ME 3671: Design and Analysis of Machine Elements II

Real Mech: Precision Tennis Ball Launcher

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Introduction:

Most people are familiar with the basics of projectile motion. This concept aims to quantify the factors that influence where a launched projectile will land. The goal is to show how the use of simple geometry can achieve great accuracy when trying to land a ball in a specific location.

Design Goals:

In order to accomplish the goal stated above, the following will be necessary aspects of the design:

- Intuitive, and easy to operate
- Simple concept, yet provides a challenge to be fun and engaging
- Strong and robust, to accommodate less than gentle users

How to Use:

To use the precision tennis ball launcher, please follow these steps:

- Rotate the whole launcher in the direction wanted
- Turn the crank to adjust the angle of launch
- Pull the wire back
- Release the wire
- Enjoy your tennis ball being sent in the air!

Design Specifications:

- At least three unique machine elements must be combined to create an exhibit showcasing an educational topic – in our case, projectile motion!
- 10’ by 10’ by 10’ size for the exhibit
- Weight of the exhibit needs to be reasonable – should be able to be moved in relatively easily
- Exhibit needs to be comfortably used by museum-goers of all ages
- Minimum of 2448 hour life without maintenance
- Reasonably manufactured and priced!

Design Procedure:

Gears:

A gear and a worm gear are used so the user can rotate the crank and adjust the orientation of the launcher. For this, a speed reduction of 30:1 is used so that the angle can be more easily adjusted. Then, it is made in such a way that each rotation of the crank would rotate the launcher by 5°. For this, the gear needs to have 72 teeth.

It is assumed that the user will rotate the crank with a force of maximum 20 lbs. with this design the factor of safety is 30 which is way above the minimum factor of safety required of 1.25.

Spring:

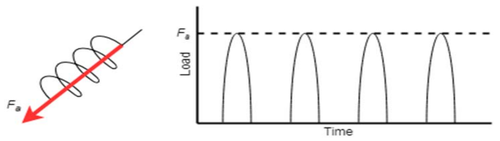
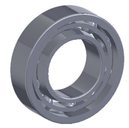


Figure #: Diagram of spring with axial load it is subjected to along with fluctuating load graph

- Energy required to launch a baseball a set distance with the launcher configured to launch max distance was calculated
- Several springs with dimensions and rates from McMaster Carr were selected
- Force required to pull wire back to launch ball set distance was calculated
- Fatigue based analysis for each spring was done to select spring with a safety factor of 1.76 at 10^6 cycles of loading

Bearing

A bearing is located between two bottom plates to make the launcher rotate left or right direction. During design process, the weight of children was considered in addition to the apparatus since a user could hang on to it. In addition, the Impact factor was estimated as 3 which is heavy impact and 99% of reliability factor was applied. For designed life, it is assumed each user makes10 rotations and three minutes of usage time.



The single-row angular contact ball bearing was selected because it should resist axial and radial load, and the size of bearing was determined based on the basic dynamic load rating. As a result, Bearing 71800 AC, which has 10mm of bore diameter and 19mm of outer diameter was chosen.

Wire:

The force required to displace the spring the desired amount is about 87 lbs which is about 387 N. It was estimated that there would be about 100 bends/day on the wire and that it would be used 5 days per week for 2 years. This resulted in a total of 52000 bends. The team designed for a static factor of safety of 3 and a fatigue factor of safety of 1.5 for the wire. The team decided on a 6 X 19 improved plow steel wire.

Calculations:	
Static:	
σd (MPa):	459.667
(dr)static (mm):	1.444
Fatigue:	
Total Bends:	52000
(Rn)f (from figure 17.17):	0.006
(p)Nf:	8.274
(pd)fatigue (MPa):	5.516
(dr)fatigue (mm) (17-33):	2.032
Wear:	
(pd)wear (MPa) (carbon steel):	6.205
(dr)wear (mm):	1.915
Failure is controlled by Fatigue:	2.032

After calculating the diameter of wire required for static, fatigue, and wear loading, the team found that failure is controlled by fatigue. Thus, the wire required to operate the launcher safely must have a nominal diameter of 2.032 mm.

Summary:

The Precision Tennis Ball Launcher is designed to provoke interests of young user, and at the same time, people could learn basic principle of mechanical components. Simple and repetitive usage of the launcher could be helpful to achieve objectives of the project. Also, lot of safety factors and tendency of user were considered during the design process to ensure safe.