MMH623670 Condition Monitoring

Introduction

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Motivation for Condition Monitoring

- You are the MD of **Universal Widgets®**
- Is your job to make widgets?
- No (possibly)
- Your job is to make money!
- To pay shareholders
- Employees
- The Government – via tax

Motivation for Condition Monitoring

- In order for **Universal Widgets®** to succeed, it must focus on *productivity* and *plant reliability.*
- Plant reliability and productivity means that that *maintenance* must be *effective* and *efficient*.

Motivation for Condition Monitoring

- Condition Monitoring is not an end in itself.
- Condition Monitoring exist to facilitate efficient and effective maintenance practices
- Maintenance promotes reliability and productivity.
- Which means more £££££££!

Motivation for Condition Monitoring?

Machines have been helping us since the invention of the wheel. Machinery maintenance has been with us since the first machines. Over the years, machinery maintenance has evolved from:

- Run to failure
- Preventative Maintenance and finally to
- Predictive Maintenance

Run to Failure

- Run to Failure occurs when repair action is taken on a problem only when the problem results in the machine's failure. Run to failure problems often cause costly secondary damage along with expenses resulting from unplanned downtime and maintenance.

Preventative Maintenance

- Preventative Maintenance occurs when a machine or parts of a machine are overhauled on a regular basis regardless of the condition of the parts. While better than run to failure maintenance, preventive maintenance results in excessive downtime due to unnecessary overhauls and in excessive costs due to replacing good parts along with worn parts.

Predictive Maintenance

- Predictive maintenance involves procedures which permit the prediction of the remaining useful life of components.
- This involves measuring physical parameters of the components in operation and comparing the results with:
- Previous performance (relative)
- Absolute standards

Condition Monitoring

- Condition Monitoring is the process of determining the condition of machinery as it operates. If a problem is indicated, condition-monitoring equipment provides information useful in determining what the problem is, and more importantly what caused the problem. This allows us to schedule efficient repairs of specific problems prior to machinery failure.

Condition Monitoring

- Modern condition monitoring not only helps plant personnel reduce the possibility of catastrophic failure but allows them to order replacement parts in advance, schedule manpower, reduce spare parts inventories, plan multiple repairs during scheduled downtime, and improve machinery operation to an optimum level often exceeding original equipment specifications.

Benefits of condition Monitoring

Maximise machine productivity:

Through effective condition monitoring one can virtually eliminate plant downtime due to unexpected machine failure.

Minimise unscheduled downtime:

Allows you to plan repair during non peak production hours.

Benefits of condition Monitoring

- **Safely extend overhaul intervals:** Condition monitoring lets you schedule maintenance on a needs only basis.

- **Minimise the numbers of open, inspect and repair if necessary overhaul routines:** Condition monitoring directs repair and overhaul actions at known problems.

- **Improve repair time:** Because you can plan a machine's maintenance, the actual repair/maintenance work is faster and smoother.

How does Condition Monitoring Work?

Condition Monitoring is the process of measuring the physical characteristics of a machine (e.g. vibration, bearing condition, temperature) while it is operating. A change in a machine's physical characteristics indicates a change in its operating condition. A wide range of hardware and software designed to assist an operator in identifiing and quantifying these changes are available.

How does Condition Monitoring Work?

Hardware

To perform these measurements, sensors are placed at strategic points on the machinery to monitor the machine's condition.

A sensor is a device which senses and converts energy (mechanical, thermal or electromagnetic) into an electrical signal that can be measured, recorded, displayed and analysed

How does Condition Monitoring Work?

Software

Measured machinery parameters can be uploaded from condition monitoring equipment to condition monitorng software for long term storage and analysis of data. Condition monitoring softwares most powerful feature is its ability to plot measurement data.

How does Condition Monitoring Work?

Trend plots show how a machine's condition changes over a specific time period. Trending a machine's condition allows you to easily compare its current measured value to previous values, indicating a change in machine condition. These plots allow for early detection of problems (before they become critical) and are used to schedule repair for problem machinery or components.

How does Condition Monitoring Work?

Some condition monitoring software produces diagnostic plots (FFT spectra, time waveforms) that indicate the cause of machinery problems. The way in which a machine's operating parameters change can indicate what is causing the damage.

What Operating Parameters Should be Measured?

- Vibration
- Temperature
- Lubrication oil analysis
- Acoustics

Vibration

- In rolling element bearings, vibration results from the impact generated by a ball rolling over a defect.
- Vibration measurements taken and analysed over time can be an indication of bearing damage.
- Analogous processes in gearboxes, shafts, pumps, fans, belts, chains…
- And electric motors

Vibration

- In fact vibration is considered the best operating parameter to judge rotating machinery conditions such as balance, alignment, bearing stability and stress applied to components.
- Measuring the overall vibration of a machine, a rotor in relation to a machine, or the structure of a machine, and comparing the measurement to its normal value (norm) and alarm set-points indicates the current health of the machine.

Temperature

- Temperature measurement is a useful indicator of mechanical condition or the load applied to a specific component such as a bearing.
- As a bearing fails friction causes its temperature to rise.

Temperature

- In electrical systems anomalous temperature signals can mean:
- Ohmic heating $P = I^2R$
- Is happening where we don't expect.

Temperature

- So why is I^2R too big ?
- Too much I ? An insulator is failing and current is flowing.
- Too much R? a conductor, or more likely, the connection between two conductors, is failing.

Temperature

Installing thermocouple sensors in the housing of a bearing and measuring temperature change within the bearing or lubricant allows you to recognise problems early and to schedule maintenance before a more serious and expensive failure occurs.

Oil Analysis (Ferrography)

Monitoring oil condition warns of an increase in foreign substances, such as water, which can degrade the lubricating properties of the oil and cause bearing failures. It also detects the presence of metallic particles carried into the oil stream. These metallic particles are analysed to determine which part of the machine is wearing and how fast.

Oil Analysis (HV Plant)

- Oil is an important insulating component in a lot of HV plant and its properties degrade with age and use.
- Chemical analysis of the oil will provide a lot of information on the health of the plant item.

Acoustics

Very high frequency, acoustically transmitted vibration is measured with a high frequency piezoelectric sensor. This sensor is excited by compression waves produced by metal-to-metal contact and by metal as it mechanically fails. The acoustic flaw detection signal is conditioned to produce outputs, which can be measured as numerical values on a meter.

acoustics

- The same hand held acoustic detector is an effective tool for isolating leaks in pneumatic lines in factory systems.
- (valuable niche application!)

Summary

When selecting condition monitoring equipment a Multi-Parameter approach is best. That is, plan on measuring several parameters (e.g vibration, temperature and speed) and on measuring specific parameters (e.g. vibration) using multiple processing methods (overall vibration, FFT spectrum analysis and trend analysis.) This allows you to analyse specific types of machinery and condition and provides more ways to measure deviations from the 'norm'

The Module

- 3 lecture threads:
  - Mechanical Condition Monitoring
  - Electrical Condition Monitoring
  - Instrumentation for Cond Monitoring.
- Lead by:
  - Colin Harrison (Mech)
  - Alan Nesbitt (Elec)
  - Peter Wallace (Instrumentation)

The Module

- Students on this module come from a wide range of backgrounds.
- Students are strongly advised to embrace the whole module.
- Few mechanical systems have no electrical components.
- Any electrical system with moving parts is also a mechanical system.
- And none of this is possible without relevant reliable measurement!

The Module - Delivery

- 3 threads, each comprising
  - Lectures (live or recorded)
  - Independent reading
  - Independent working (tutorial exercises)
  - Live sessions (tutorials, discussions, Q&A)

The Module - Assessment

- Examination: 50%
  - open book,
  - remote completion,
  - electronic upload.
- Coursework:
  - Electrical 20%
  - Inst.Mechanical 30%
  - Both are online tests.

The Module – Communications

- Information will be posted as announcements on GCUlearn – or sent as an email directly via GCUlearn.
- In either case, the notification will go to your *Caledonian* address.
- Make sure that your devices sync with this mailbox.

The Module - Housekeeping

- Live lectures and discussions will be hosted on one of the three permanent sessions which are live on Collaborate Ultra.
  - Mechanical
  - Electrical
  - Instrumentation
- Recordings of live sessions will be hosted there too.

The Module - Housekeeping

- Pre-recorded material is likely to be made available via links to the Edshare repository.

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Week commencing 25/01

	9-10.00	10-11.00	11-12.00	12-13.00	13-14.00	14-15.00	15-16.00	16-17.00
Mon	Module Introduction. PW	Introduction to Mechanical Cond Mon CH			Introduction to Instrumentation for Cond Mon: - PW		Introduction to Condition Monitoring for Electrical Machines: AN	
Tues								
Wed	Electrical - AN				Mechanical CH		Instrumentation PW	
Thur		Instrumentation PW				Mechanical CH		
Fri								

Week commencing 01/02

	9-10.00	10-11.00	11-12.00	12-13.00	13-14.00	14-15.00	15-16.00	16-17.00
Mon		Electrical AN					Mechanical CH	
Tues					Industrial lecture			
Wed					Electrical AN		Instrumentation PW	
Thur					Mechanical CH		Instrumentation PW	
Fri								