Vibration control

Whether it's everyday gear backlash or an unexpected shock load, vibration is a fact of life for modern motion systems. In this forum, *Motion System Design* editors speak with two industry experts about the best ways to confront system vibration — and keep it to a minimum.

Meet the experts

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HOW DOES VIBRATION CONTROL — OR LACK THEREOF — AFFECT PRODUCTIVITY AND THROUGHPUT IN INDUSTRIAL MOTION SYSTEMS?

Jeff • Enidine: Vibration control affects productivity through its impact on the accuracy and repeatability of manufactured parts. Motion within a machine will inherently excite the natural frequencies of its components and the part being manufactured. These natural frequencies will lead to unwanted relative motions. Imagine a controlled conveyor moving parts into a delicate wafer-handling system. A force is generated when the part is stopped in the desired location. This force has the possibility of exciting natural frequencies in both the machine and the part itself.

If speed is increased in an effort to increase throughput, then the force required to stop the part must also increase, leading to greater relative motion. The relative motion created this way by inherently non-rigid systems limits the accuracy and repeatability of a motion control system. This may also force a part in production to dwell at a given location to allow these relative motions to decay. The same mechanism is at work in larger systems as well, such as heavy punch presses.

David • Lord Corp.: Vibration can affect productivity in a number of ways. Not only are machines and foundations adversely impacted by vibration, but also humans and their productivity.

Controlling unwanted vibration in high-speed grinding, for instance, or the chatter of a cutting bit not only allows for faster operations, but also achieves greater accuracy. As the vibration is reduced, more and better parts start coming off the line.

Large punch presses designed to produce high-volume precision parts at low cost, such as aluminum beverage can production, benefit greatly from reduced vibration. At rates of 450 CPM, for example, any unwanted vibration can cause the machine to produce scrap, at a very high rate. Controlling the vibration, such as the ram motion, can allow the press to run at even

Vibration education

Would you like to learn more about practical vibration technology? The 2007 National Technical Training Symposium, the Vibration Institute's 31st annual meeting, will be held June 19-22 in San Antonio. Sessions will focus on bearing and gear analysis, machine diagnostics and case histories, modal analysis, rotor dynamics and case histories, field balancing, predictive maintenance, and much more. For more information, visit vibinst.org.

faster speeds, thereby improving productivity.

Man/machine interface is another area where controlling vibration pays off. Exposure to vibrations generated by operating equipment — from handheld pneumatic tools and jackhammers to vehicles such as dozers and class 8 trucks — can have negative effects on operator health and productivity. The exposure a human can have to vibration is time-limited; the higher the vibration, the shorter the operating time. This relates to decreased productivity, as well as operator fatigue.

WHAT ARE THE MAIN CHALLENGES IN OVERCOMING VIBRATION AND WHAT ARE SOME OF THE ADVANTAGES AND DISADVANTAGES TO DEALING WITH VIBRATION EITHER BEFORE OR AFTER IT HAS OCCURRED?

Jeff • Enidine: Careful design of a motion control system can address relative motions early in the design stage. Computing a system's natural frequencies can be accomplished with many finite element packages, but the real challenge is to account for damping in the system. These values tend to be non-linear and difficult to predict.

Empirical measurement and monitoring of existing systems provide actual in-situ machine vibration levels. However, modifications to existing systems can be costly. One approach is to design vibration control elements into a system during the early design stages. These vibration control elements can then be modified or eliminated during system checkout. The key is to reserve space early in the design process for motion control elements.

To control vibrations in an existing system, a number of motion control devices and approaches can be used. Active vibration control measures problematic vibrations, and then applies an equal — but out of phase — frequency force to cancel or minimize the vibration. Passive vibration control absorbs or attenuates vibrations by using products such as shock absorbers and vibration isolation mounts.

David • Lord Corp.: In most passive systems, the major challenges come from a tradeoff of isolation versus allowable motion. To gain higher levels of isolation, softer suspensions are required, but with softer systems come increased motions. Most applications have a limited package and space envelope.

Also, the consideration that the suspension system is merely moving the vibration to a frequency of less concern can be an issue. Damping may be required to minimize motion at the natural frequency of the system, but the introduction of damping also causes an increase in the transmitted vibration.

Semi-active systems allow the benefits of damping at the system's natural frequency, while also maintaining isolation comparable to an undamped system. This is accomplished through the use of a controllable damping device, like those used in seat dampers, for example. In this case, a controllable damper using magneto-rheological fluid is driven via an electronic controller. Sensors are used to determine the level of damping when it's required.

DESCRIBE A SCENARIO OF HOW DESIGNERS WILL SOMEDAY EMPLOY VIBRATION CONTROL TECHNOLOGY BEYOND WHAT'S POSSIBLE TODAY AND SOME OF THE ASSOCIATED BENEFITS.

Jeff • Enidine: As vibration is minimized, system accuracy and repeatability will increase. Positioning a part accurately without dwelling to let the part settle will increase throughput. One day, active materials will allow the performance of vibration control elements to be adjusted automatically within a system. Designers will simply employ a "black box" vibration control mechanism at critical system interfaces. These black box systems will identify incoming vibrations and automatically adjust their performance to control the vibrations. These systems will also be linked to provide motion control on a system level or factory level basis.

David • Lord Corp.: As technology advances due to new materials, smaller sensors, efficient power sources, and improved actuators — all at lower cost — vibration control systems will become commonplace in all aspects of motion and vibration control. Practical ways of converting energy dissipation into usable energy rather than heat, or designing a prosthetic joint to rival a biological joint, will be possible. Technology driven from the benefits of current vibration control will enable this to happen.

For more information on vibration control, visit motionsystemdesign.com's Knowledge FAQtory and look for links that will connect you to content related to minimizing vibration.

DBO ✔list

✔ Efficiency results from many components working well together

✔ In a motion system, efficiency begins with the motor, but also includes interface, drive, and control dynamics

✔ Think about loss points during the motor's conversion of electrical power to mechanical energy

✔ Try to reduce iron losses and resistance losses

✔ Optimize cooling fans to reduce friction and winding losses

✔ "Right size" the motor to fit the application; 55% of all motors are oversized

✔ Motors should run at 80 to 100% of full load to reach peak efficiency

✔ Use adjustable speed drives for variable torque loads, rather than a fixed speed, on/off drive

✔ Think about digital drives with flexible modulation schemes to reduce current ripple

✔ For efficient commutation at high speeds, use field-oriented control instead of sinusoidal commutation

✔ At lower speeds, sinusoidal drives are probably more efficient

✔ Tune your system correctly; excess vibration uses more energy

✔ System stiffness is your friend; resonance, your enemy

✔ Proper lubrication can increase the efficiency of just about any mechanical motion component

✔ Replace V-belts with synchronous belts and sprockets, or with cogged belts