

GOOD VIBRATIONS

DONALD LYON, MANAGING DIRECTOR OF MONITRAN EXPLAINS THE NEEDS OF TWO INDUSTRIES FOR HIGHLY ACCURATE VIBRATIONS SENSORS

Accelerometers (or vibration sensors) have for many years been used within scientific and research establishments to measure absolute acceleration values. This research was, and remains, an aid in the design of components, systems and engineering structures within, amongst other industries, automotive, aerospace and construction.

However, vibration monitoring is playing an increasingly important role in industries including water treatment, petrochemical and paper making. This role is largely to protect against the untimely failure of expensive plant machinery, unscheduled maintenance and plant shut-down.

For example, before vibration monitoring was employed, machinery (including motors, drives, gearboxes and pumps) in many industrial plants was either left to run until failure or it was replaced at regular intervals – irrespective of its use. In the former case, plants experiencing machinery failure were also running the risk of injury to personnel. In the latter case, in replacing equipment at set intervals companies were often removing and disposing of machinery unnecessarily.

Today though “predictive maintenance” is the buzz-phrase and accelerometers are playing a crucial role in detecting the vibrations and ‘noise patterns’ which are the earliest indicators that maintenance is required. Implementing vibration-based condition monitoring is now generally regarded as an essential part of any predictive maintenance routine.

TRANSDUCERS

There are essentially two types of accelerometer, namely piezoelectric and piezoresistive. Whilst other types do exist, these two equate for about 90% of the market.

The piezoelectric accelerometer is perhaps the most popular type for making vibration measurements. It is a robust device with no moving parts, as it consists of a crystal of piezoelectric material to which is attached a seismic mass (see Figure 1). When the crystal is stressed in tension or compression, it generates an electrical charge which is

proportional to the acceleration level it is experiencing. Internal circuitry converts the charge into a voltage or current which is used for vibration analysis, machine control projection or projects. It offers long-term stability and reliability, it has wide frequency range (typically from less than 1Hz to more than 10kHz) and its signals can be integrated to produce velocity and displacement values.

Piezoresistive accelerometers on the other hand consist of a seismic mass that is attached to a cantilever beam. The beam is deflected when the transducer experiences g forces, and this movement is converted to an electrical signal by resistance changes in a semiconductor sensing element. Internal electronics provide amplification of the signal and temperature compensation. Its frequency range (which is typically from 0Hz to about 750Hz) is lower than that of a piezoelectric device, but this is an advantage if you wish to monitor static or DC acceleration levels.

Most accelerometer casings are made from stainless steel but other materials can be used, for example aluminium where weight-saving is important. They are typically sealed to IP65 but, increasingly, applications are calling for higher standards such as IP68 (for submersible use). Further, most accelerometers are welded during their construction so, if hunting around for sensors, it is worth checking that the manufacturer is certified to EN287/288.

As for electrical connection, most accelerometers are supplied with integral, screened cables, with cable entry either through the top or the side of the casing. However, sensors can also be supplied with connectors (for example BNC) on the body or, in some cases, just solder pins.

Installation of an accelerometer is achieved through one of three fixing methods: mechanical (i.e. some sensors have a threaded base), adhesive or magnetic.

The type of sensor, fixing method, electrical connection type, sensor casing material and sealing standard will

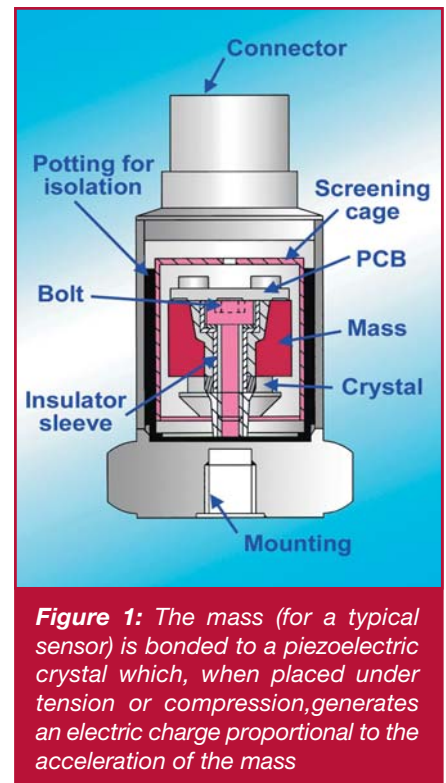


Figure 1: The mass (for a typical sensor) is bonded to a piezoelectric crystal which, when placed under tension or compression, generates an electric charge proportional to the acceleration of the mass

typically all be driven by the application. However, a word of warning: incorrect selection of an accelerometer, or incorrect installation of a correct sensor, will most likely lead to unreliable performance and erroneous data.

If in doubt, contact the manufacturer to establish: a) their manufacturing standards and b) their experiences in your industry.

SHARED ACCESS

When installing any transducer it is important to consider the information (derived from the sensor's outputs) that needs to be presented and, possibly, stored. For process monitoring purposes, simple readings may suffice – with predefined alarm limits, if applicable. For maintenance purposes, data trending will certainly be required. And for fault-finding it may be necessary to view the raw data.

Accordingly, during installation it is important to consider the intended use of the data, by answering the traditional questions of Who, What, Where, When and Why. Within a factory for example, it is common-place to employ numerous accelerometers located around the site and have the data present in one location, for example a control room. However, it is often impractical to route all of the sensors' outputs into the control room.





Figure 2: Underground engineers keep a keen eye on vibration levels

For this reason signal conditioning is best performed on a group of sensors, as close to the sensors as is practicably possible and then communicate the readings over a data bus. Whilst sensible, until recently, the engineering difficulties and costs proved prohibitive, as it was often necessary to call in third parties. Now though, things are much easier.

The last few years have seen a number of low-cost solutions come to market. For example, Monitran's MultiSelect units can give manual access to up to 256 accelerometers and remote access to considerably more. A self-contained MultiSelect unit has a control panel and switching circuitry. It has inputs for up to 16 standard accelerometers, a control knob to select one of the 16 inputs, an industry standard 4-20mA output, an AC + bias output (available via the unit's connector pins and a BNC on the control panel), an RS-485 interface connection and a digital display.

Units like the self-contained MultiSelect can either poll the sensors to which they are connected or they can access a specific accelerometer. Units can be daisy-chained to create a network of sensors (here up to 256) and data can easily be presented in a single location. Further, via a PC and using the RS-485 bus (which is multi-drop) it is possible to create even larger networks. It is also possible to access the data from offsite, via the Internet.

GOING WITH THE FLOW

Accelerometers are fulfilling vital roles in enabling plant managers to implement predictive maintenance routines. One sector implementing such routines is the water treatment industry.

For example, Bedford Pumps, one of the UK's largest manufacturers of medium and large sewage and water pumps, at its endusers' requests is supplying many of its products with accelerometers already fitted. Some of the manufacturers' pumps have flow rates of up to 6,000 litres per second, although the company has experience of pumping at up to 21,000 litres per second.

When pumping clean water, vibration levels are unlikely to vary from one day to another. As such, reading the levels may not require the use of permanently fixed accelerometers, and weekly or even monthly site visits using hand-held equipment will probably suffice.

However, in an unscreened sewage pumping station, everything that flows down a sewer pipe will get pumped. In theory this is just sewage and waste water but in practice it can be anything from bits of wood to shopping trolleys. Consequently all pumps going into this environment must be sufficiently robust to withstand shock loading and even blockages.

Here, continuous vibration monitoring is a must. But there is a snag. The pumps are operating in particularly hazardous environments because methane and other potentially explosive gases are sometimes present. As such, any machinery operating in this environment has to be rated EExD (flameproof) and the risk of failure of equipment (causing fire) in this environment must be minimised. Accordingly, any vibration sensors used must be intrinsically safe (see box 'Protecting Pumps').

As for vibration levels, in Bedford Pumps's experience clean water pumps will vibrate at less than 3mm/s during normal operation. For sewage applications though, normal levels will fluctuate around this figure. If there is a blockage the levels will rise significantly – and they can be used to initiate a local shut-down and, if suitable communications are in place, flag the fact to a central control.

UNDERGROUND

Another application for accelerometers is in the coal mining industry, where the importance of vibration-based monitoring has been well understood for decades – and one of the UK's keenest advocates of the technology is UK COAL, Britain's biggest producer. The company has four ongoing deep mines located in Yorkshire and the Midlands. It employs about 3,300 people and supplies around 7% of the country's energy needs for electricity generation.

The depths of the company's mines vary from 800m to 1km and all have at least two shafts. Further, all operate 24/7 and, at any one time, there will be up to 200 miners underground at each colliery. As you'd expect, there is much equipment underground for not only the transportation of men and minerals but also for the removal of water and the circulation of air. This equipment, along with lighting, gives rise to one of the industry's biggest threats to mine safety – fire, as a result of machinery failure igniting coal dust.

Some of the work faces in UK COAL's mines are up to 10km away from the shafts and extensive conveyor belt systems are employed to transport minerals.



IN 3D

Whilst traditional accelerometers measure displacement in one axis, a number of applications require measurement in three. For example, 3D measurements are often required in aerospace and automotive applications.

Until recently it was necessary to mount three accelerometers at 90 degrees to each other on a bracket. Now though, manufacturers like Monitran are producing tri-axial sensors.

The MTN/1310 weighs only 35g and incorporates three piezoelectric accelerometers mounted in the X, Y and Z planes, all within a hermetically sealed stainless steel enclosure.



Figure 3: The MTN/1310 incorporates three piezoelectric accelerometers in one package

These systems are driven by electric motors which, even under normal operating conditions, produce heat.

They have typical power ratings of between 500 and 750kW and all produce heat as a consequence of their operation. However, if conveyor drive motors develop misalignment faults (offset or angular) then they will produce additional heat. Heat is also produced by the conveyors' roller bearings, as the balls and runners wear and excessive wear can easily result from overloading the system or as a result of inadequate servicing.

Whilst monitoring the temperature of the conveyors' motors and bearings is a

PROTECTING PUMPS

The Bedford Pumps's DV.90.23.10 Volute pump was installed by Bedford Pumps in November 2006 at Thames Water's Datchet Pumping Station, near Windsor.

Driven by a 6.6kV variable speed 730kW (6.6kV) motor, this pump has a rated flow of between 50 and 225 million litres per day, and the assembly is fitted with four accelerometers and seven temperature sensors – all feeding into a Monitran MTN/6000 monitoring unit.

Figure 4: Bedford Pumps DV.90.23.10 Volute pump



common practice in mines, it does not always provide the earliest indication of wear and tear. However, vibration levels can not only provide the earliest indication of wear and misalignment issues, but they can also indicate the nature and location of faults. This is because each type of machine part (such as a motor or bearing) produces a specific vibration pattern, the frequency and amplitude of which is determined by the machine's geometry, load and operating speed. Interestingly, a single vibration measurement provides information about multiple components.

For example, four different frequencies are present in the vibration profile of a roller bearing, namely: ball spin frequency, fundamental train frequency, ball pass frequency (inner race) and ball pass frequency (outer race).

This is therefore a great aid to in-situ diagnostics, as the nature of a specific fault can be determined with the component in place and without disrupting its operation.

In UK COAL's case, its maintenance strategy includes a strict policy of measuring the vibration levels of all major conveyor drums at regular intervals. The data is collected using handheld instruments and then downloaded to a PC (one per colliery) for a low-level analysis, which provides an early indication of motor and bearing health.

Whilst 'lowlevel' the analysis of the data is sufficient to determine:

- Are vibration levels as per expected?
- If there's a deviation from expected is any immediate action required?
- Should the next scheduled service be brought forward?
- Should an additional inspection be conducted in the near future?

PREDICTIVE ROUTINES

The use of permanently installed vibration sensors is enabling the implementation of predictive maintenance routines in an evergrowing range of industry sectors. This provides users with an extremely cost-effective method of reducing or even eliminating unscheduled and costly down-time.

In addition, industry is experiencing the added benefits of the improved safety that early warning of possible machine failure is able to afford. The result is that for all sorts of reasons, both social and economic, a wellplanned programme of vibration monitoring has become an almost essential ingredient of predictive maintenance in a wide range of industries. ■

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