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EXPERIMENT NO. 9

NAME OF EXPERIMENT: TO DETERMINE THE FREQUENCY OF A.C. MAINS USING A SONOMETER

APPARATUS REQUIRED

1. Sonometer
2. Spring balance
3. Physical balance
4. Horseshoe magnet
5. kg. weight
6. Stepdown transformer

THEORY

When the wire resonates the frequency (f) of the mains is equal to the frequency of vibration of the spring. Then,

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

where, μ = mass per unit length (m/l)

T = Tension on the wire

So,

$$f = \frac{1}{2l}\sqrt{\frac{T}{m/l}} \quad \text{---------- (i)}$$

Since,

$$\frac{m}{l} = \frac{\rho V}{l} = \frac{\rho . A . l}{l} = \frac{\pi d^2}{4} . \rho$$

Putting the value in eqn (i)

$$f = \frac{1}{2l}\sqrt{\frac{T}{\frac{\pi d^2}{4} . \rho}} = \frac{1}{2l} \times \frac{2}{d}\sqrt{\frac{T}{\pi \rho}}$$

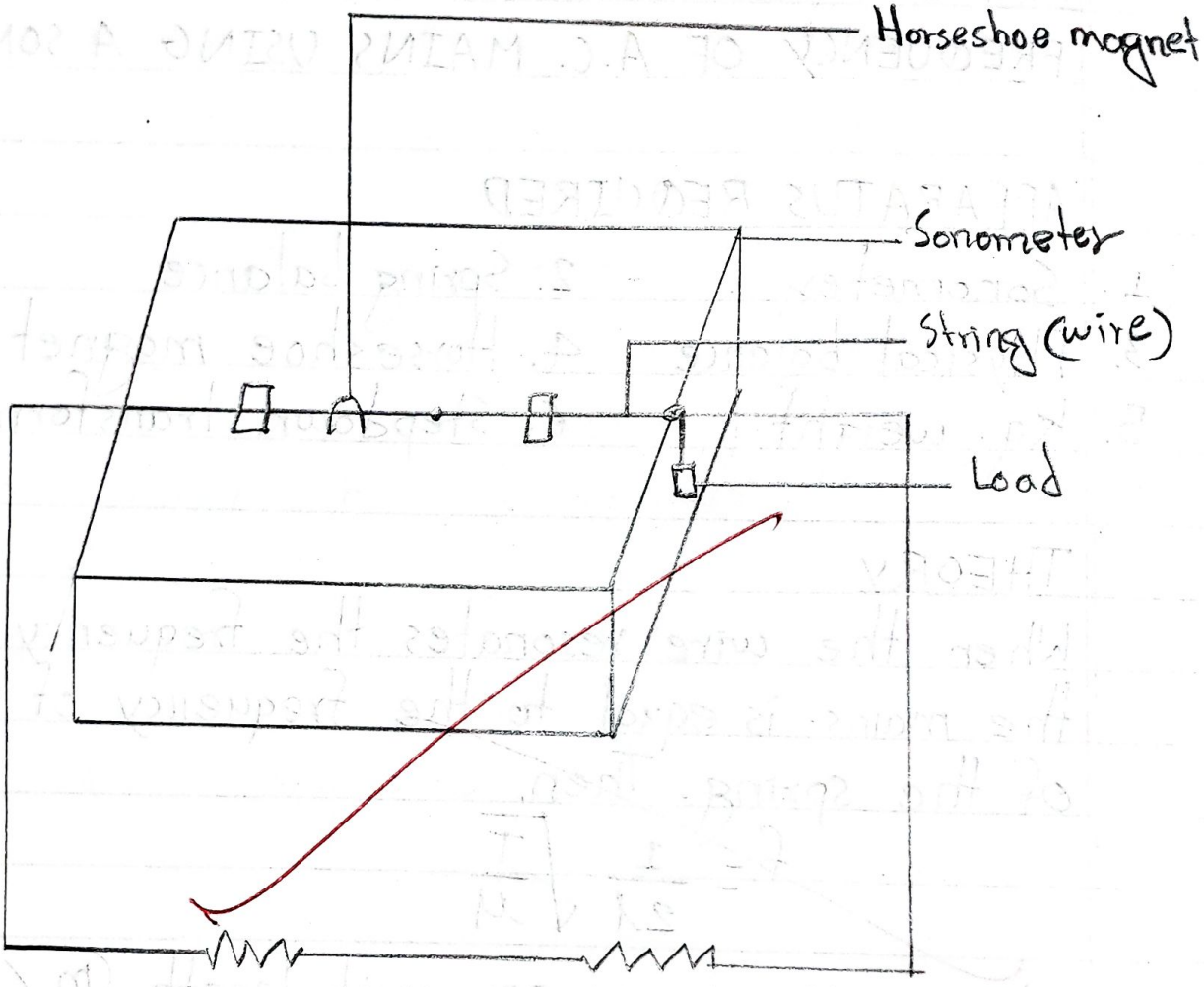

fig. Sonometer

$$f = \frac{1}{d\sqrt{\pi s}} \cdot \frac{\sqrt{T}}{l}$$

$$\therefore f = \frac{1}{d\sqrt{\pi s}} \cdot \frac{\sqrt{mg}}{l} \quad [\because T = mg]$$

Where, $\frac{1}{d\sqrt{\pi s}}$ is a constant.

PROCEDURE

1. The sonometer was placed on the table and the string was stretched.
2. The horse shoe magnet was placed on the box in exactly mid way between the bridge and poles perpendicular to the place of wire.
3. The step down transformer was connected across the wire with a secondary voltage of 6V.
4. A load was placed on the initial mass hanged to the string and the position of bridges were adjusted to get the max frequency.
5. The distance of bridges i.e. resonating length and mass hanged on string wire was noted.
6. Steps (4) and (5) were repeated by adding masses two more times.
7. The diameter of the wire was measured with the help of screw gauge.

OBSERVATIONS

In micrometer screw gauge,
0 lies in 7 division up the lines
least count (d) = 0.01 mm
∴ Error = 7 × 0.01 = 0.07 mm
Diameter of wire (d) = 0.46 mm
∴ Actual diameter = (0.46 + 0.07) mm
= 0.53×10^{-3} m
Density of wire (ρ) = 8400 kg/m³.

OBSERVATION TABLE

No. of Obs.	Weight on scale in kg	Total load in 'N' T = m.g (g = 10m/s)	Resonating length (l)	Frequency 'f' Hz	Mean (m) frequency Hz
1.	0.5035 kg	5.035 N	0.5 m	51.65	
2.	1.0035 kg	10.035 N	0.7 m	52.08	52.07 Hz
3.	1.5035 kg	15.035 N	0.85 m	52.50	

CALCULATIONS

1. $f_1 = \frac{1}{d\sqrt{\pi\rho}} \times \frac{\sqrt{T}}{l}$

$= \frac{1}{0.53 \times 10^{-3} \sqrt{\frac{22}{7} \times 8550}} \times \frac{\sqrt{5.035}}{0.5}$

$= 11.51 \times \frac{\sqrt{5.035}}{0.5}$

$= 51.65$ Hz

2. $f_2 = \frac{1}{d\sqrt{\pi s}} \times \frac{\sqrt{T}}{l} = 11.51 \times \frac{\sqrt{10.035}}{0.7} = 52.08\ Hz$

3. $f_3 = \frac{1}{d\sqrt{\pi s}} \times \frac{\sqrt{T}}{l} = 11.51 \times \frac{\sqrt{15.035}}{0.85} = 52.50\ Hz$

$\therefore$ Mean (m) frequency (obs.) $= \frac{f_1 + f_2 + f_3}{3}$

$= \frac{(51.65 + 52.08 + 52.50)\ Hz}{3}$

$= \frac{156.23\ Hz}{3}$

$= 52.07\ Hz$

Frequency observed (f_{obs}) = 52.07 Hz

Frequency standard (f_{stnd}) = 50 Hz

$\therefore$ Error % $= \frac{f_{obs} - f_{stnd}}{f_{stnd}} \times 100\%$

$= \frac{52.07 - 50}{50} \times 100\%$

$= 4\%$

RESULT

Hence the frequency of AC mains was found to be 52.07 Hz.

PRECAUTION

1. Wire of uniform thickness should be used.
2. Resonating length should be measured carefully.

Sagarmatha