Fault Detection and Diagnosis of Ball Bearing Using Advanced Vibration Analysis Techniques

Introduction
The antifriction bearing vibration measurement is one of the most challenging tasks in regular use. By measuring the velocity, acceleration, and frequencies emitted from a rolling bearing, it is possible to tell its condition and the prospect of imminent failure.

Bearing Fault Characteristic Frequencies
The bearing characteristic defect frequency (BCF) depends on the geometry of the bearing.

Outer race fault frequency
\[ f_{ORF} = \frac{N_b}{2} f_A \left[ 1 - \frac{D_B}{D_P} \cos \theta \right] \] (1)

Inner race fault frequency
\[ f_{IRF} = \frac{N_b}{2} f_A \left[ 1 + \frac{D_B}{D_P} \cos \theta \right] \] (2)

Where
- \( N_b \): number of balls
- \( f_A \): shaft rotational frequency (Hz)
- \( D_B \): ball diameter (mm)
- \( D_P \): Pitch circle diameter (mm)
- \( \theta \): contact angle between inner and outer races – 0° (because there is no axial load).

<table>
<thead>
<tr>
<th>Load</th>
<th>Shaft Speed (Hz)</th>
<th>Inner Race (Hz)</th>
<th>Outer Race (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: 0</td>
<td>24.9341</td>
<td>135.2487</td>
<td>89.1582</td>
</tr>
</tbody>
</table>

Test Facilities and Bearing Faults

1. Flexible Couplings
2. Bearing house
3. Vertical Sensor
4. Horizontal Sensor
5. Load gauge

Conclusion
➢ The initial result shows that the envelope analysis spectrum is powerful to detect, diagnosis, and prognosis faults on the bearings.

➢ The bearing faults were significantly detected and diagnosed in both the inner race and outer race, which is the frequency value of the inner race fault is identified clearly at 134.8 Hz. Furthermore, this frequency value is very close to the calculated value at 135.2487 Hz.

➢ The frequency value of the outer race fault are identified clearly at 90.08 Hz. Furthermore, this frequency value is very close to the calculated value at 89.1582 Hz.

Future Work
➢ Perform and carry out some further experiments to study and investigate the performance of vibration signal analysis.

➢ Study and understand signal processing method such as (Empirical Mode Decomposition (EMD) and Cyclic Autocorrelation Function (CAF)).