1. Background

The motion of the damper can be modeled with a classic equation.

$$F = m\ddot{x} + c\dot{x} + kx$$

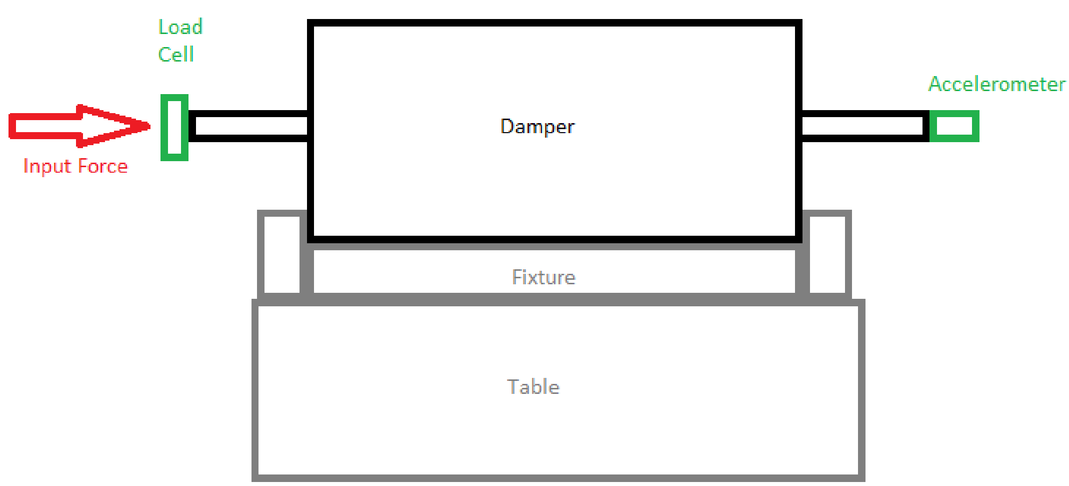
Constants: m is the mass of the moving portion of the damper, c is the damping constant, and k is the spring constant of the system.

Variables: F is the input force to the system. Meanwhile $\ddot{x}$, $\dot{x}$, and x are acceleration, velocity, and displacement of the damper respectively.

The objective of testing is to find the damping constant c.

2. Method: Shaker Table

Consider the following cartoon.



The damper is attached to a granite isolation table using a fixture (ours was built from 80-20 aluminum stock parts). The shaker used in the vibration lab, located in room 09-2230, provided the input force to the damper.

2.1. Measurements:

2.1.1. Constants other than c:

m: found by weighing the rod-and-vane assembly that would be moving using a calibrated scale. Performed before or separately from the shaker testing.

k: spring constants can be found by exposing the spring to a known static force (a hanging weight) and measuring the displacement. Repetitions at different weights provide statistically meaningful data. Dividing the imposed force by the resulting displacement yields the k value.

2.1.2. Variable inputs:

F: a load cell, attached between the face of the shaker and the threaded rod, could measure the force exerted on the damper system. A sinusoidal input cure is preferred.

Acceleration, $\ddot{x}$, can be measured with an accelerometer attached to the free (rear) end of the rod in the rod-and-vane assembly of the damper.

Velocity, $\dot{x}$, is the resultant of numerically integrating the acceleration.

Displacement, x, is the resultant of numerically integrating the velocity.

2.1.3. Finding c:

Once all other terms of the equation are found as above, curve-fitting or optimization software (possible with excel, Matlab, or other packages) can be applied to the equation of motion using the numerical data from the load cell and the accelerometer. The oscillating beam experiment performed in the System Dynamics class is a good example of this sort of curve-fitting problem.

2.2. Outcome:

Three major problems arose that resulting in a suboptimal outcome. Unrelated to the testing itself but also worrying, rubbing was observed.

2.2.1. Load cell

The load cell associated with the shaker was broken. Without it, measuring the force directly was not possible. A replacement was not found in time.

2.2.2. Accelerometer

The accelerometer presented noisy data, contaminated by its electrical power. Because the damper was tested at low frequency, the accelerometer required a high gain setting, which amplified the effect of noise.

2.2.3. Overheating

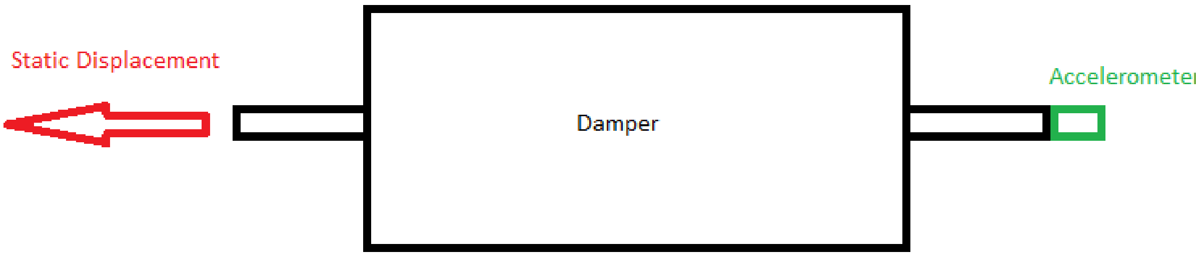
Both previous problems were surmountable. However, after 30-40 minutes of testing with the shaker, the damper provided so much resistance that the shaker cell overheated and automatically shut down to prevent damage. More shaker testing was discouraged to protect the shaker.

2.2.4. Rubbing

Contact friction between some of the magnets and vanes was observed.

3. Method: Simple Displacement

Consider the following cartoon.



A simpler method of collecting data. The damper is fixed in place, the rod assembly is pulled outward to a static displacement, and then released. The spring pulls the damper back to the neutral position, while the inertia and damping resist the return motion. The equation of motion therefore becomes like this:

$$kx = m\ddot{x} + c\dot{x}$$

While initial x is known because of the static initial displacement, no load cell was needed, and the accelerometer would deliver all of the data needed to (with known m and k) develop c.

3.1. Outcome

An attempt at solving the rubbing problem was made. The damper was disassembled. The magnets were pulled from their cast-iron housing. There cradles were epoxied, and the magnets were put back in place. They were left to cure overnight. Finally the damper was reassembled.

That was the point at which the quarter came to an end. Testing using the displacement method was not performed.

3.2. Results

The system was overdamped, as expected, but rubbing prevented c from being characterized.