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Excellence in Vibration Monitoring

Vibration monitoring for pharmaceutical manufacturers

Accurate data capture is essential as part of a predictive maintenance plan in today's pharmaceutical manufacturing. Here's how modern vibration monitoring techniques and technology can maximise performance.

Vibration monitoring – Tried and tested technology

Vibration monitoring has been employed for some time now; indeed, we can be certain that it has been in use for almost two thousand years. The oldest vibration sensor known to historians was a seismograph invented by Chinese astronomer Chang Heng in the second century AD. This device responded to distant disturbances by depositing a bronze ball from the mouth of one of eight dragons placed at intervals around a large urn, thus indicating the direction of a distant earthquake and potentially saving lives by enabling the government to send assistance to the affected area.

Vibration monitoring is therefore one of the oldest solutions in the engineering workplace, with a lineage that outstrips other technologies by centuries. However, today's vibration monitoring systems are no longer sculpted in the forms of mythical beasts; the development of vibration monitoring has been less concerned with visual impact and more concerned with enhancing performance. This is because the users of each application in which vibration sensors are used demand ever-greater productivity from each mechanical system. There has therefore been a corresponding growth in the need for sophisticated vibration sensors that maximise the performance of many engineering processes. Today's designers and engineers of vibration sensors have not only succeeded in providing devices of exceptional reliability but also in packaging that functionality in a variety of resilient and extremely compact enclosures to enable its use within a wide range of applications.

Vibration monitoring in action

Vibration sensors are used widely in pharmaceutical manufacturing. Air control, for example, is a method of manufacturing medicine that is probably older than even vibration monitoring, although the drying of animal flesh and bone to produce powdered drugs no longer represents the height of pharmaceutical technology.

Today, successful and effective air handling in the pharmaceutical sector requires machinery that can stabilise air conditions within precise limits during the manufacturing process, with no sudden changes to air flow rate, temperature or humidity. To ensure that these levels are carefully managed, machinery must be correctly specified, maintained and run, since a mechanical failure will make a degradation in air standards almost inevitable, with the potential for lost production, the risk of penalties from late orders and the danger of customer dissatisfaction.

Taking advantage of vibration monitoring

Vibration monitoring systems can help engineers protect air handling units from unexpected failure. Ensuring this comes down to several key factors: installing accelerometers correctly;

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gathering and analysing data properly; and taking the necessary action (in some cases, the best course of action may be 'no action').

As condition monitoring has become increasingly commonplace in industry, training in the use of components such as vibration sensors is now provided by organisations such as BINDT (British Institute of Non-Destructive Testing). This is important because, even though a vibration sensor offers high levels of performance and reliability, the component is only as good as its installer. For example, when mounting a sensor there may be a choice between drilling, tapping or gluing; but engineers need to understand and consider how these methods may affect the warranties on their equipment. However, with the right advice and assistance, the rotating elements of air handling units can be cost-effectively monitored to enable vibration engineers pick up early signs of any degradation in the equipment, so that maintenance can be planned and carried out with minimal expense and disruption to service.

A closer look at vibration sensors

An accelerometer contains a piezoelectric crystal element, which is bonded to a mass. When subjected to an accelerative force, the mass compresses the crystal, and this causes the crystal to produce an electrical signal that is proportional to the force applied. This output is then amplified and conditioned by inbuilt electronics to produce a signal that can be used by higher level data acquisition or control systems either online or offline.

'Vibration monitoring systems can help engineers protect air handling units from unexpected failure.'

An online system is one that measures and analyses the output from sensors, which interface directly with a PLC. An offline system is created by mounting sensors onto machinery and connecting them to a switch box; engineers can then use a hand-held data collector to collect readings.

There are two main categories of accelerometer: AC accelerometers, which are typically used with data collectors for monitoring the condition of higher value assets such as critical process systems, and 4-20mA accelerometers, which are commonly used with PLCs to measure lower value assets, such as motors, fans and pumps. Both AC and 4-20mA accelerometers can identify misalignment, bearing condition and imbalance, while AC versions offer the additional capability to detect gear defects, belt problems, looseness and cavitation.

Inside the air handling unit

A typical air handling unit comprises a supply fan and an extractor fan, coils that circulate steam or hot water for heating, chilled water for cooling and air filters, encased within a large metal enclosure with removable panels. The complete fan and motor assembly are contained within the enclosure, so

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engineers can easily gain access to carry out any necessary maintenance procedures by removing the panels. The supply fan and extractor fan can either be direct-drive or non-direct drive. Direct-drive fans may require a vibration sensor on both the drive-end and non-drive-end bearing, while non-direct drive fans may require the addition of two accelerometers on the journal bearings of the gear shaft.

An established and cost-effective technique for identifying imbalance and misalignment in air handling units employs 4-20mA sensors mounted onto bearings and shafts, with the velocity readings being fed back to a PLC, allowing overall vibration trends to be monitored. A dual output sensor can provide both a 4-20mA output and an AC output, allowing engineers to take in-depth vibration analyses via a data collector.

In an air handling unit, an M12 connector used in conjunction with separate M12 cable assemblies offers an effective option, as the M12 connector is of a smaller size than many alternatives, and the associated cable assemblies have a tight bend radius.

A further option is to use fixed AC sensors hard-wired to switch boxes outside the air handling unit, allowing data to be collected safely from the same positions on a regular basis. The limitation of this option is that readings only apply to the moment in time that they were taken. If there is limited access, for example, near the belt guards, it is worth considering that side entry sensors and compact small footprint sensors can be used for small air handling units.

Specification and installation

When it comes to switch boxes, stainless steel units are often compulsory in pharmaceutical applications. An established supplier will offer valuable advice on specification issues such as this, and offer important guidance on installation. For example,

accelerometers should be mounted directly onto the machine surface. This surface should be flat, smooth, unpainted, free from grease and oil, and larger than the base of the accelerometer itself. The accelerometer should also be positioned as close as possible to the source of vibration.

'Rotating elements of air handling units can be cost-effectively monitored to enable vibration engineers pick up early signs of any degradation in the equipment'

If conditions (and product warranties) allow, the preferred mounting technique is to drill and tap a thread directly onto the machine so that an accelerometer with an integral ¼-28UNF, M6 or M8 mounting thread can be screwed into place. This 'drill and tap' method can also be used to fix a mounting stud, to which an accelerometer can then be attached; specialised installation kits are available for this task.

It is important to take care and use the right tools for the job, as tightening the sensor outside the appropriate torque levels can damage equipment

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or reduce its effectiveness. Over-tightening, for example, can damage the sensor by stripping the thread, while under-tightening will lead to inaccurate readings due to poor contact with the vibrating surface.

If drilling and tapping is not an option, the next best thing is to attach mounting studs using adhesive. The issue to be aware of here is that you may need to consider the temperature present within your application and choose an adhesive that is capable of coping with that temperature. For applications at temperatures up to 100°C, a metal-filled epoxy adhesive would be the appropriate substance to use.

A good spot facing kit will provide all the necessary tools needed to accurately mount a vibration sensor onto the rotating machine, including a tapping drill, taps, tap wrench and a spot facing tool. These kits are now available to allow for different mounting threads; ¼, M6 and M8. Correct mounting of the sensor is vital to ensure true readings and, where possible, mounting a sensor via a drilled and tapped hole directly to the machine housing will give the best results. However, if the housing is not flat, a spot facing installation kit allows creation of a flat surface.

Having installed accelerometers as carefully as possible, ensure that the accelerometer cable is clamped to the body of the accelerometer itself with cable ties. This will not only prevent strain but also prevent the false readings that can be generated when loose cables create excessive movement.

If all of these specification and installation issues are carefully considered, not only will the air handling unit be able to maintain air control consistently to the benefit of the plant as a whole, but it may also be possible to extend the operating life of equipment beyond recommended maintenance intervals – guarding against the expense generated when increases in vibration lead to machine failure, downtime and unwelcome reductions in production volume or quality.

Chris Hansford
Managing Director, Hansford Sensors Ltd.

Chris Hansford is a qualified electro-mechanical engineer with over 30 years' experience in the vibration monitoring industry. In 1986, he was involved in the formation of a sensor manufacturing company and, as Managing Director for 20 years, successfully grew the business and gained a wealth of commercial experience within the UK market. In 2006, Chris moved on to set-up Hansford Sensors Ltd, a manufacturer of accelerometers and ancillary equipment that has already become a global market leader.

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