Fall 2014

Treadle Driven Can Opener

Chris Lowery  
*Washington University in St Louis*

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*Washington University in St Louis*

Dom Quaranta  
*Washington University in St Louis*

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1. Introduction

1.1 Project problem statement

We are designing a treadle-driven can opener that could be used at a restaurant. The can opener is designed to utilize large muscle groups. A traditional can opener requires the user’s hands which can tire out easily with extended use. The treadle works much the same as an old sewing machine. Someone can use our can opener to open many cans in a row. Our can opener must be robust, efficient, and fast.

1.2 List of team members

The members of the Treadle-Driven Can Opener team are Dominic Quaranta, Chris Lowery, and Stewart Martens

2. Background Information Study

a. A short design brief description that defines and describes the design problem

Our problem was to design a can opener that operates with a treadle. The can opener will be used in restaurants to open many cans at a time and utilizing large leg muscle groups for the activation force.

b. Summary of relevant background information (such as similar existing devices or patents, patent numbers, URL’s, et cetera)

US6158130 A – industrial can opener

US2607309 A – old sewing machine treadle press
3. **Concept Design and Specification**

a. **User needs, metrics, and quantified needs equations.** This will include three main parts:

i. **Record of the user needs interview**

<table>
<thead>
<tr>
<th>Question</th>
<th>Customer Statement</th>
<th>Interpreted Need</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Should the device be portable?</td>
<td>Doesn’t need to be more like a permanent mechanism in restaurant</td>
<td>No weight restrictions</td>
<td>2</td>
</tr>
<tr>
<td>How much human effort should be required to set up the can opener?</td>
<td>Shouldn’t need strength to operate, Both hands are available to use</td>
<td>Doesn’t exert max muscle force</td>
<td>3</td>
</tr>
<tr>
<td>What is the variation in can size?</td>
<td>There is only a minimum diameter that needs to be worried about</td>
<td>Minimum diameter of 2.5”</td>
<td>4</td>
</tr>
<tr>
<td>How quickly should it take to open the can?</td>
<td>Same to slightly better speed of hand can opener, Main point is to key in on bigger muscle group</td>
<td>Speed of .2 to .5 rot/sec, Utilizes calf muscle</td>
<td>5</td>
</tr>
<tr>
<td>Does it need to be completely hands free</td>
<td>The worker has two hands so they are free, Has two manual controls</td>
<td>Has two manual controls</td>
<td>1</td>
</tr>
</tbody>
</table>

Customer Data: Treadle Driven Can Opener

Customer: Professor Jakiela

Address: Washington University

Date: 10 September 2014

Customer Statement

Interpreted Need

Importance
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Notes</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>or locked into place?</td>
<td>to use on mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can it be electrical?</td>
<td>no</td>
<td>No electrical</td>
<td>3</td>
</tr>
<tr>
<td>Does it need to dispose of the top?</td>
<td>Human can dispose of the top</td>
<td>Lid can stay attached to device</td>
<td>1</td>
</tr>
<tr>
<td>Does someone need to be trained in order to use the can opener?</td>
<td>no</td>
<td>Simple process to operate</td>
<td>5</td>
</tr>
<tr>
<td>Does the can opener have to be safe?</td>
<td>yes</td>
<td>The number of sharp edges on the can opener needs to be minimized</td>
<td>5</td>
</tr>
</tbody>
</table>
iii. List of identified metrics

<table>
<thead>
<tr>
<th>Need Number</th>
<th>Need</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Can opener is portable</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Human exerts less than 10 lbs of force</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Minimum diameter of 2.5”</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Speed of .2 to .5 rot/sec</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Utilizes human leg muscles to activate</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Can opener works hands free</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>No electricity required</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>Lid removed by can opener</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>&lt; 5 minutes of training required for operation</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Minimal sharp edges</td>
<td>5</td>
</tr>
</tbody>
</table>

iv. Table/list of quantified needs equations

<table>
<thead>
<tr>
<th>Design Metrics: Treadle Driven Can Opener</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric Number</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
</tbody>
</table>
b. Four (4) concept drawings
C. Concept selection process. This will have three parts:

i. Concept scoring (not screening)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Concept 1: Blade Runner</th>
<th>Concept 2: Mag-Lev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need</td>
<td>Can opener is portable</td>
<td>Can opener is portable</td>
</tr>
<tr>
<td></td>
<td>is rated high</td>
<td>has moderate utility</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

for each concept:

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</tr>
<tr>
<td></td>
<td>is rated high</td>
<td>has moderate utility</td>
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<td>0.5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

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<td>Need</td>
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</tr>
<tr>
<td></td>
<td>is rated high</td>
<td>has moderate utility</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.5</td>
</tr>
</tbody>
</table>
ii. Preliminary analysis of each concept’s physical feasibility

Concept 1: Blade Runner

There are multiple problems that first come to mind when analyzing the blade portion of this device. The first is the safety of an open saw rotating at dangerous speeds with free hands moving about the device at all times. Along with danger to flesh, dangers to cans should be considered because a typical can is opened from the top while this device will slice open the side of the can. The choice of metal to create the saw with is difficult because this device needs to last over an extended period of time so it is required to have a very durable saw. Another problem consists of the force needed to activate and maintain the saws speed. It might be easy for the treadle to get the saw up to high speeds. But once it experiences resistance from the can, it will be difficult for the targeted muscles group (the calves) to
maintain a constant and fast speed. The need for only one hand is ideal but not an important requirement. This design targets the needs of having a small minimum diameter along with a lightweight design. The lightweight design is not as important as other factors but having no limit to the minimum diameter is a key point.

Concept 2: Mag-Lev

This concept utilizes the technology and ease of a handheld can opener. This allows for a safe device with no sharp edges from the can opener itself but a couple sharp edges protrude from the corners of the magnet. Like concept 1, this device only requires one hand of use ontop of the calf driven treadle, but it is a much safer use of one hand. This requires a clamping of the can opener instead of the rotation of a can around a blade. This concept might be a little heavier due to the weight of the magnet but it is not significant enough to have a huge impact of the mobility of the device. This design keys in on the ease of use by the operator and requires minimal time to learn how to use. The simple magnet allows for a wide variety of diameters but it forces the user to exert more force than some other designs. Due to the restricting force of the magnet, the treadle needs to exert enough force to rotate the magnet with resistances of both the can and magnet.

Concept 3: Lock-Tite

The Lock-Tite concept is fairly simple compared to the first two designs. We would need to make the treadle and foot pedal as in every other design. We would need to attach a can opener to a stand and attach the treadle belt to the can opener to allow it to rotate. The adjustable locks would need to screw in to hold the can opener in place. Some of the possible downfalls of this design are friction between the can and the locks and the feasibility of the adjustable locking mechanism. The locks would need to be loosely fit to the can in order to minimize friction and allow the can to rotate. The lock system could be a challenge to perfect, but it should be possible to create. Additionally, if this design can be properly constructed, it could be the fastest working.

Concept 4: Two-Handed

Concept 4 is the simpliest design. It works very much in the same way as Concept 3, except the adjustable locking system is replaced by one of the user’s hands. Although this design is the simpliest, it could be slower and more cumbersome than some of the other designs. There is a speed limit that we would want a can to rotate in someone’s hand to keep the system safe. Also, using no hands is preferable to having to use one of your hands while the can is being opened.
iii. Final summary

WINNER: Concept 3

Concept 3 seems to be the most favorable concept for a treadle driven can opener. It combines the desired qualities of speed, safeness, and feasibility. Concept 1 suffers from a safety issue. We are concerned that blades rotating about the can while someone is holding the can may cause injuries. Concept 2 will require a greater activation force than the other concepts, and if a worker were to open many cans in a day, this would not be desirable. Concept 4, albeight the simpliest concept, could end up being one of the slowest, and suffers from requiring someone to use both hands. Concept 3 is likely to work the best because it can be used for all different can size, allow for the fastest rotation, and will provide the most stability for the can while rotating.

D. Proposed performance measures for the design

1. The can opener suffers less than 15 seconds of down time when changing can size.
2. The can opener takes less than 5 seconds to open any one can
3. The can opener does not suffer any performance decrease after opening 100 cans.
E. Embodiment and fabrication plan

a. Embodiment drawing
### b. Parts List

<table>
<thead>
<tr>
<th>Part #</th>
<th>Part Name</th>
<th>Model # (McMaster unless specified)</th>
<th>Quantity</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18’ of 2”x4” wood</td>
<td>n/a</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Drive Shaft 36” long 1/2” dia.</td>
<td>1346K19</td>
<td>1</td>
<td>23.53</td>
</tr>
<tr>
<td>3</td>
<td>Drive Shaft 12” long 1/2” dia.</td>
<td>6061K37</td>
<td>1</td>
<td>7.51</td>
</tr>
<tr>
<td>4</td>
<td>Steel Flanged Ball Bearing</td>
<td>6383K234</td>
<td>2</td>
<td>15.84</td>
</tr>
<tr>
<td>5</td>
<td>12”x16” (1/2” thick) plywood</td>
<td>n/a</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>3’x2’ (1” thick) wood</td>
<td>n/a</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>A-Section V-Belt</td>
<td>6186K182</td>
<td>1</td>
<td>15.43</td>
</tr>
<tr>
<td>8</td>
<td>A V-Belt Pulley 8.75” OD</td>
<td>6407A33</td>
<td>1</td>
<td>66.78</td>
</tr>
<tr>
<td>9</td>
<td>A V-Belt Pulley 4.75” OD</td>
<td>6407A18</td>
<td>1</td>
<td>39.19</td>
</tr>
<tr>
<td>10</td>
<td>Manual, Hand Held Can Opener</td>
<td>6118T1</td>
<td>1</td>
<td>7.32</td>
</tr>
<tr>
<td>11</td>
<td>Steel Threaded One-End Pipe</td>
<td>7753K165</td>
<td>1</td>
<td>8.73</td>
</tr>
<tr>
<td>12</td>
<td>Malleable Threaded Floor Flange</td>
<td>Home Depot: 521-604HN</td>
<td>1</td>
<td>1.91</td>
</tr>
<tr>
<td>13</td>
<td>Set Screw Shaft Collar</td>
<td>9414T15</td>
<td>1</td>
<td>1.90</td>
</tr>
<tr>
<td>14</td>
<td>Set Screw Eye Bolt</td>
<td>3014T46</td>
<td>1</td>
<td>3.20</td>
</tr>
<tr>
<td>15</td>
<td>General Purpose Low Carbon Steel</td>
<td>6544K65</td>
<td>1</td>
<td>20.34</td>
</tr>
<tr>
<td>16</td>
<td>1”x2” Pressure Treated Board</td>
<td>Home Depot: 415412</td>
<td>1</td>
<td>2.17</td>
</tr>
<tr>
<td>17</td>
<td>Mounted Bronze Bearing</td>
<td>5912K5</td>
<td>1</td>
<td>12.28</td>
</tr>
</tbody>
</table>
c. Draft detail drawings for each manufactured part

1.1 Part Draft Drawing Details
McMaster-Carr - A-Section Rubber V-Belt, Trade Size A98, 100" Outer Circle

<table>
<thead>
<tr>
<th>Trade Size</th>
<th>A98</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer Circle</td>
<td>100&quot;</td>
</tr>
</tbody>
</table>

Additional Specifications: A-Section V-Belts

An industry standard, these classical V-belts are made of rubber with polyester reinforcing cords. Color is black.

Part 7

Part 8
Part 9
Can Opener
Manual, Hand Held Vinyl-Cushioned Handles

<table>
<thead>
<tr>
<th>Material</th>
<th>Chrome-Plated Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Can Height</td>
<td>Any</td>
</tr>
<tr>
<td>Overall Size</td>
<td>7&quot; Lg. x 2 1/4&quot; Wd.</td>
</tr>
<tr>
<td>Additional Specifications</td>
<td>Manual Opener, Hand Held</td>
</tr>
</tbody>
</table>

(P-R) Manual Openers—Style Q has vinyl-cushioned handles for a firm grip.

Part 10

Part 12
d. Description of the design rationale for the choice/size/shape of each part

Base

The base of our can opener consists of 3 2x4 pieces of wood and 4 support blocks to elevate the pedal from the ground. Two of the 2x4s are 2 feet in length and run parallel to each other. They are connected in back by another 2x4 with nails and in the center by the drive shaft. The outer pieces of
wood have 2 ¼” holes cut in their centers. Bearings will be force fitted inside. On the four corners of the base, 2”x2”x4” pieces of wood will be nailed.

**Pedal Assembly**

The foot pedal is a 16”x12”x½” piece of wood with two holes centered and 2 ¼” apart. A mounted bearing is bolted to the bottom of the foot pedal. The ½” drive shaft runs through the mounted bearing and bearings in the base.

**Upper Can Opener Assembly**

A commercial grade vertically rotated steel can opener is the base implement for cutting. The hand operated rotational component will be replaced with a 6 inch steel drive shaft (shaft C) of ½ inch diameter. The steel shaft will need to be spot welded to the rotational center of the can opener drive. The steel on steel weld done with an oxy-acetylene torch should have ample strength to withstand the torque generated by our foot driven treadle. Two 12 inch 2”x4” boards will be bolted vertically to our table base which rests on the vertical beams of our base. The table base measures 2’x3’. The 12” inch vertical beams will support the steel commercial hand operated can opener by way of 4 threaded ¾-20 bolts. This system allows us to firmly attach and support not only the can opener, but also the drive shaft and the upper pulley.

**Vertical Adjustment Assembly**

Our treadle driven can opener will also have the added feature of being able to accommodate any can size seamlessly. To accomplish this unheard of feat of engineering a base for a separate vertical shaft will be mounted to the front edge of the table in close proximity to the can opening implement. This shaft (Shaft D) will have a sliding collar and set screw for adjustment. The collar will have a horizontal sheet metal base extending from the middle to accommodate the weight of the can. This allows for any can (8oz to 64oz) to have its lid cleanly and precisely cut off without the operator having to hold the can or worry about dropping once the lid is removed. The user simply slides the freshly opened can from the collar mounted base to be used in a bevy of cooking endeavors. The lid, meanwhile, remains in the can opener until removal by the user when a new can needs to be opened.

**Belt size rationale:**

To choose the right belt size we had to take into account both pulley sizes as well as the height of our machine as a conglomerate. The lower puller is 8” inches in diameter. The upper puller is 4” inches in diameter. With a total machine height of 4 feet our belt needs to be 80 inches in circumference. This assumes our distance between pullies is 2.5 feet.

\[ 2.5ft = 30 \text{ inches} \]

\[ 30 \text{ inches} \times 2 = 60 \text{ inches} \]

\[ \pi r_1 + \pi r_2 = 3.14 \times 6 = 18.84 \text{ inches} \]
60 + 18.84 inches = 78.84 inches

With some design flexibility an 80 inch belt fits our needs most appropriately.

**Pulley size rationale:**

A 1 Hz rotation of the treadle is assumed.

With a 8 inch diameter lower pulley and a 4 inch upper pulley, this equates to a 2 Hz rotation of the upper pulley. 6 turns of the original can opener opens a standard 12 oz can. At a 2 Hz rotation of the upper pulley, a standard can is opened in 3 seconds.

8 inches at 1 Hz

8 in/4in = 2

1 Hz x 2 = 2 Hz

6 rotations/ 2 Hz = 3 seconds.

**F. Engineering analysis**

a. Engineering analysis proposal

   i. A form, signed by your section instructor (insert your form here)

   (no signature was given on our proposal due to the fact we were electronically approved)

**ANALYSIS TASKS AGREEMENT**

PROJECT: Treadle Can Opener NAMES: Dominic Quaranta INSTRUCTOR: _____________

Chris Lowery__

Stewart Martens__

The following engineering analysis tasks will be performed:

Before our prototype is built, we have two main concerns: the average power that a human calf can transmit to the treadle and the size of the wheel attached to our can opener. In order to get transmitted power, we will estimate the force of someone pushing their foot down on a pedal
and the frequency they will pump the pedal with. With these numbers, will we be able to get
average power transmitted. Once we know the power, and assuming our treadle wheel is a
standard size (about 14”) we will be able to calculate the desired diameter for the power
transmitting wheel given a desired rotational speed that we will also estimate. Another concern
involves the force that is being applied to the wheel. There are two points throughout the turning
of the wheel that will have no force and rely solely on momentum due to the transition from
force of heel to force of front of foot. With a can, it will be difficult to cut through the material
solely on momentum. We need to calculate the force of that momentum and the fore needed to
open a can and check to see if it will be enough to continue the process of opening the can for
that brief moment.

After the prototype is built we will focus our analysis on testing our performance goals.
Our goals were for the can opener to open a can in 5 seconds or less and not wear down after use.
The first goal can be tested by taking the average opening time for 10 cans. The second goal can
be tested by observing whether the time for the 10th can was significantly higher than the time for
the first can.

The work will be divided among the group members in the following way:

Dom will be in charge of the pre-prototype testing. Chris and Stew will be in charge of the post-
prototype testing.

Instructor signature: ___________________ ; Print instructor name: ______________

(Group members should initial near their name above.)
b. Engineering analysis results

i. Motivation

The application of a treadle driven can opener would most likely be in an industrial setting like a restaurant or a shelter. This is where the advantages of being hands free and using your leg muscles would show up over the course of opening a great many cans. For these reasons we found that the most pertinent analysis had to do with speed, durability and ease of use. There were ancillary concerns, like size (for instance), but the analysis we undertook relied heavily on what the machine can do for you over the alternative. Going forward, we think it is easy to say that all three primary concerns can either be improved upon or confirmed. Post initial prototype, the hope will be to improve the speed and usability, while also continue to confirm the durability of the stainless steel can opener in its current configuration.

ii. Summary Statement

We set a standard of speed for our can opener of a 5 second open time. To confirm that we hit this mark it was essential to calculate how many revolutions are needed at the can opener and then translate that number down to the large pulley driven by the treadle. For example, if the can opener needs to rotate 6 times and it has a 2 inch diameter we only need to rotate the treadle driven pulley a total of 3 times due to the advantage in size between the large pulley and the small pulley.

With respect to durability, this was harder to test over a long run due to time constraints. However, hypothetically a stainless steel can opener with a hardened steel blade cutting through aluminum and lighter steel cans should have a lifetime that well exceeds the expected lifetime of an industrial kitchen implement.

To calculate ease of use, we employed the services of some of our classmates. The only instruction we gave them was, “open the can.” In the end, all of the students were able to open the can. That being said, some students did have difficulty. The majority of the issues had to due with friction in the treadle not allowing for easy rotation. This is an issue that will be resolved in the next stage of prototyping.

iii. Methodology

We wanted to test three things about our can opener. First, the can opener needed to quickly open a can. We set the minimum opening time at 5 seconds and the time needed to set up the can at 10 seconds. To test this performance metric, we simply opened a can and measured usage times. Second, the can opener needed to be durable. We tested our design’s durability by opening 10 cans in a row. We figured if we can open the 10th can successfully, our can opener will last. Instead of opening 10 different cans, we used the same can as to not be wasteful. Finally, the can opener needs to be easy to use. We tested the ease of use by asking someone who was not in our group to open a can for us. If they were able to open a can with little instruction from our group, we would conclude that the can opener is user friendly.
iv. Results

1. Speed - Our can opener is easily adjustable. With an Allen key, the user can adjust the can to the proper height and clamp down the teeth in under 10 seconds. Once a can is set up, it can be opened in under 5 seconds. This makes us believe that our calculations for pulley ratio and pedaling frequency were correct. However, the treadle arm sometimes gets stuck in the upswing of the treadle. It was very difficult to get the treadle arm the exact size for flawless motion. The consistency of the can opener can be improved.

2. Durability - Our can opener was able to successfully open 10 cans in a row. The only problem with its durability is tightness of some of the bolts. Especially during building, we noticed that the nuts holding our bolts in place tended to unwind with the motion of the treadle. We will address this problem more for the final prototype.

3. Ease of use - A non-group member was able to open a can using our treadle-driven can opener. As mentioned above, the treadle arm sometimes gets stuck, so a new user becomes more adept with practice. Also, our current design requires the operator to use both hands. This is an issue we will address going forward.

v. Significance

The initial prototype differs from the initial expected construction of our treadle driven can opener. Originally, the can opener was bolted onto two 2”x4” blocks. We determined this was unnecessary. Also, we determined the strength of the shaft connected to these 2”x4” will not be strong enough to hold the tension of the pulley so a bearing system was implemented for the top drive shaft that acts as support for the shaft and the can opener (shown in below diagram). The original plan to weld the can opener to the drive shaft failed due to the inability to weld the two different metals together to a point where the connection will be strong enough. A custom piece of wood was used with multiple bolts to connect the shaft and can opener. On the treadle, we needed to flip the arm around to the other side of the treadle and pedal from the opposite side as anticipated. This created an awkward grip on the can opener.

After analysis of the initial prototype, we may want to rethink the length and positioning of the arm for the treadle. The awkwardness is a problem for the fluency of the pedaling. All other connections and machining are working as expected and will most likely remain the same.
vi. Summary of Codes and Standards

Basic standards for a hand-held can opener don’t have that many limitations. A can opener can open every size can. In our mechanism, the height is limited to a can of max 15” in height and 6” in diameter. This accounts for the majority of cans in the world. Our mechanism was not designed to open industrial sized cans, but only simple everyday restaurant owned cans or cans owned within a household. In this sense, our design meets all requirements.

OSHA has guidelines for chemical safety and utensils within the kitchen. They require in restaurant kitchens for all sharp edges that are stationary and immovable to be covered and protected. The only sharp objects in our system are the blades of the can opener and these are well guarded by the block of wood and built in metal covers within the can opener. If this was used in a household, the same guidelines are suggested. Either way, our treadle driven can opener meets all standards and OSHA codes.
G. Working prototype

a. A preliminary demonstration of the working prototype (this section may be left blank).

b. A final demonstration of the working prototype (this section may be left blank).

c. At least two digital photographs showing the prototype
d. A short videoclip that shows the final prototype performing

http://youtu.be/NUWfsKnrn2A
e. At least four (4) additional digital photographs and their explanations

-Angle view of final. See counterweight.
Front view of final. See bracing slats and linearity.
-Back view of final. See pulley system and counterweight.
-Lower treadle drive on final. See treadle arm offset and length.
H. Design documentation

a. Final Drawings and Documentation
   
i. A set of engineering drawings that includes all CAD model files and all drawings derived from CAD models. See Appendix C for the CAD models.

   ii. Sourcing instructions
       A zipped file containing all of the CAD drawings can be found in our team’s file exchange under Final Drawings.

1.2 Final Presentation

   iii. A live presentation in front of the entire class and the instructors (this section may be left blank)
       The powerpoint slides to our presentation can be found in our group’s file exchange under Presentation

   iv. A link to a video clip version of 1
       http://youtu.be/lG453lk_LAY
1.3 Teardown

Instructor comments on completion of teardown/cleanup tasks:

Instructor signature: [Signature]
Print instructor name: [Name]
Date: 12/3/2014

(Group members should initial near their name above.)
I. Discussion

a. Using the final prototype produced to obtain values for metrics, evaluate the quantified needs equations for the design. How well were the needs met? Discuss the result.

Using our final prototype we obtained metrics and then evaluated our quantified needs equation. After calculation we found that we had vastly improved both the performance and usability of our treadle driven can opener. In the end, all needs were met and some were exceeded. In particular, the speed of our can opener was considerably higher than we expected. This was seen as a good thing.

b. Discuss any significant parts sourcing issues? Did it make sense to scrounge parts? Did any vendor have an unreasonably long part delivery time? What would be your recommendations for future projects?

Sourcing for our project proved to be very easy and quick. We scrounged wood from the senior design lab, and counterweight steel from the machine shop. Our other parts were purchased from either Grainger or McMaster-Carr. We used the purchase order system for our order from McMaster and we picked the parts up from Grainger at the downtown location. Delivery time was more than adequate. We would recommend purchasing as much of the needed parts from a real store. We found it nice to see the part before we purchased it.

c. Discuss the overall experience:

i. Was the project more of less difficult than you had expected?
Some parts of the project were less difficult than we expected, while others were more difficult than we expected. At the beginning of the semester, the process of going from scratch to a workable prototype seemed very daunting, and we did not believe that we would actually get something that would work. However, we just needed to put in the necessary time, and we were able to get a working can opener. The part of the project that was more difficult than expected was the initial concept design. We needed to change our design several times after building and rebuilding due to some of the problems we encountered.

ii. Does your final project result align with the project description?
We believe our final project result does align with the project description. We were tasked with creating a treadle driven can opener which could be used in a restaurant to
open many cans in a row. Our project was able to successfully open cans, and the input force is pumping a treadle. Furthermore, our project was fast, cheap, and sturdy.

iii. **Did your team function well as a group?**

Our team functioned quite well together. For the most part, we made group decisions which required the agreement of all three members. While we did have disagreements, they were handled constructively and actually helped us find better solutions to our problems.

iv. **Were your team member’s skills complementary?**

All three team members had similar skill sets. We all had a basic understanding of the machine shop, an entry level engineering background, and little experience with treadles. However, some additional skills complemented other team members. Dom was the most comfortable with CAD, so he did a lot of the CAD modeling. Stew was most familiar with mechanical

v. **Did your team share the workload equally?**

Our team shared the workload almost entirely equally. We only worked on assignments and building when all three members of the team were present. Therefore, we spent approximately equal time working on the project. Towards the end of the semester, we worked separately more often but did the same amount of work.

vi. **Was any needed skill missing from the group?**

The largest skill missing from the group was previous design experience. None of us are on the WU Racing team or another school related engineering group or have taken a design class. We needed to learn the design process on our own. Previous design experience would have definitely made our project work smoother.

vii. **Did you have to consult with your customer during the process, or did you work to the original design brief?**

Professor Jakiela was the customer for our project. We interviewed Professor Jakiela and went through a few iterations of designs before selecting a design to work on. Through this process, we met with our customer a few times to fully understand the design brief. We did not need to consult with him much after our initial design was formed.

viii. **Did the design brief (as provided by the customer) seem to change during the process?**

As said before, the design brief did not change much after we selected a design concept. Our design brief was to design a treadle driven can opener for restaurant use. After we learned more about treadles and how they worked, our design brief and goals remained constant.
ix. **Has the project enhanced your design skills?**
Senior Design class has definitely enhanced our design skills. We all came into the semester with essentially no designing experience. Going through an entire project from customer interviews to final prototype is crucial to any engineer. If our group needs to design something else, we will be much more prepared due to this semester.

x. **Would you now feel more comfortable accepting a design project assignment at a job?**
We would feel much more comfortable designing something for a job after having completed Senior Design class. The largest hurdle is coming up with a feasible design. After building our can opener, we have a better idea of designs and machining techniques that do and do not work. With this knowledge, we are better suited to begin the design process with a good concept allowing us to make faster progress with fewer iterations.

xi. **Are there projects that you would attempt now that you would not attempt before?**
We would attempt a larger variety of projects now that we have completed our treadle driven can opener. We are more confident in our machining and designing abilities. We would be comfortable working on any of the other treadle projects as well as many other mechanical projects. We would still be hesitant to attempt a project requiring motors and controls because we did not use any electricity in our can opener.

9. **Appendix A - Parts List**

<table>
<thead>
<tr>
<th>Part #</th>
<th>Part Name</th>
<th>Part #</th>
<th>Part Name</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Steel Block Weight</td>
<td>13</td>
<td>Set Screw Shaft Collar</td>
</tr>
<tr>
<td>2</td>
<td>Drive Shaft 36” long 1/2” dia.</td>
<td>14</td>
<td>Wooden Shunt</td>
</tr>
<tr>
<td>3</td>
<td>Drive Shaft 6” long 1/2” dia.</td>
<td>15</td>
<td>Can Opener Holder (plywood)</td>
</tr>
<tr>
<td>4</td>
<td>Mounted Bronze Bearing</td>
<td>16</td>
<td>Steel Ball Bearing 1” OD</td>
</tr>
<tr>
<td>5</td>
<td>Pedal (plywood)</td>
<td>17</td>
<td>2’ long 2”x4”</td>
</tr>
<tr>
<td>6</td>
<td>Table (plywood)</td>
<td>18</td>
<td>3’ long 2”x4”</td>
</tr>
<tr>
<td>7</td>
<td>FHP V-Belt 4L</td>
<td>19</td>
<td>6” long 2”x4”</td>
</tr>
<tr>
<td>8</td>
<td>Zamak V-Belt Pulley 8” OD</td>
<td>20</td>
<td>Large Pulley Support</td>
</tr>
</tbody>
</table>
10. **Appendix B - Bill of Materials**

<table>
<thead>
<tr>
<th>Part #</th>
<th>Part Name</th>
<th>Model # (McMaster unless specified)</th>
<th>Quantity</th>
<th>Cost ($)</th>
</tr>
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<td>1</td>
<td>Steel Block Weight</td>
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</tr>
<tr>
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<td>Drive Shaft 36” long 1/2” dia.</td>
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</tr>
<tr>
<td>3</td>
<td>Drive Shaft 6” long 1/2” dia.</td>
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<td>2</td>
<td>0</td>
</tr>
<tr>
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<tr>
<td>6</td>
<td>Table (plywood)</td>
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<td>1</td>
<td>0</td>
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<tr>
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<td>FHP V-Belt 4L</td>
<td>Granger:4L800</td>
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<td>Zamak V-Belt Pulley 8” OD</td>
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<td>9</td>
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<td>10</td>
<td>Manual, Hand Held Can Opener</td>
<td>6118T1</td>
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<tr>
<td>11</td>
<td>Steel Threaded One-End Pipe</td>
<td>7753K165</td>
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<td>Wooden Shunt</td>
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</tr>
<tr>
<td>15</td>
<td>Can Opener Holder (plywood)</td>
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<td>0</td>
</tr>
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<td>Steel Ball Bearing 1” OD</td>
<td>Granger</td>
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<tr>
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<td>3’ long 2”x4”</td>
<td>n/a</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>6” long 2”x4”</td>
<td>n/a</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>Large Pulley Support</td>
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<td>0</td>
</tr>
<tr>
<td>21</td>
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<td>0</td>
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<td>Small Pulley Support</td>
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<tr>
<td>23</td>
<td>Large Pulley Block</td>
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<tr>
<td>24</td>
<td>Treadle Arm</td>
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</tbody>
</table>
11. Appendix C - CAD Models

Part 1

Part 2&3
Part 4

5/8" 11/32"

2 1/2"

3 1/4"

1 9/16"

3/4"

5/16"

+0.001" to +0.0017"

McMASTER-CARR

PART NUMBER 5912K5

http://www.mcmaster.com

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Aluminum Base-Mounted
Bronze Bearing
Part 10

McMaster-Carr - Can Opener, Manual, Hand Held Vinyl-Cushioned Handles

Can Opener
Manual, Hand Held Vinyl-Cushioned Handles

<table>
<thead>
<tr>
<th>Material</th>
<th>Chrome-Plated Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Can Height</td>
<td>Any</td>
</tr>
<tr>
<td>Overall Size</td>
<td>7&quot; Lg. x 2 1/4&quot; Wd.</td>
</tr>
<tr>
<td>Additional Specifications</td>
<td>Manual Opener</td>
</tr>
<tr>
<td></td>
<td>Hand Held</td>
</tr>
</tbody>
</table>

(P-R) Manual Openers—Style Q has vinyl-cushioned handles for a firm grip.

Part 11

McMaster-Carr
PART NUMBER 7753K165

http://www.mcmaster.com
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Information in this drawing is provided for reference only.

3/4 NPT Pipe Size, 14 Threads Per Inch, 0.55" Thread Engagement
0.113" Wall Thickness
0.824"
Part 12

Tolerances
\( X = \pm 0.1 \text{ in.} \)
\( XX = \pm 0.03 \text{ in.} \)
\( XXX = \pm 0.010 \text{ in.} \)
Angles \( \pm 1/2 \text{ deg} \)
Part 13
Part 14

Part 15
a. Annotated Bibliography (limited to 150 words per entry)

-Costanzo; Frank T. (Phoenix, AZ), Noyes; Robert R. (Winnipeg, CA), Sharkey; Leo J. (Doyles Town, PA) Assignee: Costal Sales Associates, Inc. 08/959,556 Filed: October 28, 1997