Advanced Predictive Diagnostic Tool for Engines and critical rotating equipment

Neptunus Power Plant Services Pvt Ltd
The Context

Today’s industry

- Faces high pressure to reduce operational costs, and yet have high reliability.
- Wants to run more efficiently, waste less and be more considerate towards the environment.
- New technologies are expensive and complicated to adopt and require highly skilled people to operate.
- Maintenance 4.0 is still a hazy term. Few know how to move forward.
- However, there is a better way to do maintenance.
- Neptunus has the right solutions for you, and still brings value to you.
A stitch in time saves nine...
Neptunus’ solution will enable detection of an emerging fault MUCH EARLIER compared to conventional maintenance methods such as linear vibration accelerometers. So you get MORE TIME to plan & take preventive / corrective action.
How?

- Use of highly advanced technology, which is easy to use and puts the power in the hands of the operators.

- **Torsional Vibration**: the most sensitive and advanced form of vibration measurement
  - Early Warning Diagnostics of machine health
  - Pre-empt failures, so you can plan maintenance cycles better
  - Change only what is faulty, and do it before time, to save on money and downtime!
Torsional Vibration: alpha system

- Most advanced Predictive Diagnostic Tool for Rotating equipment
- Uses Torsional Vibration, far more sensitive than traditional linear vibration.
- Detect Cancer at Stage ZERO!
- Non-invasive, user-friendly methods
- IOT-Ready: Monitor equipment health remotely on your mobile devices
- Enables on-site, over the network or remote cloud based connectivity for real time monitoring of machine health anytime and from anywhere
The Alpha System

**Principle** - Measurement of Torsional Vibration and analysis of its variation through statistical and mathematical computation to derive component specific and overall engine health indicators.

- MPU measures the Torsional vibration
- TDC Sensor references the cylinders
Torsional Vibration: Theory

Indicators
- Mechanical Health
- Engine Efficiency
- Injection
- Bearing
- Misfiring
- Twist Angle
- Mounts
- Compression
- Mech. Stresses
- ...

Time Domain
- Angular
  - Acceleration
  - Velocity
  - Displacement
- Mean
- Variance
- Skewness
- Kurtosis

Frequency Domain
- Frequency distribution

alpha system

Torsional Vibration
Torsional Vibration: Theory

Theoretical Signal (Carrier Frequency)

Measured Signal

Hilbert transform (velocity)

Angular Displacement
Phase difference between Hilbert transform & carrier signal

Angular Velocity
Magnitude of Hilbert transform

Angular Acceleration
Derivative of velocity

Stochastic computation of statistical moments:
- Mean
- Variance
- Skewness
- Kurtosis

Harmonics appearance or disappearance phasing

Indicators
# Torsional vs Linear Vibration

<table>
<thead>
<tr>
<th></th>
<th>Lateral Vibration</th>
<th>Torsional Vibration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Movement or mechanical oscillation about an equilibrium position of a machine or component</td>
<td>Changes in the relative angular displacement between two points on a rotating shaft</td>
</tr>
<tr>
<td><strong>Sensor</strong></td>
<td>Accelerometer (mostly)</td>
<td>MPU, Speed sensor, Encoder</td>
</tr>
<tr>
<td><strong>Sensor location</strong></td>
<td>Very critical parameter. If location is wrong, lots of false alarm</td>
<td>On rotating shaft</td>
</tr>
<tr>
<td><strong>Transmission path/Frequency range</strong></td>
<td>Right accelerometer for target frequency range</td>
<td>Independent of frequency range. Normally speed sensor works from 0-25KHz</td>
</tr>
<tr>
<td><strong>Vibration</strong></td>
<td>External disturbance could change the behavior</td>
<td>Independent of external vibration</td>
</tr>
<tr>
<td><strong>Repeatability/Calibration</strong></td>
<td>Calibration required</td>
<td>Not required</td>
</tr>
<tr>
<td><strong>Result analysis</strong></td>
<td>Analysis compared as per ISO 10816-3 Vibration severity chart.</td>
<td>not compared. In-situ real time diagnostics</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>The measurement of lateral vibrations is an <strong>indirect</strong> measurement of the forces of the component that could fail.</td>
<td>The measurement of torsional vibrations is a <strong>direct</strong> measurement of the forces of the component that could fail.</td>
</tr>
</tbody>
</table>
Alpha System Applications

Motors
Applications: Electric Motors

- Compares theoretical signal of rotation of shaft to measured signal
- Puts the signal difference through statistical and mathematical computation
- Algorithm helps derive component specific and overall motor health indicators.
- MPU measures the Torsional vibration on the motor shaft
- Gives you a detailed report without the need for vibration level 1 or 2 analyzers.
- This is remarkable technology.
Motor/Alternator Indicators

OVERALL INDICATORS
- Bearing/Damage
- Stability
- Electromagnetic Stress
Motor/Alternator Indicators

- This indicator measures unexpected stress pulses in movement of rotating system.
- Potential problems could be shocks stemming from stress on rotating shaft during operation:
  a. Inadequate lubrication
  b. Misaligned shaft
  c. Insufficient bearing load
Motor/Alternator Indicators

- This indicator measures the stability of the speed by measuring shaft speed change in percentage.
- Potential problems could be unbalances of shaft movement due to:
  a. Broken rotor bar
  b. Mass unbalance
  c. Air gap eccentricity
  d. Rotor winding failure, stator winding failure
Motor/Alternator Indicators

- This indicator measures presence of unbalance supply voltage or current, single phasing, under or over voltage, reverse phase, overload, etc.
- Faults under this classification are:
  a. Under or over voltage of current or unbalance supply voltage or current
  b. Single phasing or reverse phase
  c. Overload or earth fault
Alpha System Applications

Turbochargers
Turbocharger: Installation

Installation:
- Two MPUs to be installed on the Engine
- One MPU to be installed on the Turbocharger
- One MPU for Power Output
Turbocharger Indicators

- This indicator shows unexpected shocks in movement of rotor system
- Potential problems could be shocks stemming from stress on rotor system during operation. Caused by:
  a. Contaminated or burnt-out oil
  b. Corrosion of bearings
  c. Metallic particles blocking rotor system
  d. Broken or bent blades of turbine or compressor
  e. Accumulation of carbon
Turbocharger Indicators

- This indicator measures speed variation of rotor system due to non-smooth rotation.
- Degradation of overall mechanical efficiency of turbine, compressor, and rotor shaft and increase of power loss of engine due to:
  a. Bearing
  b. Friction
  c. Mechanical problems in rotor system
  d. Low oil pressure
  e. Interruption in oil supply
Alpha System Applications

Diesel Engines
Diesel Engines: Installation

Module consists of:
- Diesel Engine Analysis
- Alternator Analysis

Installation:
- Two MPUs to be installed on the Engine
- One MPU to be installed on the Alternator
- Current Monitoring Sensor on switchboard
Diesel Engine Indicators

OVERALL INDICATORS

- Mechanical Health
- Operating Condition
- Mechanical Stresses
- Stresses on foundation
- Torsional Angle
- Power in KW
Diesel Engine Indicators

- **Mechanical Health**
  - Snapshot of minor and major mechanical problems in the moving parts, which indicates impending damage.
  - Calculated from the wear/friction, cylinder pressure and crankshaft bearings indicators.
  - If the status of the indicator is Alarm, the engine should immediately be taken out of operation and serviced in order to avoid serious damage to the engine.

- **Operating Condition**
  - This indicator indicates efficiency of the engine with regards to fuel consumption.
  - Calculated from the injection timing and condition and compression indicators.

- **Mechanical Stresses**
  - This is an indicator of stresses on the crankshaft calculated from its instantaneous angular acceleration.
  - It can be affected by a misalignment of the main bearing or high mechanical stress on the bearings.
Diesel Engine Indicators

- This indicator responds to the global movement of the engine which is caused not by the engine itself.
- Extreme vibrations in the engine, in particular from a defective dampening element, can be detected with this indicator.
- Damage to the foundation upon which the engine is installed can influence this indicator.

- This indicator is primarily influenced by the operating condition of the engine, the load and speed, and gives an image of the BMEP.
- A significantly poor condition of the injection can be identified through a high twist angle in combination with harmonic analysis, as determined in the injection condition indicator.

- This indicator directly gives power generated by the Alternator in KW
- The green bar on the top provides a graphical representation of the load at which the condition of the bearing is considered
# Diesel Engine Indicators

## Cylinder Specific Health Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>General in %</th>
<th>1</th>
<th>4</th>
<th>2</th>
<th>6</th>
<th>3</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injection Timing</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injection Condition</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Diesel Engine Indicators

The ignition timing points of an engine (measured in degrees of the crankshaft) are monitored by this indicator.

If the measured time difference between two cylinders varies from the expected time, this is an indication of varying compression in one or more cylinders.

The cause of this time deviation is the velocity of the piston, which is dependent upon the resistance of the air pressure during the compression stroke. If there is an air leak in a cylinder, the resistance of the compression is lower and the air pressure itself is also lower, and consequently the piston velocity increases, which can affect the ignition timing.

This can occur from leakage in the cylinder caused by poor valve sealing, resulting from improper valve adjustment or a worn valve guide.

Other causes include carbon deposits on the piston rings, combustion chamber walls, or piston crown, as well as wear or damage to the liner or piston rings, or any other leak from which the compressed air can escape.
Diesel Engine Indicators

CYLINDER SPECIFIC HEALTH INDICATOR

- This indicator expresses the quality of injection timing for every single cylinder and the regularity of the power of the combustible gas on each cylinder during the power stroke.
- It is a measure of the regularity of the combustion over all cylinders.
- The indicator is derived from the amplitude of the 1st harmonic for 2-stroke engines or the 1st half-harmonic for 4-stroke engines as a fraction of the overall rotational energy.
- Poor injection leads to abnormal angular displacement of the crankshaft.
- Poor injection due to nozzle deposits, for example, typically degrades the injector spray pattern, reducing the engine’s maximum power and torque.
- If the diesel fuel at the start of injection is not sufficiently atomized, it combusts with a certain delay. A low combustion temperature at the time of the start of injection can also influence the injection timing. It is for this reason that a cold engine always shows a certain injection delay.
Diesel Engine Indicators

CYLINDER SPECIFIC HEALTH INDICATOR

- This indicator shows more serious cases of injection and is calculated in the same way as the injection timing indicator.
- Conditions which could trigger this indicator include: complete shutoff of fuel to a cylinder, no atomization of the fuel, or too much fuel delivered to a particular cylinder.
- Poor injection condition is also correlated to the twist angle. If the frequency component of the twist angle at the 1st harmonic for 2-stroke engines or the 1st half-harmonic for 4-stroke engines is exceptionally high, it is a sign of poor injection condition.
Diesel Engine Indicators

CYLINDER SPECIFIC HEALTH INDICATOR

- This indicator gives an indication of the damage and dynamic behavior of the moving parts of the engine, such as the main bearings, connecting rod bearings, and the piston assembly.
- It is calculated from the 4th stochastic moment of the angular displacement, angular velocity, and angular acceleration of the crankshaft. It can be influenced by bearing play, friction, deformation or misalignment of the rack aisle, poor lubrication, etc.
Alpha System Applications

Torque
Applications: Torque

TORQUE IS CALCULATED BY MEASURING THE PHASE SHIFT BETWEEN SENSOR A & SENSOR B
Applications: Torque

- alphatorque is used to determine static and dynamic torque on shafts of all diameters and speed ranges.

- No electronic parts have to be installed on the shaft. The system is easy to install, both on new installations and shafts that are in operation.
Torque: Indicators

- Static Torque
- Dynamic Torque
- Torsion
- Power
- Shaft Health

<table>
<thead>
<tr>
<th>Date (UTC)</th>
<th>Name [Torque]</th>
<th>Speed ± Delta</th>
<th>Torsion Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.08.2018 12:24:12</td>
<td>Propulsion Shaft</td>
<td>83 ± 3</td>
<td>1.3°</td>
</tr>
<tr>
<td><strong>Static Torque</strong></td>
<td>115 kNm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dynamic Torque</strong></td>
<td>950 Nm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Torsion</strong></td>
<td>0.8°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Power

- 1.7 MW

Shaft Health

- 58% WARNING
Torque: Indicators

<table>
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</tbody>
</table>

Static Torque: 115 kNm
Dynamic Torque: 950 Nm
Torsion: 0.8°

**Power**
This indicator displays power transfer done by the shaft

**Shaft Health**
The shaft health is impacted by a variety of parameters like bearings, gearboxs, the propulsion system etc.
Alpha System Applications

Bearings
This indicator measures unexpected stress pulses in movement of rotating system.

Potential problems could be shocks stemming from stress on rotating shaft during operation:

- Inadequate lubrication
- Misaligned shaft
- Insufficient bearing load
alphaBEARING Indicators

- This indicator measures the stability of the speed by measuring shaft speed change in percentage.
- Potential problems could be unbalances of shaft movement due to:
  a. Broken rotor bar
  b. Mass unbalance
  c. Air gap eccentricity
Remote monitoring of plant assets

Advanced Predictive Maintenance solutions with cloud connectivity for monitoring critical equipment health on real time basis from any remote location
Remote monitoring architecture
Direct Benefits of the Alpha System

- Considerable savings in fuel consumption & overall efficiency
- Pinpoint faults during troubleshooting to trigger regular course corrections through trend monitoring
- Extend Overhaul intervals safely
- Eliminate catastrophic machine breakdowns
- Reduce Operational and Downtime costs
- Eliminate Breakdowns and the concept of overhauls completely
- Indicate overall health of the equipment
- ROI in less than six months
To know more, please contact

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