Load Cell Module

Engineering Question

Understanding vehicle performance is an important part of engineering. How would an engineer measure the amount of payload a quadcopter could carry?

Objectives

Students shall demonstrate the ability to use an instrumented load cell to measure the lift produced by a small quadcopter.

Students shall demonstrate the ability to use a calibrated load cell to measure:

a. Static weight of a quadcopter
b. Lift produced by a quadcopter
c. Dynamic loading produced by a quadcopter

Knowledge needed: students should complete the Bending Load & Calibration Module before working on this module.

Definitions

Load cell: A load cell is a specific type of transducer that is used to create an electrical signal that is directly proportional to the force being measured.

Transducer: a transducer is a measuring device that converts variations in a physical quantity into a measureable quantitate. A mercury-in-glass thermometer is a simple example of a transducer, and so is a strain gage.

Quadcopter: something that can be fun to play with in this lab.

Instrumented helipad: The transducer (load cell) in this lab is an instrumented beam. The beam deflects an amount proportional to an applied force. The deflection causes a change in resistance in a strain gage, and finally, the strain indicator uses a Wheatstone bridge to convert the change in resistance and gage factor into a strain reading. (It is common for there to be many different parts to a single measurement device).

Background

Everyone has used a scale to weigh something; themselves, quantities in a chemistry lab, etc. However, often times in engineering, special apparati are needed to achieve the desired measurement. In a previous module, you learned to calibrate an instrumented beam in order to measure applied forces. This laboratory module is meant to help students learn to apply that knowledge in a unique engineering situation.

A normal weight-scale is not properly designed to measure the lift produced by a helicopter. This module includes a calibrated load cell (a cantilever beam, very similar to what you used in the bend load & calibration module). This load cell has been designed specifically for measuring the weight and lift of a small quadcopter.

Materials and Supplies

- An instrumented "helipad" (including calibration factor)
- 50 g and 100 g "pseudo-certified" weights
- P3-strain indicator
- A standard weight-scale
- One fully functioning quad-copter

Procedures

1) Zero the weight-scale then check the calibration of the weight-scale by weighing two different "pseudo-certified" weights (50g, 100g). Enter the values in Table 1. (We will use grams as a measure of "weight" and lifting "force").
2) Using the weight-scale, weigh the quadcopter. Record weight in Table 2.
3) Since the weight-scale cannot measure upward force, we need to "trick" the scale. Remove the quadcopter from the scale and place a 100g weight on the scale. Zero the scale. Place the quadcopter on the scale, attaching it to the Velcro® (it should indicate that it weighs the same as it did in step 2). Gradually increase power until full-speed is reached. The weight indicated on the scale should be negative (upward force). Record that value in Table 2.
4) Zero the strain indicator attached to the helipad.
5) Check the calibration of the helipad by weighing two different "pseudo-certified" weights (50g, 100g). Enter the values in Table 3.
6) Place the quadcopter on the helipad.
7) Measure the strain produced by placing the quadcopter on the pad. Using the calibration factor, determine the weight as measured by the helipad's load cell. Record this in Table 4.
8) Gently, throttle-up the quadcopter until it is at maximum power and measure the strain produced during full power. Calculate the lift produced and record that in Table 4.
9) Now for fun, try to get the quadcopter/beam to "bounce" by increasing and decreasing the power (do **NOT** touch the quadcopter or instrumented beam). Have fun, but don't get too carried away. You do not need to record data.

Post-lab questions:

1) Determine the percent difference between the weight as measured by the scale and the instrumented helipad. Why do they differ and comment on which one is correct. (Hint, this may in-part be a trick question).
2) Determine the percent difference between the lift as measured by the scale and the instrumented helipad. Why do they differ? Is the difference nearly the same between the lift measurements as compared to the weight measurements? Are the differences due to measurement error? Think about this from an engineering perspective – always ask yourself what it is you are really measuring. One of the biggest danger with interpreting data is that you may not really be measuring what you think you are measuring!
3) What caused the beam to deflect more dynamically (step 9) than it did quasi-statically (step 8)? Is the quadcopter really producing more lift? What is meant by "resonance"?

ORIGINAL DATA SHEET

Lab title: Force Measurement   Date conducted:____________Location__________
I actively participated in the collection of this data. The information contained here has not been falsified and to the best of my knowledge correctly records the data obtained in lab.

Print name:______________________Signature:___________________________

Table 1 – calibration data for weight-scale

Calibration weight	**Measured weight**
0g	
50g	
100g	

Table 2 – quadcopter “forces” using weight-scale

Quadcopter weight, g	
Quadcopter lift, g	

Table 3 – calibration data for helipad

Helipad number	
Calibration factor (grams/$\mu\varepsilon$)	

Calibration weight	**Strain indicated ($\mu\varepsilon$)**	**Weight (g)**
0g		
100g		
200g		

Table 4 – quadcopter forces using instrumented helipad

Strain produced by quadcopter’s weight ($\mu\varepsilon$)	**Quadcopter weight (g)**
Strain produced during full power ($\mu\varepsilon$)	**Quadcopter lift (g)**