Development of Vibration Detection Analysis

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Project Investigation

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Location: UJ on Empire (8th floor)

CONTENT

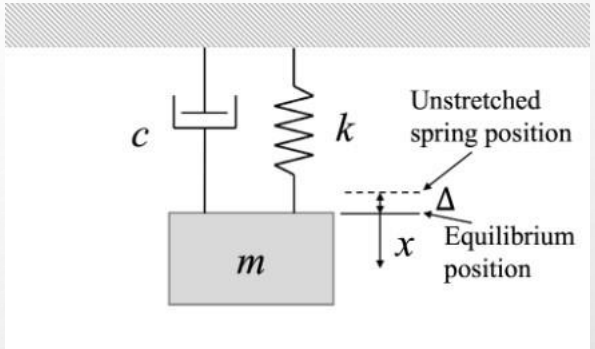
- Introduction
- Aim and problem statement
- Methodology
- Experimental design
- Conclusion

INTRODUCTION

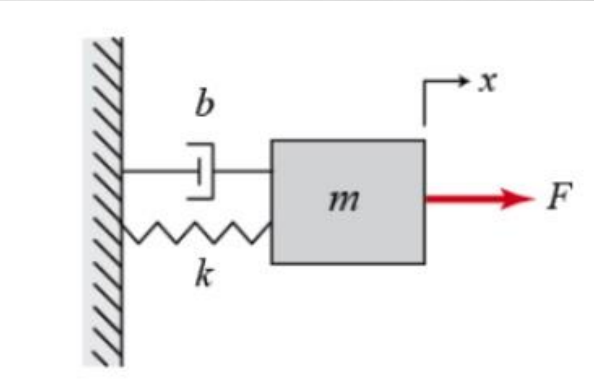
- Vibrations may be defined as an oscillatory motion of a system.
- Two common types of vibration
  - ➢ Free vibration (damped)
    - $m\ddot{x} + c\dot{x} + kx = 0$

    Where $m = mass$ of the system, $\ddot{x} = acceleration$, $c = damping\ coefficient$, $\dot{x}$ = velocity, k = spring stiffness, x = displacement
  - ➢ Forced vibration (damped)
    - $m\ddot{x} + c\dot{x} + kx = F_o \cos(\omega t)$

    Where $F_o = amplitude\ of\ the\ external\ force$, $\omega = forcing\ frequency$



Free vibration



Forced vibration

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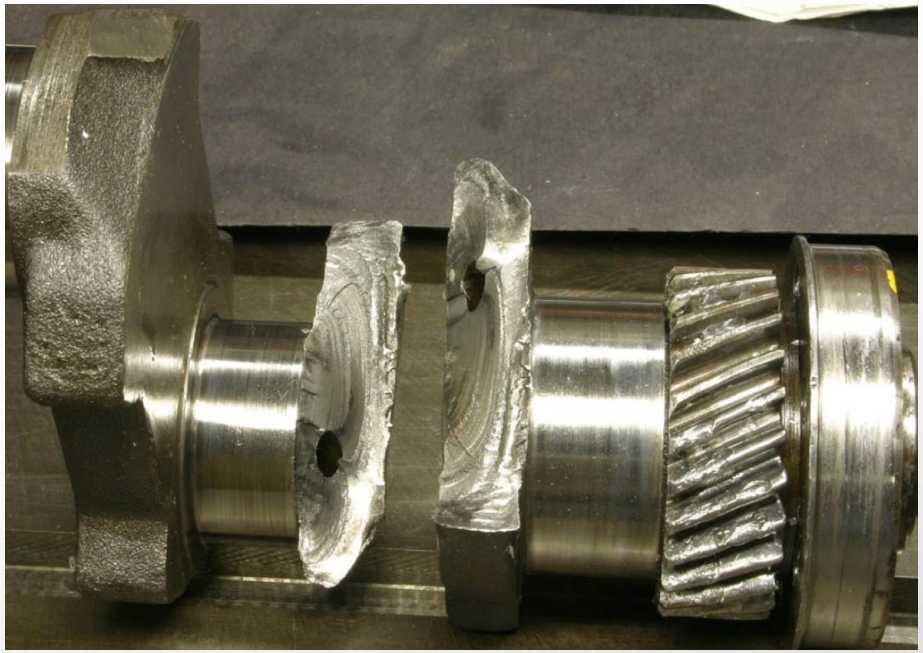
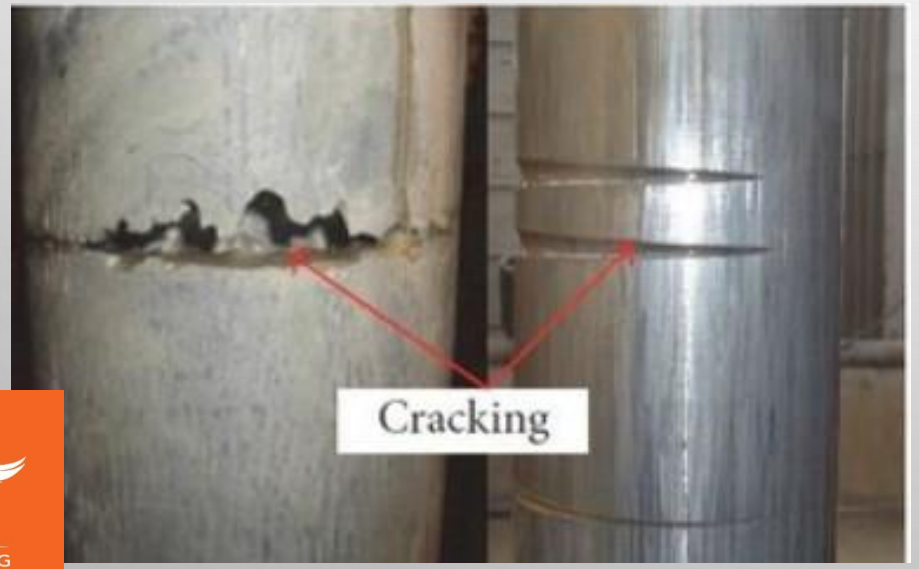
Introduction Cont..

- Vibration monitoring is crucial in industries such as manufacturing, civil engineering, and aerospace.
- Benefits of vibration monitoring:
  - Ensures safety.
  - Early fault detection.
  - Prevents downtime.
  - Saves money.




Cracking


Buckling

Vibration Measurement Techniques

Accelerometer

- Measure acceleration directly via Micro-electro-mechanical Systems (MEMS) or piezoelectric sensors.
- Advantages
  - ➢ Compact and cheap
  - ➢ Accurate
- Disadvantages
  - ➢ Very sensitive to noise

Laser Doppler Vibrometer

- Use Doppler effect to detect surface motion.
- Advantages
  - ➢ Non-contact
  - ➢ High precision
- Disadvantages
  - ➢ Expensive
  - ➢ Not suitable for all surfaces

Strain Gauges

- Measure strain, indirectly infer vibration.
- Advantages
  - ➢ Good for structural analysis
- Disadvantages
  - ➢ Limited frequency range

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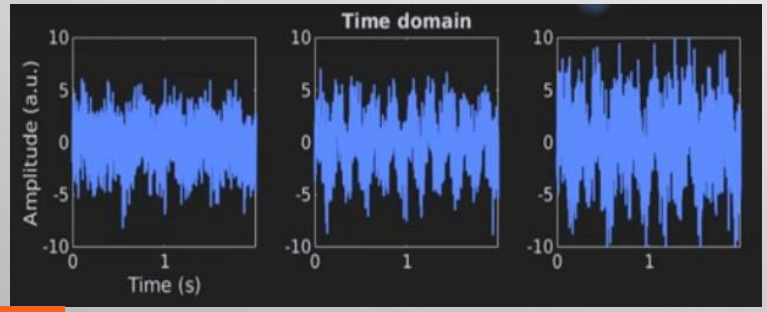
Types Of Vibration Analysis

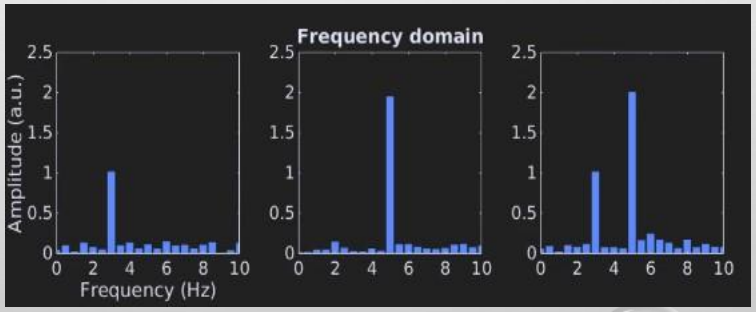
Time-domain Analysis

- This technique evaluates raw vibration signals from waveforms.
- It identifies transient events, tracks vibration levels, and sets operational limits.



Frequency-domain Analysis

- This technique typically utilizes the Fast Fourier transform (FFT) to convert time-domain signals into frequency-domain.



Vibration Modal Analysis

- An advanced method that pinpoints a machine's natural frequencies aiding in understanding the machine's dynamic behavior and potential structural or resonance issues.

Aim and Problem Statement

- Aim
  - To measure the acceleration data on a shaft using an accelerometer and analyze data/ create a data analysis technique that is more reliable.
- Problem statement
  - MEMS accelerometers commonly used.
  - Chosen for low cost and ease of use.
  - Vibration data often not fully analyzed.
  - Need for better vibration analyzing tools.

Methodology

- The following steps will be followed to conduct the experiment

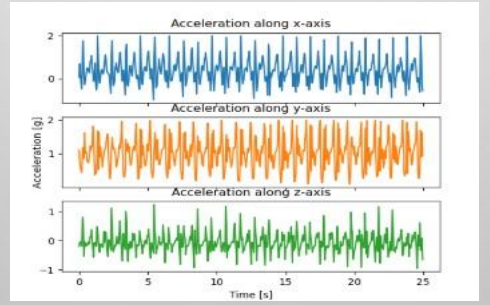
Building a shaft test rig

Select suitable accelerometer

Data acquisition (Using Arduino)

Data filtering and noise reduction

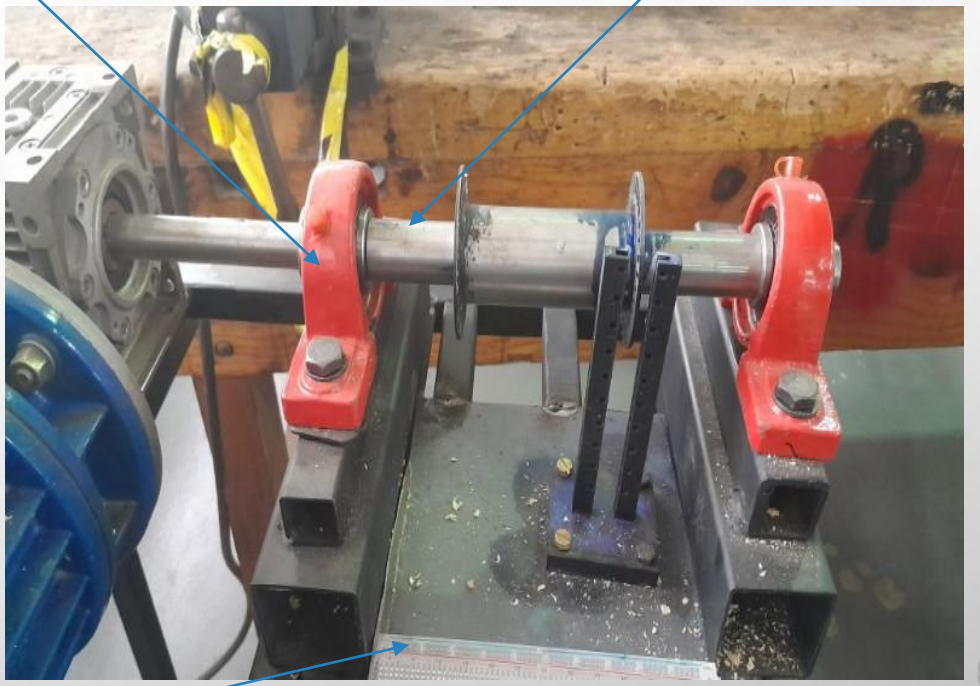
Visualization (acceleration plots)



Data analysis

Experimental Design

- Aim of the experiment
  - ➢To collect acceleration data on a rotating shaft obtained by using an accelerometer.
- Independent variables
  - ➢ Position of accelerometer on a shaft.
  - ➢ Rotational speed of the motor.
  - ➢ The induced damaged (Crack).



Experimental Design Cont…

- Dependent variable
  - Acceleration
- Controlled variables
  - Type of MEMS accelerometer to be used.
  - Bearing and support setup.
  - Sampling frequency.
    - The sampling frequency will be determined by bandwidth of an accelerometer.
  - Shaft geometry.

Test	Shaft speed (RPM)	Damage
1	100	Healthy
2	100	Healthy
3	100	Healthy
4	150	Healthy
5	150	Healthy
6	150	Healthy
7	250	Healthy
8	250	Healthy
9	250	Healthy

Test	Shaft speed (RPM)	Damage
10	100	Crack
11	100	Crack
12	100	Crack
13	150	Crack
14	150	Crack
15	150	Crack
16	250	Crack
17	250	Crack
18	250	Crack

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Conclusion

- MEMS accelerometers are cost-effective and suitable for small-scale applications.
- ADXL 345 accelerometer will be used for the experiment to obtain the accelerations.

Any Questions?

THANK YOU