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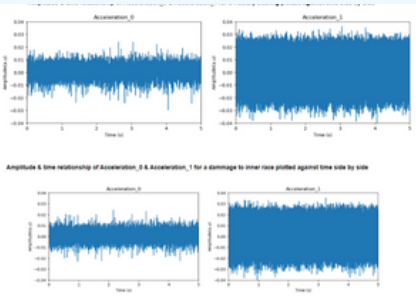
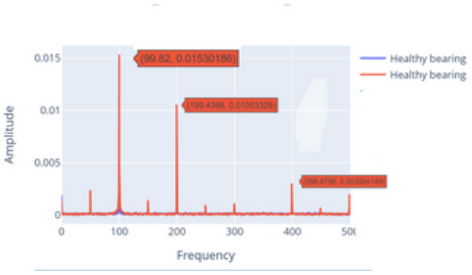
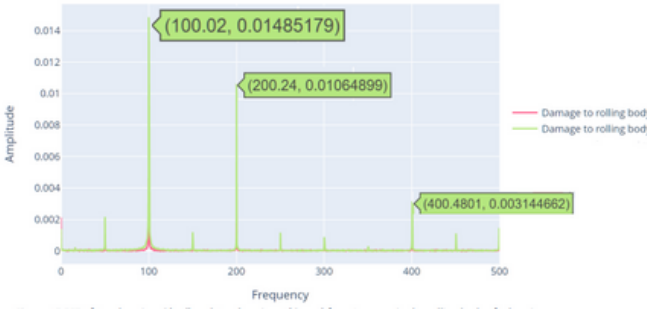
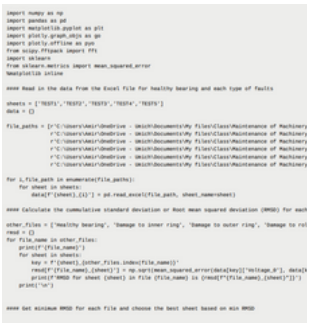
FAILURE ANALYSIS FOR PREDICTIVE & PREVENTIVE MAINTENANCE OF MACHINE ELEMENTS

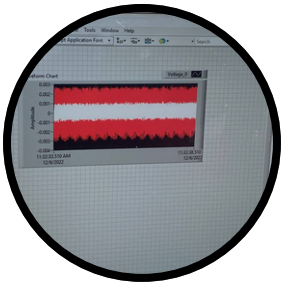
A. ROLLER BEARINGS











What?

- Investigated and analyzed roller bearing failures to detect underlying machinery issues. Utilized vibration analysis and conducted 4 experiments simulating different bearing damanges.

How?

- Used **PT 500.12 Rolling Element Bearing Faults Kit**.and collected vibration data using **As-020 sensor** with a sensitivity of **100mV/g** and LabVIEW.
- Data was pre processed to remove outliers and voltage data was converted to acceleration data
- Applied **Fast Fourier Transform (FFT)** for frequency-domain analysis and finally visualized results using Matplotlib and Plotly.

Results

- Healthy bearing showed low amplitude (baseline) and high-frequency vibration. with a consistent drop in amplitude from **2.5 at 0Hz** to **0.5 at 400 Hz** was observed
- Damage frequencies repeated for harmonics and increased in magnitude compared to healthy bearing with large sidebands due to alternating load zones indicating an inner race damage.
- For outer race damage number of harmonics increased with severity from **4 to 0 Hz** to **10 to 400 Hz**
- Roller element damage showed irregularities due to roller body not always passing the damage point. But frequency and harmonics with side bands were observed
- Highlighted limitations of FFT, particularly in non-periodic signals.

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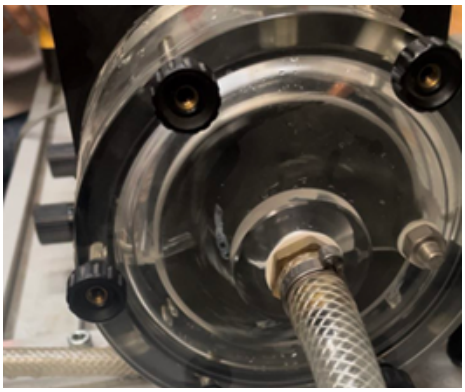
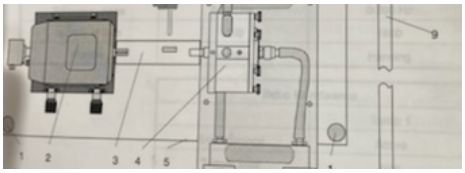
B. CENTRIFUGAL PUMP





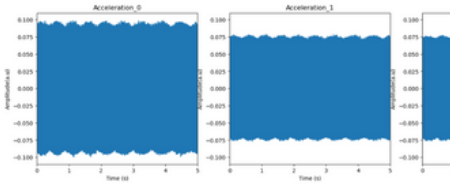
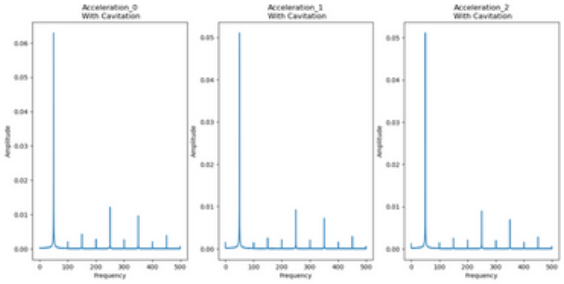
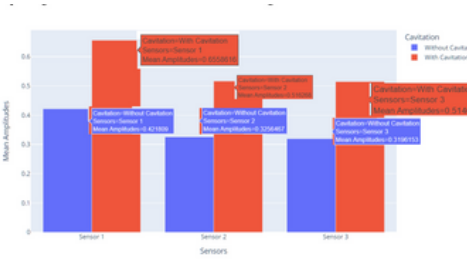
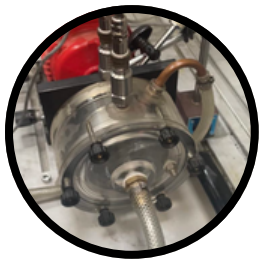


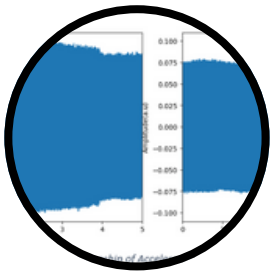
Figure 2Amplitude & time relationship of Acceleration_0, Acceleration_1 & Acceleration_2 for a pump with

Figure 3 FFT Result across all the 3 sensors summarized using Plotly library









What?

- Investigated pump condition focusing on cavitation effects by measuring frequency, amplitude, and direction of vibration during pump operation at **2500 rpm**.

How?

- Used **PT 500.12 cavitation in pumps kit,Bruel & kjaer Vibro equipment**, and NI USB 4431 for data collection
- Mounted a **centrifugal pump** with vibrational sensors and collected data through LabView.
- Connected pump inlet and outlet tubes to a water bucket with both intake and outlet tubes fully submerged, using tap water as a working fluid.
- Gradually reduced intake valve openings to induce cavitation and monitored inlet and outlet valve pressures.
- Recorded amplitude and time relationships with sensors during pump operation and applied FFT analysis to understand frequency content.

Results

- The results reveal significant differences in amplitude-time relationships during normal pump operation **(1-2 m/s^2)** compared to cavitation conditions (**4-6 m/s^2**), indicating potential issues.
- The FFT analysis demonstrated a lower amplitude in the frequency domain during cavitation. Mean amplitude values for sensors under cavitation further highlighted variations: Sensor 1 showed **2 m/s^2** in normal operation and **4.5 m/s^2** during cavitation, Sensor 2 had **1.8 m/s^2** (normal) and **3.8 m/s^2** (cavitation), while Sensor 3 exhibited **2.2 m/s^2** (normal) and **4.2 m/s^2** (cavitation).
- These quantifiable metrics provide insights into the impact of cavitation on pump vibrational signals, aiding in risk mitigation and damage prevention.