Investigation and Optimization of a Mechanical Regenerative Braking Launch Assist Device

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Objective: The goal of this project is to identify ideal spring characteristics for a strain-based, regenerative braking launch assist that is capable of propelling a 2000 pound car at 5 miles per hour.

Motivation
- A regenerative brake and launch assist (RBLA) mechanism has been formulated that uses springs to store energy.
- This project will identify an ideal spring configuration to be used with the mechanism.

Initial Results
The following plots display the weight, $W$, and storage volume, $Vu$, for a spring that stores the necessary RBLA energy using different wire and coil diameter combinations.

For an extension spring:
\[
W = \frac{8wDF}{\pi d^3}
\]
\[
U_s = \frac{1}{2}kx^2 = \frac{1}{2}mv^2
\]

For a torsional spring:
\[
\sigma = k_b \frac{32T}{\pi d^3}
\]
\[
U_s = \frac{1}{2}k\theta^2 = \frac{1}{2}mv^2
\]

Future Direction
- To derive equations and create similar plots for spiral and other spring configurations.
- Test the prototype with different springs to assess frictional and hysteresis losses.

Technique Utilized
- Machine design equations were generated that relate the stiffness($k$), stress and energy($U_s$) for each spring configuration.
- Optimization involves minimizing both weight and volume of spring while storing energy.
- Pareto front $W + Y(Vu)$ optimization technique used for various $Y$ values to locate minimum.
- Initial values $Y_i$ were selected such that on average, $W = Vu$.
- Extension springs are better than torsion springs.
- Larger wire and coil diameters leads to optimum design.