avoid unexpected machining trouble and improve machining accuracy," notes research in the *International Journal of Production Research*.

Think about it as you would an overloaded washing machine: If your washer runs out of balance continually, its parts will begin to wear and the machine will break down more quickly than it otherwise might. Adjusting the wash load to achieve stability would increase the opportunity for optimal speed to finish a cycle, plus allow the machine to last much longer.



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The Four Principles of Vibration Analysis

Essentially, vibration (data gathered using sensors and accelerometers) is converted into electrical charge and measured as a signal. Vibration analysis compares and provides insights based on measurements of vibration frequency, displacement, velocity and acceleration.

Then, four principles allow for representing and comparing the signal data gathered from your machining setup. Those four principles are time domain, frequency domain, joint domain and modal analysis.

“Each domain provides specific information on the working conditions and features of the vibrating part,” explains *ScienceDirect*.

What is time domain?

A signal travels as a wave. The time domain is simply how that wave changes over time—its amplitude.

“While most machine vibration issues are detected using spectrum analysis, some types are more easily seen in waveform,” explains an *article in Reliable Plant magazine*.

But it can be hard to use time domain information to identify where the amplitudes happen and so isolate and calibrate your machine appropriately.

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What is frequency domain?

In contrast to time domain, frequency looks specifically at the waves at set points—and how the amplitude of the wave changes at those distinct points, or frequencies.

“When displacement, velocity and acceleration amplitudes are expressed in the frequency domain—that is, amplitude versus frequency—abnormalities, in the form of high amplitudes at certain frequencies, become visible,” explains engineer Danielle Collins in an ***article for Motion Control Tips***. “And because many vibration-related issues occur at specific frequencies, the cause and location of the vibration can be narrowed down or identified based on variations in amplitude at certain frequencies.”

What is joint domain?

Joint domain is just what it sounds like: It pairs time and frequency domains to address the fact that vibration analysis involves the study of nonstationary items.

What is modal analysis?

Modal analysis defines the natural frequencies of vibration based on the structural materials of the setup, the machine and the workpiece. It creates the baseline against which the vibration analysis can pinpoint when and to what extreme a tool setup and machine are outside the desired calibration for the specific job.

Ultimately, the goal of these analyses is to identify the stable speed for a specific project using a specific setup on a specific machine.

Are your toolholders prompting chatter on your high-performance machines? Read our article on selecting the right toolholders to find out.

How do your machinists manage chatter? What approaches have you found most successful? Share your thoughts in the comments below.