Hansford Sensors
Excellence in Vibration Monitoring



# Vibration monitoring to boost efficiency

**In this article Chris Hansford, Managing Director of Hansford Sensors, explains how predictive maintenance, in particular vibration monitoring, helps to maximise the efficiency of machinery used in cement manufacturing, by reducing downtime to a minimum.**

**It includes advice on how to specify and install suitable solutions.**

Cement manufacturing is one of the most aggressive of all production processes. The chemicals used to produce Portland and Masonry cement – particularly silicates, aluminates and aluminoferrites – can combine to create high levels of fine particles, creating significant problems for production and handling equipment. Rotating components are at greatest risk, and they are commonly found in the motors, pumps and fans used in crushers, mills, precipitators, kilns and silos.

Equipment with moving parts is usually fitted with a protective cover, or sealed to high IP standards, but it is impossible to prevent the ingress of fine particles, which are typically between 15 and 45 microns in size. This ingress can affect the efficiency of lubricants, leading to increased wear of bearings, shafts and seals, followed by the risk of premature failure. These problems can quickly escalate, especially in areas with high operating temperatures.

Worn rotating parts lead to an increase in internal tolerances, causing mechanical imbalance, loose components and rubbing parts. This manifests itself as vibration, which can be detected by appropriate sensors. Because these sensors can detect very low levels of vibration – and tiny changes in one vibration state to another – it is feasible to assess the rate of wear and take action before a problem develops.

**Boosting efficiency**

There's a reason why manufacturers should monitor the ongoing health of their machinery: production efficiency. The cement market is growing at a huge rate, and the most efficient producers stand the best chance of capitalising on the opportunity.

World cement volumes are expected to enjoy a Compound Annual Growth Rate of 4.9% to 2017, according to

## Vibration monitoring in the cement industry

figures from CW Group in its latest survey of the industry. It predicts an increase in per capita cement consumption from 539kg in 2012, to 645kg in 2017. This would take world consumption beyond 4.5 billion tonnes.

Other analysts are in broad agreement: PCA Market Intelligence, which tracks figures for Portland Cement, said in a 2013 report: "World cement consumption is expected to grow by 4.0% in 2014, and remain near 4.0% annual growth during 2015-2016."

To achieve this profitably in such a competitive and cost-sensitive market, suppliers must ensure that their production systems operate at maximum reliability under demanding conditions.

Many cement plants still operate below their potential capacity, which is partly due to the time spent on machine maintenance.

New technologies can help to boost machine reliability and plant productivity. But it is the ability to optimise the capability of existing systems that will have the largest effect on cutting maintenance time – and one way of doing this is to protect systems using vibration monitoring.

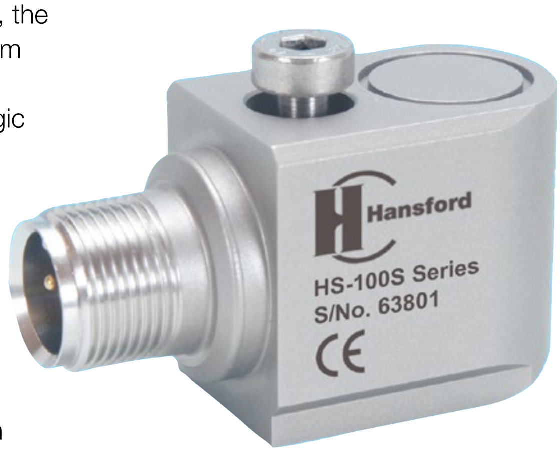
**Vibration monitoring**

Vibration monitoring equipment was originally developed to help the industrial manufacturing and process industries boost productivity and profitability. In recent years, the industry has moved steadily from reactive to predictive long-term maintenance. This more strategic approach is often implemented on a process-wide basis, incorporating every stage in the production process in an attempt to maximise uptime and productivity while reducing operating costs. Tools such as vibration sensors are a critical element in this process.

Vibration sensors – otherwise known as accelerometers – contain a piezoelectric crystal bonded to a mass. When subjected to an accelerating force such as vibration, the mass compresses the crystal, causing it to produce an electrical signal that is proportional to the force. This is then amplified and conditioned to produce a measurable signal, which is suitable for use by higher level data acquisition or control systems.

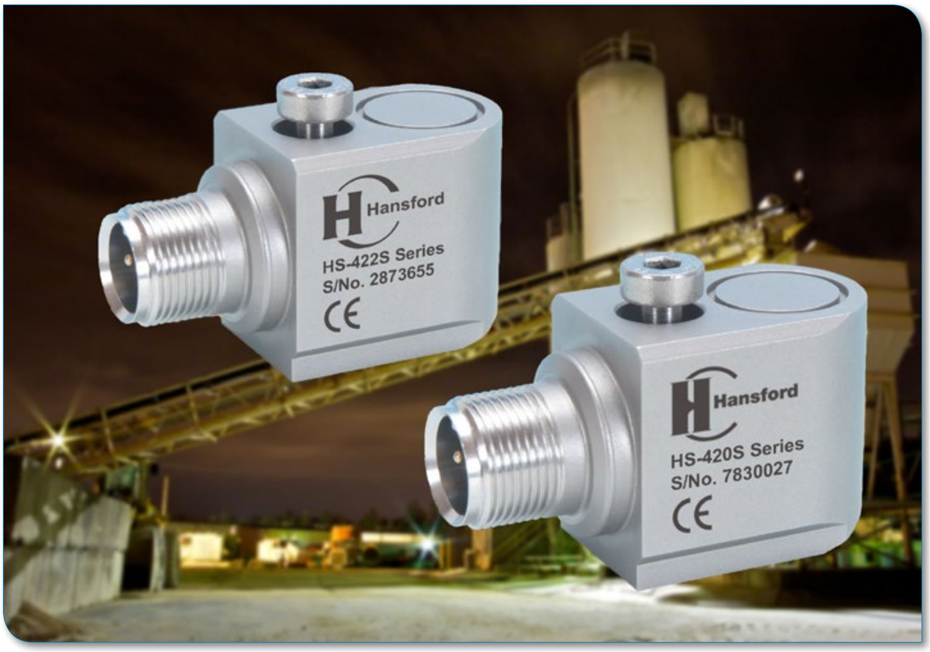
Output data from accelerometers mounted in key locations can either be read periodically using hand-held data collectors – for immediate analysis or subsequent downloading to a PC – or routed via switch boxes to a centralised or higher level system for continuous monitoring.

In cement manufacturing, the key components to monitor – in kiln drives, crushers, screens, conveyor belts, raw mills, elevators, separators and blowers – are the motor and gearbox assemblies. In each case it is critical that the correct type of sensor be selected, for ease of installation and access, and for reliable operation and data collection.



Hansford Sensors
Excellence in Vibration Monitoring

## Vibration monitoring in the cement industry




When sensors are to be installed on a crusher, screen, conveyor pulley or drive, for example, a side-entry model may be preferred over a top-entry component, so that debris cannot damage the sensor. In high temperature areas, an appropriately protected sensor should be used.

**Specify and install**

To specify an accelerometer correctly, engineers must consider the vibration level and frequency range to be measured, environmental conditions – such as temperature – and whether corrosive chemicals are present.

Further considerations follow on from here: is the atmosphere combustible, for example? And are there weight constraints?

*'Cement manufacturing is one of the most aggressive of all production processes.'*

The best solution is to work closely with the sensor supplier, to ensure that the selected units perform correctly. Hansford Sensors has, within its family of vibration sensors, an extensive range that is designed to withstand the harsh conditions of cement manufacturing, and offers multiple connection, output and environmental options.

Accelerometers used to measure vibration levels are usually easy to install and use – though an accelerometer is only as good as the engineer responsible for it. If poorly installed or maintained, it will not offer suitable precision or longevity.

Condition monitoring depends on stability: a poorly mounted accelerometer may give readings that relate not only to a change in conditions but also to the instability of the sensor itself.

Modern accelerometers for vibration monitoring can operate over a wide temperature range, measuring both high and low frequencies with low hysteresis characteristics and high accuracy.

### Typical products within the cement industry

**Offline (set-up 1)**

- HS-620 Portable vibration meter

**Offline (set-up 2)**

- HS-100 Top entry or side entry
- Junction enclosure (optional) in stainless steel, polycarbonate or mild steel - HSJE-XXX
- Twisted pair cable
- BNC bracket

**Online (set-up 1)**

- HS-420 for imbalance/ misalignment (mm/sec)
- HS-422 for bearing condition (g)
- Twisted pair cable
- Junction Box (Optional)

**Online (set-up 2)**

- HS-100 (100mv/g)
- HS-535 Triple Output (Output-1 Bearing condition, Output-2 Imbalance/misalignment, Buffered Output for data collection)
- HS-510 Local monitoring with Relay 1 & 2 (Optional)
- Twisted pair cable
- HS-570 Power supply
- HS-580 Enclosure

Hansford Sensors
Excellence in Vibration Monitoring



They are robust and reliable, thanks to stainless steel sensor housings that can prevent ingress of contaminants.

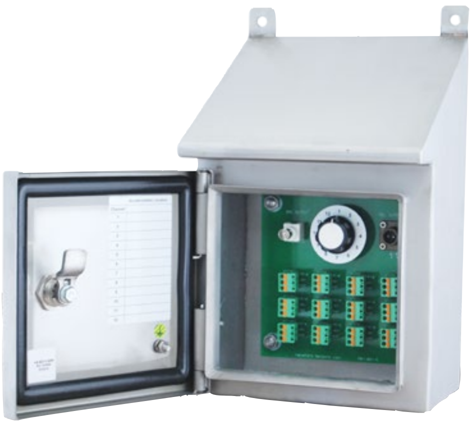
To install an accelerometer correctly, engineers should mount it directly onto the machine on a flat, smooth, unpainted surface that is larger than the base of the accelerometer. The installer must ensure that the surface is free of grease and oil, as close as possible to the source of vibration and perpendicular to the axis of rotation. These guidelines will help to ensure that the device gives the most accurate possible measurements of vibration levels – giving the maximum boost to the maintenance regime.

***'Accelerometers used to measure vibration levels are usually easy to install and use.'***

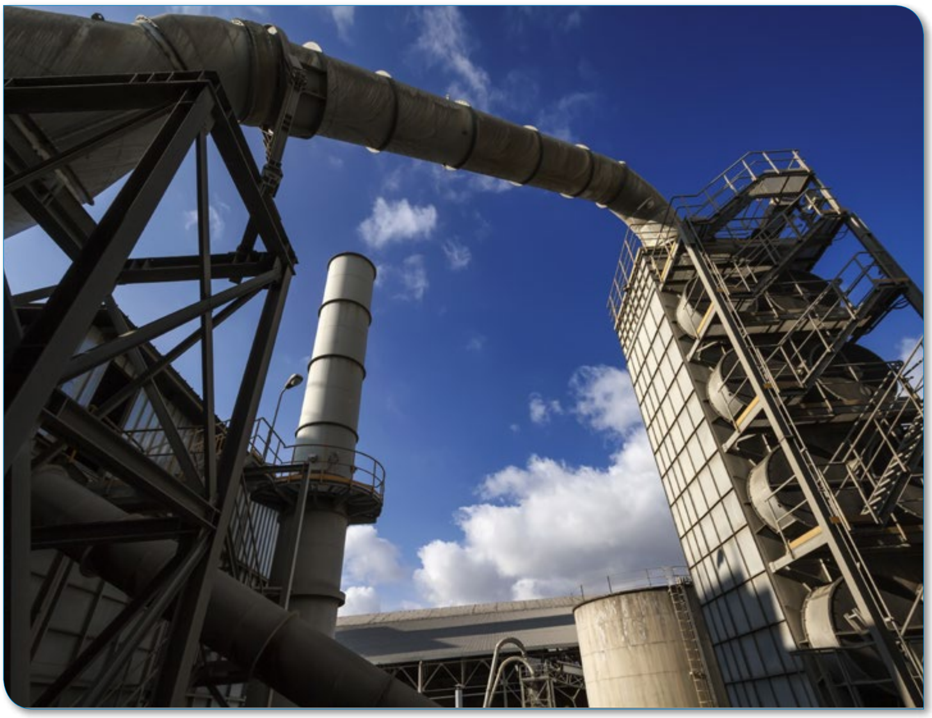
A good spot facing kit has the tools needed to mount a vibration sensor onto the rotating machine accurately – including a tapping drill, taps, tap wrench and a spot facing tool. These kits are now available to allow for different mounting threads, including ¼, M6 and M8. Correct mounting of the sensor 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. If the housing is not flat, a spot facing installation kit allows creation of a flat surface.

**Mounting**

Correct sensor installation is essential for reliable and consistent operation. A vibration monitoring system must take into account issues including imbalance, misalignment, bad bearings, mechanical looseness, hydraulic forces (cavitation, resonance) and rubbing. To detect these faults, sensors should be located to ensure that horizontal, vertical and axial movement are measured effectively.



For horizontal measurement, vibration sensors should be mounted on the two motor bearings or pump bearings. This measures velocity in mm/sec (Peak or RMS) to detect imbalance, and problems with structural rigidity and/or foundation. For vertical measurement, sensors should be located on the motor or pump drive end bearings. This measures velocity in mm/sec (Peak or RMS) to detect looseness and problems with structural rigidity and/or foundation.



For axial measurement, sensors are attached to motor or pump drive end bearings. This measures velocity in mm/sec (Peak or RMS) to detect misalignment between the motor and the fan.

Depending upon the criticality of the application, and the budget available, a greater number of sensors can be installed to give additional information – but the key components to measure using vibration monitoring are the motor and gearbox assemblies.

For a typical crusher motor, accelerometers are mounted radially on the Drive End (DE) and Non-Drive End (NDE), in order to monitor the motor bearing condition (g).

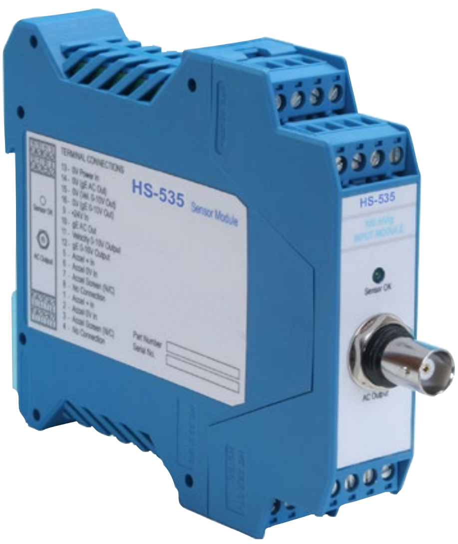
Hansford Sensors
Excellence in Vibration Monitoring

# Vibration monitoring in the cement industry

In a gearbox, the sensor will be mounted radially on input and output shafts. This enables the condition of the bearings (g) and fan out of balance (velocity) to be monitored. An optional axial accelerometer on the input shaft would give a good indication of the thrust on the shaft.

Cement manufacturing applications typically use 4-20mA accelerometers connected to PLC systems. Each sensor is connected to a local junction box, then multicore (screened twisted pair) cable is connected to the PLC system for data trending and alarming.

With the sensors installed in this way – depending on accessibility – a local junction box can be installed close to the motor. Multicore cable is used to connect the junction box back to a main switch/connection enclosure. In some applications the sensor cable is connected directly to the switch enclosure – a sealed industrial enclosure that has been designed to withstand harsh conditions. It is available in various forms such as mild steel, stainless steel or polycarbonate, depending on environmental conditions.



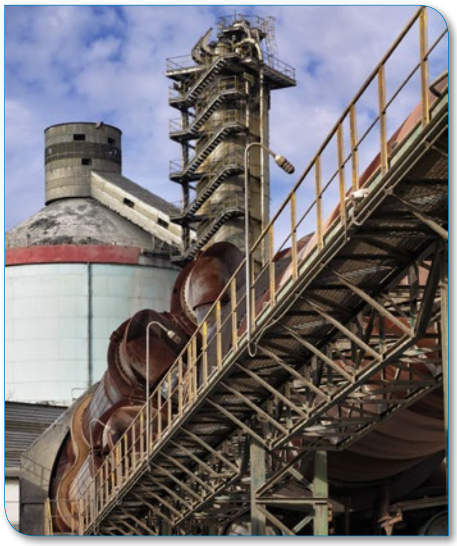

**Data collection and analysis**
Offline vibration monitoring in a cement manufacturing plant is performed using portable data collectors: a maintenance engineer gathers data manually using a single temporary sensor and handheld instrument, or a handheld monitoring device that connects to the outputs from permanently mounted sensors located at strategic points around the plant.

Maintenance teams must develop data collection routes based on equipment criticality, allowing each maintenance engineer to take the most efficient path through the plant. These routes are normally held in the data collector. In a cement manufacturing plant there may be a series of routes, taking in everything from small blowers to an entire finishing mill area.

***'Carefully collected and analysed data can help to boost plant efficiency'.***

With the most efficient routes defined, engineers can check and analyse more pieces of equipment in the time available. Because the frequency of data collection is based on the criticality of the equipment there may also be periodic additions of non-critical pieces of equipment that are not visited on a regular collection route. Increasingly, sensors are being hard-wired back to centralised control systems, with data monitored in real time. Although this is more expensive, it is also more efficient and safer.

Regardless of how data is captured, it is critical to analyse different frequency spans: these are dictated



by the fault frequencies of the fastest-turning component in the machinery being monitored. The frequency span of a slow turning ball mill, for example, will be narrower than that of a high speed fan.

Once the frequency span is known, the resolution needs to be set within the vibration software for spectrum analysis so that fault frequencies of rotating components are not mistaken for other – correct – machine frequencies.

Carefully collected and analysed data can help to boost plant efficiency. For example, vibration readings from a cooling fan may reveal that – during initial installation – the bearings were incorrectly aligned with the shaft, or that the outboard bearing was never locked down correctly, or that the grid coupler was found to be dry. Or, it could be any combination of those or other issues.

The results of inspection can be surprising: a process dust collector fan that is vibrating severely may suggest that the fan rotor needs balancing – but an unrelated issue,

Hansford Sensors
Excellence in Vibration Monitoring

## Vibration monitoring in the cement industry

such as a filter bag failure, can cause build-up of dust on the edge of the rotor, causing imbalance.

Whether the cause was predicted or not, vibration monitoring alerts the engineer before further damage can occur.

**Summary: Top Tips**

The cement industry is a punishing environment for machines – and for the sensors that monitor them. These pointers should help in selecting the most appropriate system.

### Identify the vibration level and frequency range to be measured.

This is the first thing to establish before choosing a vibration monitoring system. Careful consideration must also be given to issues such as temperature and humidity.

### Consider the working environment.

The cement industry is one of the most demanding environments, so sensors must be sealed to a high level. High temperatures and corrosive chemicals are also common. Further options are available for vibration monitoring at low speeds, where signals generated by bearings are harder to detect.

### Online or offline?

An online system measures and analyses the output from sensors that interface directly with a PLC. In an offline system, engineers use a hand-held data collector to collect readings from sensors mounted onto machinery.

### Install close to the source of vibration.

For best results, accelerometers should be as close as possible to the vibration source.

### Establish a network.

A dedicated condition monitoring system, with a network of accelerometers positioned close to relevant machine parts, improves operational efficiency and prevents problems before they occur.

### Maximise stability.

Accurate monitoring relies on stability. Sensor instability can be eliminated using spot mounting. There may be a choice between drilling, tapping or gluing, but consider how each method may affect warranties on equipment.

### Train your operators.

With so many sensors in operation, problems associated with human error must be addressed. Many organisations, such as the British Institute of Non-Destructive Testing (BINDT), provide appropriate training.

### Use the information that vibration monitoring provides.

Vibration monitoring systems cannot save a plant if the warnings they generate are ignored. Yet warnings are often disregarded in order to continue production. It's better to perform simple maintenance straight away than risk more costly failure further down the line.

### Consult an expert.

With so many variables to consider, professional advice is crucial. To achieve the best specification, it makes sense to work closely with a supplier – such as Hansford Sensors – that has a depth of industry experience and knowledge.

**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.