Violation of the Equilibrium of Working Bodies Causes Torsion of the Suspension Thread

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Abstract

This study demonstrates experimentally that a suspension thread can undergo torsional motion when the mass or spatial configuration of the working bodies in a torsion system is altered. Two experimental setups are proposed to investigate thread twisting caused by disrupting the mechanical equilibrium through changes in the effective arm length of the working bodies.

Keywords: suspension thread, torsional motion, thermal expansion, working arm length, mass variation.

1. Introduction

Torsion balances and related devices are widely used to measure extremely small forces. In such systems, even slight disturbances of equilibrium can lead to measurable rotational motion.

This study considers two mechanisms capable of producing torsion in a suspension thread:

1. Changing the effective length of the working arm.
2. Changing the mass distribution of the working bodies.

Both mechanisms modify the torque acting on the system and may produce rotation that is independent of the primary physical effect being measured.

2. Effect of Changing the Working Arm Length

2.1. Description of the Torsion Device

The torsion device (Fig. 1a) consists of a suspension thread *T* and a horizontal rod with endpoints O_1 and O_2. Each endpoint carries a pair of spheres: *Kw1, Kb1* on one side and *Kw2, Kb2* on the other. The spheres have equal masses but are made of a material that exhibits thermal volumetric expansion.

Initially, all spheres are positioned symmetrically at equal distances from O_1 and O_2.

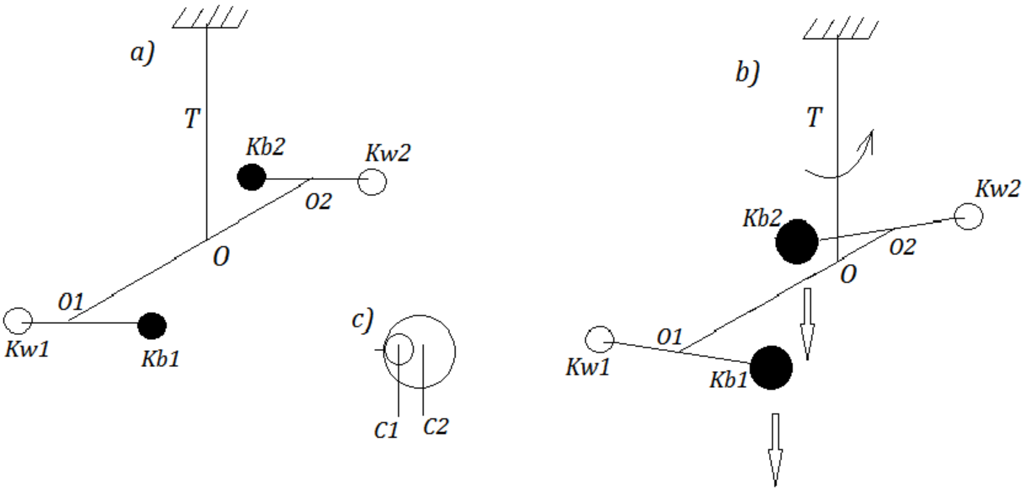

Fig. 1

2.2. Thermal Expansion and Resulting Torque

When spheres *Kb1* and *Kb2* are heated, their radii increase. As a result, the distances (*Kb1*, O_1) and (*Kb2*, O_2) become greater than those of *Kw1* and *Kw2*.

This asymmetry produces buoyant-force–induced tilting of the rods (*Kw1–Kb1*, *Kw2–Kb2*) in accordance with Archimedes' principle (Fig. 1c).

The tilt acts like a screw mechanism and generates torsion in the thread *T*, as shown in Fig. 1b.

3. Proposed Experiments

Experiment 1: Heating in a Vacuum Chamber

The torsion device is placed inside a vacuum chamber (Fig. 2). Radiative heat sources *S1* and *S2* are directed at the black spheres *Kb1* and *Kb2*.

The goal is to isolate thermal-expansion-induced torque from air-convection effects.

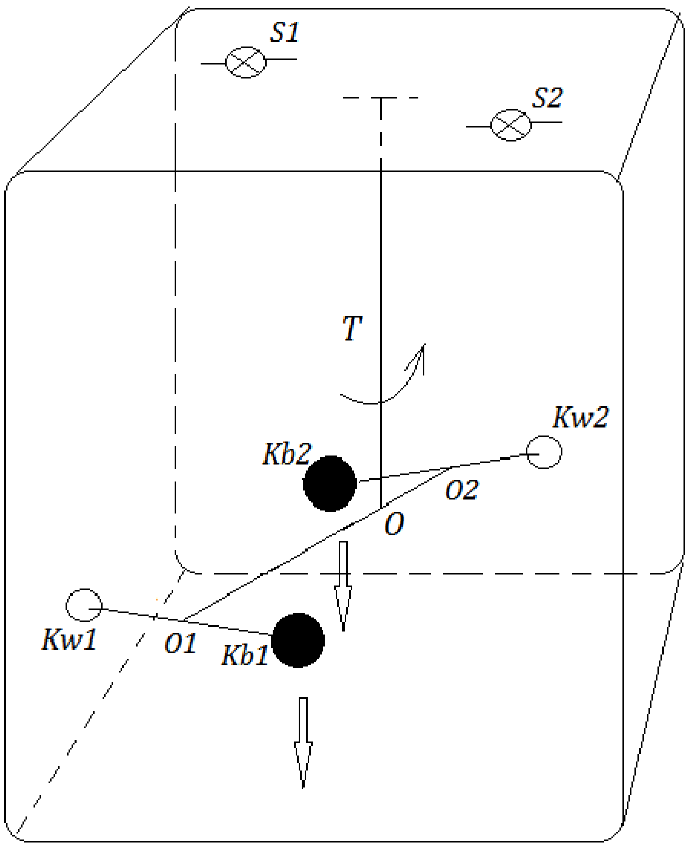

Fig. 2

Experiment 2: Heating of Black Plates

A modified apparatus similar to that used in classical measurements of light pressure is employed (Fig. 3). Instead of spheres, black plates are heated electrically, causing thermal expansion and subsequent asymmetry in the working arm lengths.

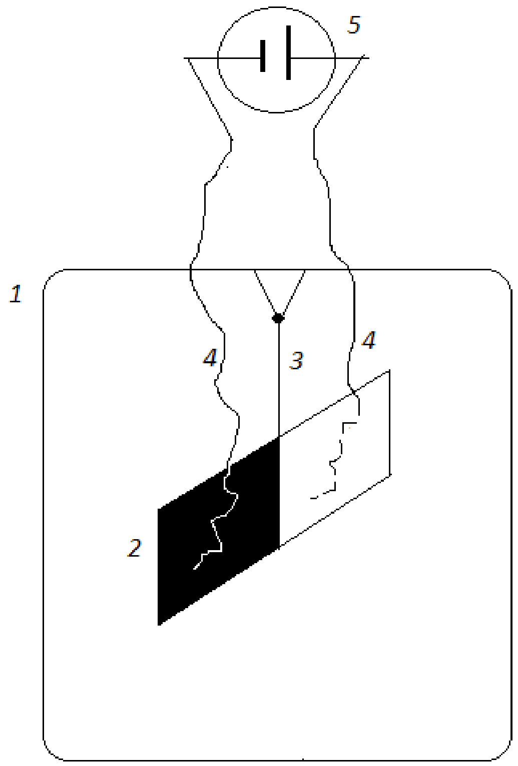

Fig. 3

4. Effect of Changing the Mass of Working Bodies

4.1. Control Experiment

The torsion device is submerged in a water-filled vessel equipped with a drain valve (Fig. 4).

The containers serving as working bodies fill completely with water. After the valve is opened, the water drains from the vessel, but the device remains stationary (Fig. 6).

4.2. Mass-Changing Experiment

In a second trial, holes are made in two containers positioned diagonally (Fig. 5).

After submersion, the containers again fill with water.

When the valve is opened, water drains not only from the vessel but also from the perforated containers.

The resulting time-dependent change in mass distribution produces a net torque that causes rotation of the device (Fig. 7).

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Videos confirm the effect:

* In video [3], containers without holes produce no rotation.

* In videos [1, 2], rotation around the suspension thread *T* is clearly observed.

5. Conclusions

If torsional motion of the suspension thread is observed in Experiments 1 and 2, this effect must be taken into account when interpreting measurements obtained with torsion-based instruments.

Unintended changes in working-body arm length or mass distribution can introduce spurious torques that resemble genuine physical effects.

References

1. (Video) https://drive.google.com/file/d/12ZCo6JbCFpn-o9sMZsxy9OgUzscEafEP/view?usp=sharing

2. (Video) https://drive.google.com/file/d/1c6GPdof_wGG2fDKNl7qBYCgze5x7iA9w/view?usp=sharing

3. (Video) https://drive.google.com/file/d/1JVccOLug734z8uSj9hPj_Owg2ETtNDXb/view?usp=sharing