Name(s)

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Project Number

J0113

Project Title

The Effect of Vane Tilt Angles on the Speed of a Revolving Lantern

Abstract

Objectives/Goals

This project is to study how the vane tilt angles of a revolving lantern affect its rotational speeds through experimental study, data analysis, and modeling.

Methods/Materials

Data generation in this project is by direct measurement of rotation period at various vane tilt angles from 15-degree to 120-degree, a stop watch is used to measure the rotation periods. The end point is the rotational speeds, which are converted from rotation periods. Additional experimental groups include different numbers of vane blades, different percentages of top surface opening, different wattages of light bulbs, and different distances between the light bulb and the lantern top. The materials used in this project include paper, wires, light bulbs, snap buttons, stop watch, thermal image camera, and convective flow simulator.

Results

Thermal images show that the light bulb heats up the surrounding air and the warm air exits through the top openings. Convective flow simulation shows the exiting warm air approaches the blades and then deflects away, out of the openings at the top of lantern. The control experiment shows the rotational speed decreases from 30-degree to 90-degree, while no motion is observed for 120-degree. Slight increase in rotational speeds is observed from 15-degree to 30-degree. Similar trends are also observed in various experimental groups. The effective force for rotation correlates to the blade angles in several aspects: the normal force exerted on the blade, its horizontal component for rotation, and the effective blade area for the oncoming air current. This leads to a relation which shows that the effective force for rotation is proportional to sin(tilt angle) x [cos(tilt angle)]^2, and the rotational speed decreases accordingly at large tilt angles.

Conclusions/Discussion

The experimental results support my hypothesis that the rotational speed decreases at large tilt angles. The relation of sin(tilt angle) x [cos(tilt angle)]^2 gives a good approximation to the trend of decreasing rotational speeds at large tilt angles. It is interesting to see the lantern rotates even at 90-degree when cos(90-degree) equals to zero. Therefore additional factors may be involved, and further studies at higher tilt angles will elucidate these factors and provide closer theoretical approximation to experimental results.

Summary Statement

The experimental results show that the rotational speed of the lantern decreases from 30 to 90 degrees tilt angles, further data analysis shows the effective force for rotation is proportional to sin(tilt angle) x [cos(tilt angle)]^2.

Help Received

None.