Measuring, Stopping and Preventing Vibration in Microscopes and Other Laboratory Equipment

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Vibration in microscopes may seem a bit baffling, but we have found that solutions to vibration problems are usually quite simple. Vibration is the result of an object being moved until it collides with another object and bounces back. Yes, it can be as simple as shaking, but the normal definition involves collisions. Some source must continuously supply energy to the moving part(s). As long as energy is supplied to the moving part(s) and the part(s) collide, bouncing can occur at a constant frequency. If the parts can be moved so they do not collide, or if the energy can be absorbed, the frequency of the bouncing can be changed or stopped. While it can be useful to know the frequency of the vibrations, we really want to know the source. Eliminate the source, or absorb the energy it is transferring, and we can stop the vibrations.

In the mid 1980's we had the privilege of having dinner with Mr. Pickering, who manufactured a very popular, magnetic phonograph cartridge. He gave a talk at that dinner. His talk was about violins and how they are made. He had made a violin that closely duplicated a Stradivarius by measuring the different resonant points of a Stradivarius with one of his magnetic cartridges. He then adjusted his violin until he duplicated those resonant points.

When we encountered vibrations the sources of which we could not identify, we decided to use a tonearm and cartridge to see if we could isolate the sources. We found that using a tonearm/cartridge with a hi-fi amplifier allowed us to hear the vibrations, and as we made changes we could hear the effects of those changes. We took it one step further by monitoring the output of the amplifier with an oscilloscope and frequency counter. These tools made it possible for us to see different frequencies and their associated levels. Of course, there were those cases when one over-powering frequency masked the others but quite often one quick measurement helped us solve the problem. Turning one machine off at a time until the vibrations disappeared from the scope solved most of the problems.

One can mount the tonearm on a ring stand allowing it to float. Rest the stylus on the surface in question, feed the output of the stylus to any hi-fi amp capable of handling a magnetic cartridge, put on the headphones and start the investigation. Many times we found the source of vibrations by touching or leaning against surfaces while listening or viewing the oscilloscope patterns. Not much headway was made by monitoring the frequencies. Frequency measurement can be vague because the frequency you are trying to isolate may be a harmonic of the source frequency. The scope patterns usually looked quite vague. However, as we touched or leaned we could see the patterns change and we used those changes as a guide.

We do not believe the problems encountered in microscopes are difficult.

How do we stop the vibration? The best way is to prevent the collisions, but that is almost always impossible, so we must steal the energy from the parts that are in motion. Moving them might help, but it is not very convenient. Sometimes fastening them together so they vibrate as a unit will help. There are some very simple techniques that can help. The first thing to do is install cushions so the moving part does not collide with any other part. Buildings vibrate due to all of the HVAC equipment, power transformers, water lines, steam lines, etc. If you can hear it, it is vibrating. We have a confocal microscope sitting on an old desk. We put chalkboard erasers under the feet of the desk to isolate it from the building's vibrations. One can also use tennis balls, air bags, shock absorbing packaging material etc. There is rarely a need to get too hi-tech.

In other cases, the instrument is in contact with the source of vibration through cooling lines, vacuum systems, air supplies and the like. In those cases one can run the suspect line through a bucket filled with sand or simply sandwich the lines between two bags of sand (Play sand is a $1.00 per bag). If a fan is causing the vibrations, move it if possible or change its mounting hardware.

Electronic equipment vibrates and can cause problems, but most of the vibration in newer electronic equipment is so high in frequency that it probably would not affect optics. The vibrations that will affect optics are probably in the 100 Hertz range and most probably 60 Hertz. During the process of elimination, it would be prudent to turn off electronics associated with the system. Do not overlook the fact that transformers are rigidly attached to equipment and all transformers vibrate, so they can be a source of trouble. Stepping motors used to move stages vibrate, and some can even vibrate when they are stopped and in the braking mode. Laser power supplies can vibrate, as well as solenoids on shutters, discharge lamp power supplies, external disc drives, and so on.

In conclusion, we can say the tonearm/cartridge is a cute tool for measuring vibration, but the real trick is finding the source. If you see vibrations of 10 kHz on the case of your instrument what does that tell you? We don't know. If you see 60 Hz on the case it does not really tell you very much because that is, in most cases, the frequency of the supply voltage in the building. Look at the measurement as if to say there is some vibration and can we change it. Those of you with problems have to make your best guess at what you think the source is, and then try simple changes to see if they have an effect.

Some common sources:

Fans: Fan blades are constantly being thrust against their bearings so they tend to bounce. While it seems like the air is moving smoothly, it can be pulsating. If a fan is mounted on the instrument you can buffer it or move it away using flexible ductwork.

Cooling water: Cooling water is circulated with pumps. At regular intervals the pumps collide with the water and push it through the lines in pulses lovingly known as shock waves. Shock waves transfer the pounding of the pump to the line, and since the lines are attached to the instrument, the pounding is transferred too and causes vibration problems. If metal pipes are used to connect the system to the cooling water, rubber hose can be substituted for a small section of pipe, or the sand bag trick can be used.

Building vibration: They all do it. Isolate the table from the floor.

Electronic equipment: Normal mechanical isolation is in order or you can use room temperature vulcanizing (RTV) to hold parts in place. Not only will it hold the parts in place, but also its elastic properties will help to absorb the nasty energy of vibration. ■

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