Motor Health Information System

Predictive Maintenance

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Problem - Operating room AH failed

- Air Handler Fan Bearings failed during middle of day
- Patients not serviced
- Operating Room shut down
- Medical staff idled
- $10,000 charge by outside vendor for emergency repair
How do we prevent emergencies with our Critical Systems

- Air Handlers
- Chillers
- Pumps for AC system
- Cooling Towers
- Fresh Water Pumps
- Waste Water Pumps
Motor/Machine Health Changes

- Environmental Changes over Time
- Component Imperfection
- Installation Errors
- Assembly Errors

Based on a study by Mars Candy Company
Installation Example

V - Vibration Trend of the Device - Machine 5

Overall Vibration in mm/sec

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Typical Maintenance Programs

- Run-to-Failure Maintenance
- Periodic Preventive Maintenance
Present Maintenance Challenges

- **Unnecessary Maintenance**
  - Machines are stopped for maintenance that is not required
  - Parts are adjusted/replaced even if machines are not malfunctioning
  - Bearings are lubricated but problem may be elsewhere

- **Spare machines that take up space and capital**

- **High Power Consumption**
  - Unhealthy machines have high vibration that require more power to operate

- **Difficulty determining the exact cause of of Machine Problem**
Predictive Maintenance Program

- Data driven
- Guidance from the data on what to do and when to do it.

Benefits
- Potential problems detected and corrected early were less expensive to fix
- Ability to schedule maintenance at convenient times
- Brought down the number of line shutdowns
- Reduced the need for large inventory of spare motors and machines

Based on a study by Harley Davidson
Motor Basics

Parts of AC Motor

- Stator
- Rotor
- Bearing
- End Bracket (Bearing Housing)
- Cooling Fan
- Frame (Yoke)
Common problems with Machines

- **Misalignment**
  - Thermal expansion, direct coupled machines not properly aligned, vibrations etc.

- **Looseness**
  - Not a source but an amplifier
  - Areas of the base (structural looseness)
  - Rotating looseness - bearing clearance, loose shaft
  - Excessive bearing internal clearance

- **Unbalance**
  - Centrifugal force
  - In other words, there is a heavy spot somewhere along the shaft
  - Accumulation of dirt on fan rotors
  - Machining errors
Causes of Failures

Common Causes For Motor Failures

- Bearing 51%
- Stator Winding 16%
- External 16%
- Unknown 10%
- Rotor Bar 5%
- Shaft Coupling 2%

Source - ABB
Indicators of Motor Failure

- **Vibrations** (Detected by Vibration analysis)
- **Excessive frictions** (Particles that can be detected by oil analysis)
- **Noise** (Audible)
- **Heat** (detected by touch or heat sensors)
- **Smoke** (detected by smell or visual checking)

Time:
- months
- weeks
- days
- minutes

Preventing time
What is Vibration

It is the response of a system to an internal or external force which causes the system to oscillate.
Basic Theory Of Vibration

It follows sine curve.
Frequency & Amplitude

**Frequency:**
How many times oscillation is occurring for a given time period?
Units: CPS(Hz), CPM

**Amplitude:**
It is the magnitude of vibration signal.
Units: Micron, MM/Sec, M/Sec²
Intensity of Vibration - ISO 10816

- Establishes general conditions and procedures on evaluation of vibrations
- Ranks machines on size and type of machines
- Three zones - Green, yellow, and Red
- Color is based on severity of vibration (amplitude)
Vibration measurement

Transducer picks up vibration signals from bearing locations and transmits them to a data collection device.

Example of a time waveform.
Easier to understand the health of a machine if data is shown as frequencies and amplitudes.

The Time Domain signals are converted to frequency domain spectrums using a mathematical algorithm called the FFT.

Amplitude describes the intensity of vibration

Frequency describes the oscillation rate of vibration

Vibration analyst can now read the RMS values or Peak values to determine the faults and severity.

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Spectrum For Common Motor Failures

- **Looseness**: Harmonics of 1X in all three directions, may extend up to 10X.

- **Misalignment**: Strong 1X & 2X peak (radial & Tangential), out of phase.

- **Imbalance**: Strong 1X peak (radial) in the vibration spectrum, proportional to severity of imbalance.

- **Bent Shaft**: Strong 1X & 2X peak in Axial direction.
Machine Alignment Spectrum

H - Velocity RMS of the Device - System3A

Strong 1X and 2 peaks
Vibration Monitoring at Plants

- Plant Engineer put his hand on machines on a daily basis to feel the Vibration
- Plant Engineer walks around listening to the sound of machines
- Plant Engineer or Outside Contractors perform Vibration Analysis with a Vibration Analyzer Machine
Challenges with Present Methodology

- Feeling the Vibration may miss early indicators that are not detectable by hand

- Hearing the Vibration may miss early indicators that are not detectable by ear

- Difficult to translate the detection of the vibration to the exact problem

- Machine may start failing between the once a quarter Measurement by Hand Held Machine

- Handheld machines operators usually take one reading and then move on to next machine; The machine could be changing its vibration pattern during inspection.
Example of data changing over time
Advanced Motor Health System Technology

- 24/7 Monitoring
- *Automation* - Software can detect changes early
- System capable of generating Alarms/Alerts
- Guidance on Maintenance/Fix
IOT Technology

SENSOR

GATEWAY

USER INTERFACE
Preventive Maintenance Program Setup

- Identify the Machines to be monitored
- Identify Machines Characteristics
  - Bearing Information
  - Type of Machine being driven - pump, fan
  - horizontal/vertical
  - Gears, belts
- Install Sensors
- Identify Machine’s running speed
- Setup Alerts - standards or customized alarm level
Motor Health Platform Output

- List of Assets Divided in Green, Yellow, and Red Bin

- Bin Classification
  - Green - Healthy
  - Yellow - Marginal (need to be looked at)
  - Red - Critical (about to fail)

- Explanation of why Motors are in Marginal or Critical Bin

- Recommendations for Preventive Maintenance
Predictive Maintenance Flow

1. **Alarm Detected**
2. **Diagnose Machine Problem**
3. **Report Maintenance Fix**
4. **Generate Work Order**
5. **Perform Maintenance**
6. **Report Maintenance**
7. **Assess Maintenance Fix**
Example of maintenance fix and result

H - Vibration Trend of the Device - System7A

Overall Vibration in mm/Sec

- Overall Trend
- Marginal limit
- Critical limit

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Conclusion

- Machines are critical to Plant Operations

- Problems can be caused by installation/assembly along with aging

- Predictive Maintenance helps avoid the “Emergency Room”

- Catch problems early when it is cheaper to fix

- Guidance on maintenance helps guide Engineering staff on maintenance to improve health of the machines