Moment Manipulating Arm Support System with Non-circular Gears

Introduction

The goal for this project was to create a variable moment system using non-circular gears that functioned the same as Levitate Technologies' current design, which utilizes tension springs and pulleys to achieve a higher cycles till failure. The cables for the pulley system were the first to fail, and would not meet a satisfactory amount of cycles. The use of gears would eliminate the need for cables, increasing the lifetime of the product and reducing its size . Using Matlab, the group was able to design a set of non-circular gears the would operate from 0 to 162 degrees.

Goals

- Maximum moment of 6.0 N-m (+/- 15%) when arms are horizontal (90°).
  - Zero moment at 180° (arms down by side, resting position).
  - Maximum moment at 90° (arms are horizontal).
  - Zero moment at 0° (arms are raised straight up)
    - Graphed moments to produce a sinusoidal curve

Gear Design

- Design the stationary gear using the equations below to create an ellipse

Center Distance:

$$E = a[1 + \sqrt{1 + (1 - e^2)(n^2 - 1)}]$$

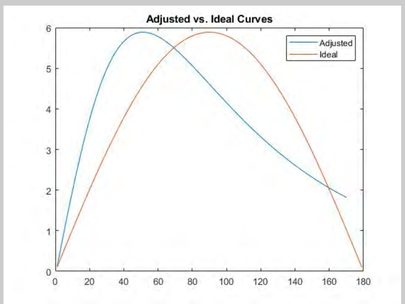
Eccentricity – Ellipse:

$$e = \sqrt{1 - (b^2)/(a^2)}$$

Equation of an Ellipse

$$\frac{(x-h)^2}{a^2} + \frac{(y-k)^2}{b^2}$$

- Use the radii of the stationary gear for each angle to develop the required radii of the moving gear, using gear ratios established by an ideal sinusoidal moment curve
- Correct the arc lengths of moving gear to match the stationary gear to produce a 1 to 1 rotation.
  - Doing this adjusts the moment curve produced shown in the figure below.
- Design gears iteratively in MATLAB and export into Solidworks for 3D printing and teeth design



Solidworks Assembly

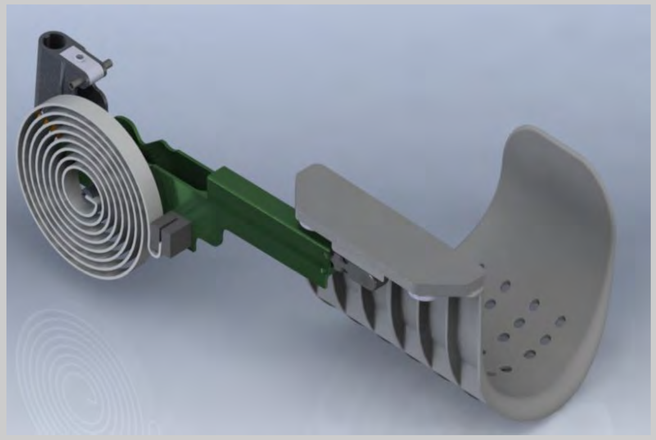


Figure 1: Isometric CAD view.

Figure 2: Arms down position

Figure 3: Arms up position

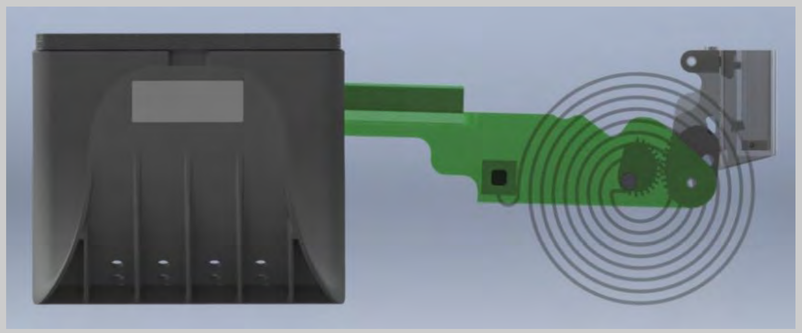


Figure 4: Arms horizontal position

Physical Product

Figure 5: Isometric view

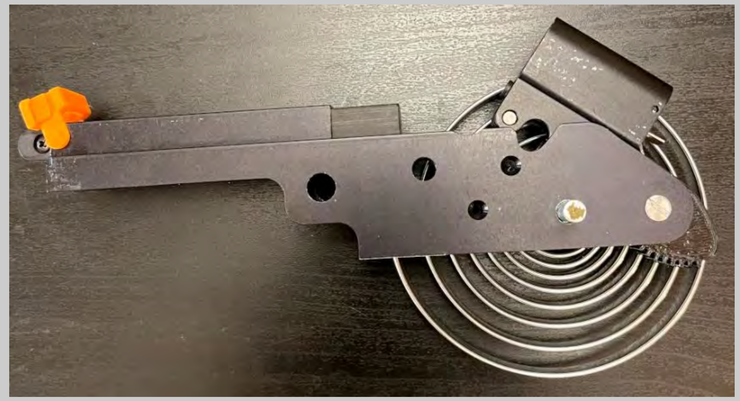


Figure 6: Side view

Team

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Michael Lester - Fabrication Advisor

References

Litvin, F. L., Fuentes-Aznar, A., Gonzalez-Perez, I., & Hayasaka, K. (2014). *Noncircular gears: Design and generation*. Cambridge: Cambridge University Press.

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