EXPERIMENT NO:06
WHIRLING OF SHAFT

Aim
To determine critical speed or whirling speed of a rotating shaft and to verify the value theoretically

Apparatus
- Shafts
- variable
- speed motor

THEORY:

Whirlingspeed is also called as Critical speed of a shaft. It is defined as the speed at which a rotating shaft will tend to vibrate violently in the transverse direction if the shaft rotates in horizontal direction. In other words, the whirling or critical speed is the speed at which resonance occurs.

At certain speed, a rotating shaft has been found to exhibit excessive lateral Vibrations (transverse vibrations). The angular velocity of the shaft at which this occurs is called a critical speed or whirling speed or whipping speed.

The frame will support motor, sliding block and shafts. When the gears or pulleys are mounted on a shaft the center of gravity of the mounted element does not coincide with the center line of the bearing (or) axis of the shaft. Due to this the shaft is subjected to a centrifugal force. This further increases the distance of center gravity from the axis of rotation and hence the centrifugal force increase this effect is cumulative and ultimately the shaft fails.

At critical speed the shaft deflection becomes excessive and may cause permanent deformation or structural damage. Hence a machine should not be operated close the critical speed. To determine critical speed of a shaft which may be subjected to point loads. UDL or a combination of both, since the frequency of
transverse vibration is equal to critical speed in rps, calculate the frequency of transverse vibration

**PROCEDURE:**

1. Fix the shaft properly at both ends
2. Check the whole apparatus for tightening the screw etc.
3. First increase the voltage slowly for maximum level and then start slowing down step by step
4. Observe the loops appearing on the shaft and note down the number of loops and the speed at which they are appearing
5. Slowly bring the shaft to rest and switch off the supply.
6. Repeat the same procedure for different shaft
7. since both the ends have double ball bearing hence both the ends are assumed fixed.

**FOR UNIT LENGTH**

φ 4mm - 0.096Kg/m

φ 5mm - 0.16Kg/m

φ 6mm - 0.24Kg/m

**TABULAR COLUMN**

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<thead>
<tr>
<th>SL NO</th>
<th>END CONDITION</th>
<th>DIA OF SHAFT (mm)</th>
<th>SPEED (RPM)</th>
<th>ANGULAR SPEED</th>
<th>SPEED (THEO)</th>
<th>% ERROR</th>
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<td>BENDING</td>
<td>TWISTING</td>
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FORMULA USED

1. For bending mode

Angular speed ($\omega$) = \( \frac{22 \times a}{L^2} \)

Where \( a = \sqrt{\frac{E \times I}{M}} \)

Theoretical speed = \( \frac{\text{Angular speed } (\omega) \times 60}{2 \times \pi} \)

% error = \( \frac{\text{theo. speed} - \text{expt speed}}{\text{theo. speed}} \times 100 \)

1. For twisting mode

Angular speed ($\omega$) = \( \frac{61.7 \times a}{L^2} \)

Where \( a = \sqrt{\frac{E \times I}{M}} \)

Theoretical speed = \( \frac{\text{Angular speed } (\omega) \times 60}{2 \times \pi} \)

% error = \( \frac{\text{theo. speed} - \text{expt speed}}{\text{theo. speed}} \times 100 \)
**TERMS USED**

E → Youngs modulus of the material = $2 \times 10^{11}$ Gpa

m → mass of the shaft = Kg/m

L → length of the shaft = m

d → dia of the shaft in m

I → moment of inertia of the shaft in m$^4 = \frac{\pi d^4}{64}$
RESULT:-