BRANCH GRIPPING TREE TRIMMER

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ABSTRACT

Tree trimming is something that many must do to keep their property free of unwanted tree limbs. Tree trimming can be done with loppers and chainsaws; for higher reach branches, pole mounted versions of these cutters are made. Standard loppers can only cut thin branches (less than 1 inch thick) so a saw must be employed for thicker branches. This comes at a cost, pole mounted chainsaws often bounce off of the limb once the saw is running due to the users’ inability to apply sufficient pressure to the saw from such a far distance. This phenomenon is often referred to as ‘backlash’. It can be dangerous and creates poor cuts through tree limbs.

Surveys show that people are dissatisfied with current thick cutting pole trimmers due to the fact that backlash makes them difficult to use. The average user of a product like this would like to see some sort of modification that would prevent backlash from happening. They are concerned about ease of use and overall effectiveness, but most of all, safety. Safety must be seen as a high priority when designing this product. All customer concerns, wants and needs were taken into consideration and built into a QFD matrix to calculate the importance of each feature while still putting out a cost effective product.

To achieve a product like this, a jaw mechanism will be mounted below the chainsaw to enable the user to firmly grasp the branch whilst cutting. The user will grip a trigger at the base which will pull a cable that runs through the entire length of the pole. The cable moves the jaw up and grips the branch with an effective amount of force to keep the saw firmly in place. This allows the user to easily and quickly remove the branch and leave behind a clean cut. Designs and models of this product have been built to simulate stress tests from forces derived from calculations. The model is also used to build a prototype which is used for demonstration and repetitive testing of its various features on tree limbs of various heights, sizes, and shapes. To ensure that the product can be recreated for mass production, a bill of materials is also necessary to go along with the models not only to ensure correct parts are always used, but also to see that cost stays at a minimum while still producing a quality product. In order to meet the budget, the efficiency of manufacturability, and to meet the demands of the customers, a jaw addition to a thick limb cutting pole trimmer is the best option.
PROBLEM STATEMENT AND RESEARCH

BACKGROUND AND PROBLEM STATEMENT

Branches and limbs of a tree are an essential part of their survival; they allow a tree to spread its leaves out over a wide area to achieve maximum photosynthesis through exposure to the sun. But as the tree ages and receives its nutrients, it begins to grow in all directions. They do this to get as much sunlight as possible. But sometimes when trees grow in many directions, it can become a problem depending on location. Some people like to trim their trees to keep them looking shapely. Other people trim their trees just to harvest their low lying wood or to simply remove the obstacles or potential hazards some branches create. There is a difficulty with doing this though; branches located out of a chainsaw’s reach will require a small chainsaw attached to a pole or require the assistance of tree trimming professionals. The disadvantage of using one of these pole trimming chainsaws is the difficulty in using them; they often create backlash (also known as kickbacks), that is, the bouncing back of the chainsaw blade upon contact with the limb. This can be a potential hazard and also does not create a clean cut.

Inexperienced users of chainsaws are often afraid of the concept of using a chainsaw, and a chainsaw requires great care to operate correctly and safely, especially when mounted on a pole. Those with lack of experience may not know how to correctly handle a chainsaw at first or be able to gauge the strength required to apply the necessary pressure and pull force to keep it in place for a safe and clean cut. Also those who are elderly may also not have the strength or coordination to operate a pole saw correctly.

This project will redesign the electric chainsaw pole trimmer to allow any user of any skill set to operate the device safely. The pole trimmer will eliminate backlash and safely allow any user to create a clean cut with little effort.

RESEARCH, TECHNOLOGY, AND EXISTING PRODUCTS

Devices used for cutting high and out-of-reach limbs is not a new technology; simple chainsaw trimmers and loppers have been mounted on poles to accomplish this task. The Heavy-Duty Bypass Trimmer (Figure 1) has been around for over 30 years and serves as a high quality, comfortable bypass trimmer (1). With its success over such a long period of time indicates that a pole mounted cutting tool is popular and desired tool. Unspecified with this tool is its lifetime, length, or thickness of branches it can cut through.

Figure 1

Even at a price of $45.95 (1) for a product containing so few components, this type of product is desired.
A similar device which can perform the same task and then some is a chainsaw pole trimmer. The disadvantage to these is they do not grip the branch that they are cutting as does a bypass trimmer. There are two types of chainsaw pole trimmers; electrical powered and Gasoline powered (2). Both have their advantages and disadvantages.

![Figure 2](image)

An electric pole saw such as the one seen in figure 2 is lightweight, quieter than a gas-powered saw, requires little maintenance, and is more powerful than a battery powered saw (2) the disadvantages to these pole saws is they have a limited distance because of the cord, and they are not as powerful as a gas powered saw (2)

The advantages a gas-powered pole saw provides is they are more powerful, they run as long as there is gas in the tank, they last a long time as long as they are maintained properly, and are easy to operate (2). The disadvantages to the gas-powered saws are they are heavier than an electric saw, they are very noisy, they are expensive, and they are costly to maintain. (2).

One will need to consider many factors about the type of pole saw they wish to use.

These include the following which are also presented in Appendix A(2)

- how much power and what blade type is needed to get the job done
- is the saw light enough for the pole withstand the weight of the saw without bending or breaking
- how strong is the saw-to-pole connection to prevent kickbacks
- can one easily afford to properly maintain the pole saw they have purchased
- does the pole saw reach the branches at an effective height
- is it suitable for use
Out of all of these pole saws and the criteria they meet, none of them were able to clearly meet what I have proposed. There is a device however that does meet the criteria of my proposal on a different level; the Black and Decker Alligator Lopper (Figure 3).

![Black and Decker LP1000 Alligator Lopper](image)

Figure 3

This device is primarily for those who are intimidated by chainsaws or are not sure how to use them (3). This device is safe, allows for a clean cuts for first time users by gripping on to the branch and stabilizing the saw (3). The Alligator Lopper can safely and easily cut through up to 4 inches of wood in seconds (3). This product not only appeals to those who are experienced with this kind of tool due to its ease of use, but is also appealing to new users of heavy duty cutting equipment. The appeal to new users is primarily the safety factor, along with the ease of use. Many older people who use this product commented on how easy and convenient it was to use, some saying “where has this been?!” (3)

One thing to note is that a pole trimming version of this device has not yet been created. With the disadvantages of the current pole chainsaws, something like this may be a good replacement for smaller high reach limbs.
CUSTOMER NEEDS, SURVEY RESULTS, AND WEIGHTED IMPORTANCE

Things considered as important regarding the customer prior to the surveys and interviews were the following:

- ease of use
- initial investment cost
- efficiency
- worker safety
- load/capacity
- Maneuverability
- Overall size
- Cutting accuracy

The surveys revealed customers rated the above criteria in the following percentages

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial investment</td>
<td>12%</td>
</tr>
<tr>
<td>cost</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>4%</td>
</tr>
<tr>
<td>Worker Safety</td>
<td>51%</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>6%</td>
</tr>
<tr>
<td>Load/Capacity</td>
<td>17%</td>
</tr>
<tr>
<td>Maneuverability</td>
<td>6%</td>
</tr>
<tr>
<td>Overall Size (length)</td>
<td>1%</td>
</tr>
<tr>
<td>Cutting Accuracy</td>
<td>3%</td>
</tr>
</tbody>
</table>

Table 1

People were also interested in the mechanism being lightweight, comfortable, requiring little effort to hold in place while it operates and has enough power to cut through limbs as a conventional pole chainsaw. This leads into the following QFD.
The QFD highlights the customer needs and relates them to what needs to be considered when engineering the device. The list in the customer requirements column stems from what customers would like to see in this product, and the engineering row is split into all of the things that will need to be considered in the engineering of this product to meet the customer requirements. Many engineering sections revolve around keeping it comfortable for the user, minimal forces and easy maneuverability are desired by the customer, maneuverability being another direct requirement for customers. Primarily customers by far are concerned with safety, and this also reaches into many sections of engineering requirements. Many of these
numbers are high due to the interest in safety by customers. Customers also seemed to consistently ask about safety relating to the features such as is it easy to hold. These include sliding, grasp torque, weight, and hold force. As a result these have been rated high on the engineering importance scale. Also regarding safety, customers were interested in the distance the saw would be from them. Another safety issue accounts for the user and distant objects exposed to the blade that should not be in contact with the blade; this is a factor must also be considered.

**PRODUCT/ENGINEERING FEATURES**

Things that must be considered when engineering this product are the following

- Strength: how much force must be applied to vulnerable sections of the device before they fail and how those areas can be strengthened.
- Durability: how much use can this device take before needing maintenance
- Speed: how fast can it cut through branches
- Comfort: is it aesthetically pleasing or intimidating, is it easy for any person, young, old, inexperienced or experienced to handle effectively.
- Maintenance; what parts may need to be replaced after so much use
- Power: how much power is required to cut through hard, soft, and wet wood quickly and cleanly; what type of electric motor
- Disposal: how will this device be disposed of once it has passed its useful lifetime
- Price: how much will this product cost to make
- Chain; what type of chain is best suited to meet the tasks this will perform
- Limits: what are the maximum abilities of this device and how will it preform

This and the customer needs will define what the best solution to the problem statement will be and will ultimately result in the final product.

**PRODUCT OBJECTIVES/CONCLUSION**

Bearing in mind the concept of this new product, the customer requirements, and engineering features that this product will narrow this product down to a branch gripping electrical chainsaw pole trimmer. This design will incorporate features seen on the Black and Decker Alligator Loppers (Appendix A) and will come in the form of a pole trimmer. The fact that the Alligator loppers were so popular among customers was their ease of use, comfortable operation, and speed. And an image of this device (Appendix A) in itself indicates that backlash would be near impossible with a gripping jaw holding the saw in place. This is why it has been decided that this may be the best path to choose in design.
PROJECT MANAGEMENT

BUDGET

<table>
<thead>
<tr>
<th>part</th>
<th>part count</th>
<th>price/part</th>
<th>total cost for parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>B&amp;D alligator loppers</td>
<td>1</td>
<td>$99.99</td>
<td>$99.99</td>
</tr>
<tr>
<td>box of bolts</td>
<td>1</td>
<td>$5.00</td>
<td>$5.00</td>
</tr>
<tr>
<td>box of nuts</td>
<td>1</td>
<td>$4.50</td>
<td>$4.50</td>
</tr>
<tr>
<td>electrical cord</td>
<td>1</td>
<td>$6.00</td>
<td>$6.00</td>
</tr>
<tr>
<td>hollow shaft (per foot)</td>
<td>9</td>
<td>$4.00</td>
<td>$36.00</td>
</tr>
<tr>
<td>clamp power system</td>
<td>1</td>
<td>$30.00</td>
<td>$30.00</td>
</tr>
<tr>
<td>labor</td>
<td>-</td>
<td>$50.00</td>
<td>$50.00</td>
</tr>
</tbody>
</table>

| Initial budget        | sum        | $311.49    |

Table 2

A brief summary of the budget:
The original budget is shown in table 2; it includes rough estimates of each component which was believed to be seen in a future design. Labor was an omitted cost. A ceiling set for this project was $500.00 to fund the prototype, and this estimate does not reach the price ceiling. This price ceiling was simply a preferred goal to keep cost to a minimum; the final cost was expected to breach this ceiling.
The final budget (Table 3) was derived directly from the bill of materials and contains a larger variety of purchased parts. Aside from 3D prints, the budget would have been below the $500 ceiling. However, due to the fact that 3D prints needed to be used in this design rather than injection molded parts, the cost went $416.86 over the initial estimated cost, and
$228.35 above the desired $500 ceiling. For a prototype, this cost is still very low; though it went past the initial price ceiling, in general it was well within an acceptable price range for a project of this scale.

**SCHEDULE**

A brief description of the function of this schedule design provided by the University of Cincinnati:

Columns are by week starting with the first design task (Concept sketches/selection). Columns give dates. Tasks are broken into 1-2 week intervals. Each task line has 2 rows in the spreadsheet to allow for the actual interval to be added. Deadlines are typed as dates in the interval (earliest option). Deadlines match the MET and advisor requirements.
PRODUCT

DESIGN

The final design of this product has been chosen to be a jaw mechanism which will grip onto the branch to prevent movement of the saw during the cutting process.

Figure 4

The theory of operation is shown in figure 4. Attached to the purchased jaw is a lever which will have a broached square hole to serve as the keyway for the square key attached to the aluminum cast jaw. Circled in red is a hole where a 0.22” diameter cable will be looped through and crimped with a two bolt cable clamp. This cable will run down the length of the inside of the pole to the base. At the base the cable is connected to a spring loaded trigger mechanism (figure 5). The user will pull the trigger which in turn pulls the cable connected to the lever. This will create a rotational motion about the keyway allowing the jaw to rotate upward and grip the branch. The cable mechanism is designed to exert 20 lbs of force and through calculation this will allow the furthest end of the jaw (indicated by the red x) to provide a normal gripping force of 2.398 lbf.
To accommodate for these additions to a conventional thick branch cutting pole trimmer, the interior would need to be redesigned. In figure 6 two aluminum support brackets (highlighted in blue) will need to be made to provide rigid support for the jaw and debris shield. In order to allow brackets to fit into the Black & Decker chainsaw set, these brackets must be built around certain components or use them as support such as what is depicted in figure 7.
Initially it was planned to have the housing itself serve the purpose of these aluminum brackets, but due to the uncertainty regarding the rigidity of the plastic and how these moving components would wear on the ABS plastic over time, the idea was scrapped. Figure 8 shows the right hand bracket mounted on the saw bolts. Between the bracket and the saw plate is an aluminum spacer with rounded edges. The spacer is necessary for creating a clearance between the saw plate and the bracket so that the chain does not come into contact with it. A similar aluminum spacer serving the same purpose is on the other side and has an
obround protrusion on it to fit into the obround hole in the saw plate for support (figure 9).

![Figure 9]

The aluminum spacers will be bolted to the inner surface of the housing with multiple bolts to provide better distribution of the forces generated during the operation. The configuration of the right hand bracket with respect to the right hand side of the housing is seen in figure 10. In figure 11, the left hand bracket is seen mounted in the left hand housing on a flat surface which is supported by ribs. Also seen in figure 11 are the motor support rings which bear a large portion of the weight of the mounted trimmer.

![Figure 10]
In figure 10, the other side of the right hand housing can also be seen; there are noteworthy angled protrusions on its surface. These are to act as stops for the jaw and the moving shield, limiting their travel distance to where they will not be able to impact the housing.

The housing is composed of those two sections shown in figure 10 and 11. Each bears some level of structural forces in the assembly and therefore subject to FEA testing. Unlike most of the load bearing components in the trimmer portion, the housing is not made of metal. It would be too heavy and costly to produce. So ABS plastic is used. Normally injection molding would be used to make this feature in a high production environment. However this project does not call for more than one prototype and producing injection dies for the ABS plastic molds would cost thousands per die. So instead, all ABS parts in this assembly will be 3D printed.

Since the housing is a plastic and care must be taken when applying loads, a component mentioned earlier was developed to reduce many stresses on the housing: the motor support ring. This ring is composed of two parts: the base, and the clamp. Both are seen together in figure 11 forming a complete ring. The purpose of this two piece component is to rigidly support the motor and gearbox. The motor and gearbox is one combined purchased component and is by far the heaviest out of all of the items on the trimmer end. Therefore this ring was designed to clamp around the motor tightly and give it direct support from the pole itself. The base ring has two holes drilled in a rectangular section attached to its main circular shape, and the clamp is circular on both inner and outer edges. They are joined together by nut and bolt on their sides. The clamp also has three holes drilled into it; this is so that it can be directly attached to the housing to provide it with extra support.
The ring can be seen supporting the motor and gearbox in the assembly depicted in figure 12. Friction alone cannot reliably keep the motor in place, and positioning the bracket seen in figure 7 seen holding the gearbox within its shape is not safe enough. So the final major support to keep the motor from potentially rotating in the ring is seen in the final assembly of the trimmer end in figure 13.

In the large obround extruded pit in the surface of the housing seen in figure 13 are the bolts
which support the right hand jaw bracket. The bracket itself is attached to the saw bolts which go through to the gearbox frame. This support from the bracket gives the inner body its final amount of needed stability. The edges of the housing bend outward 90 degrees to allow for a surface with which the two housing sections can be bolted together with. This is seen in figure 13. Two, 3 inch long \( \frac{1}{4} \) 20 bolts will be run though the two holes as the bases of the housing section and the ring base, and run through two holes drilled in the pole. The wires for the motor along with the jaw cable will be funneled down into this area so that they can be concentrated inside of the pole.

Figure 14

The pole seen in figure 14 is the 6 foot long thick walled aluminum pole which the trimmer will be mounted on. It has an outer diameter of 1.66” and an inner diameter of 1.278”. Due to its length and the immense stress it will be under, FEA testing on this component was critical. On the far left of figure 14, a notch has been cut in the pole. This is to accommodate the cable for it must be mounted on the handle in a position where the cable’s bending radius would be affected drastically from being funneled into the pole. This notch will be covered by the handle.

Figure 15

The handle or “base” is seen in figure 15. It has a notch like the one seen on the pole in figure 14 and is there for the same purpose: to accommodate the cable radius. Figure 15 illustrates
the most important features of the base which is of course the notch, the v-mount where the trigger will be mounted, the small hole in the very end where the electrical cord will enter, and the bolt holes which will connect the base to the pole. The base will be mounted to the pole using the same type of bolts used to mount the trimmer to the pole: two 3 inch long ¼ 20 partially threaded bolts

The wires will enter the small hole in the back, feed through the top of the trigger’s v-mount, bypassing the trigger itself. The wires will then enter the electrical terminals of the flush push button switch. The saw will only run when this button is pushed down. The button has been put in a location where the users’ hand can operate both the trigger and the button at the same time so that their other arm can support the pole. A button mounted to the side of the pole where the user could push it with their other hand (the one not activating the trigger) but this idea was scrapped because people of many different sizes will be using this product; a button located in one designated place may limit the ease of use for smaller people. Also cutting a hole in the side of the pole for wires could potentially compromise its structural integrity and is a risk that needed to be avoided.

The resulting pole trimmer in figure 17 (jaw open and shield lifted) could be longer because of the lightweight nature of the trimmer itself. But in order to prove the concept and avoid further hurdles, a 6 foot pole was sufficient for demonstration.
CALCULATIONS

Calculations needed to be made to see the magnitude of forces which could cause vulnerable areas of the assembly to fail. A calculation also needed to be made to see how functional the jaw would be in operation. They include the pull force on the assembly generated by the chain based off of forces created by motor from its voltage and angular velocity and forces exerted by the user and how it translates to the force applied by the jaw. The summation of the weight of the trimmer needed to be calculated but that was done by solidworks and applied in the FEA with various safety factors.

The pull force generated by the saw was of importance: the brackets would be exposed to high amounts of stress should the pull force be high.

First the rotational speed in RPM. The chain of a chainsaw travels at roughly 88 ft/s(5).

Chain speed= 88ft/s
Chain gear radius=0.59 in

\[ r = \frac{0.59 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}}}{1} = 0.049 \text{ ft} \]

\[ \text{circumference} = 2\pi r = 2\pi(0.049 \text{ ft}) = 0.30892328 \text{ ft} \]

\[ \text{chain speed} = \frac{88 \text{ ft}}{s} \times \frac{60 \text{ s}}{1 \text{ min}} = 5280 \text{ ft/min} \]

\[ \text{chain gear rpm} = \frac{5280 \text{ ft/min}}{0.30892328 \text{ ft}} = 17091.5 \text{ RPM} \]

Gearbox ratio was 7-74

\[ \text{motor RPM} = \frac{17091.5 \text{ RPM}}{7/74} = 171101.1979 \text{ RPM} \]

Rated motor power 4.5 amps 20 volts

\[ \text{watts} = A \times V = 4.5 \text{ amps} \times 20 \text{ volts} = 90 \text{ watts} = 0.120692 \text{ HP} \]

\[ \text{Torque} = \frac{P \times 5252}{\text{RPM}} = \frac{0.120692 \text{ HP} \times 5252}{171101.1979 \text{ RPM}} = 0.0037 \text{ lb} \cdot \text{ft} \]

\[ \text{chainsaw gear torque} = \frac{0.0037 \text{ lb} \cdot \text{ft}}{7/74} = 0.0392 \text{ lb} \cdot \text{ft} \]
\[
\text{force generated by saw} = \frac{0.0392 \, lb \cdot ft}{0.049 \, ft} = 0.1052 \, lbf
\]

Consider that this force is traveling at 88 ft/s impacting the wood with small sharp teeth, but the effect it has on the overall infrastructure is very little.

Calculating the force generated by the jaw at tip

Jaw weight=0.49375 lbs
Cable force= 20 lbs
Cable angle=10° to normal
Distance to CG=0.3444 ft
Moment due to gravity=\(\alpha\)
Moment from pull force=\(\beta\)

\[
\alpha = 0.3444 \, ft \times 0.49375 = 0.17 \, lb \cdot ft
\]

\[
\text{perpendicular pull force on lever} = 20 \, lbcos(10°) = 19.696 \, lbs
\]

Distance to cable connection=0. 089 ft

\[
\beta = 0.089 \, ft \times 19.696 \, lbs = 1.753 \, lb \cdot ft
\]

\[
\sum \text{moments} = \beta - \alpha = 1.753 \, lb \cdot ft - 0.17 \, lb \cdot ft = 1.583 \, lb \cdot ft
\]

Distance to jaw tip = 8 inches = 0.6667 ft

\[
\text{force from jaw tip} = \frac{1.583 \, lb \cdot ft}{0.6667 \, ft} = 10.6678 \, N = 2.74 \, lbf
\]

\textbf{STRESS TESTS}

The stress tests focused on parts that would likely fail, some numbers were based on weight, some estimated and tested with a safety factor of 2. Others were tested far beyond expected loads (lever, key). It is VERY IMPORTANT to note that the deformations in these images do not represent true deformation but an exaggerated deformation so it can be seen how the forces affect the shape of the part.
Figure 18
The base was tested at 45 lbs, a fair estimation for a design factor of 2. The manner in which the forces were distributed with respect to the fixed position where the handle and the pole meet show that the highest stresses were seen at the area where the pole ends (the semi-circle in the center).

NOTE: The Solidworks simulation for ABS plastic was inconclusive due to the fact that it does not have factor of safety capabilities with that material; in this case, only physical testing could determine whether or not ABS could withstand the test.
Figures 19 and 20 show the von-mises testing for the left-hand side housing. It was tested twice with the same force applied: 90 newtons downward. This is a force far beyond what would be expected in this area. One test (figure 20) was conducted with the housing bolt holes fixed, that is, the bolt holes for the bolts that connect the left-hand housing to the right-hand housing. The other test exclusively had the ring bolts, the motor ring, and the pole case fixed. Both tests focused on the area of most concern, the bracket. The same test was conducted on the right-hand housing seen in figures 21 and 22.
The right hand housing has no ring to support the section coincident with the motor unlike the left hand housing, and removing the bolts on the edges leaves only the pole casing area as the fixed point.

Unlike ABS samples, the aluminum samples could be tested for their limitations. Solidworks had defined yield strength for aluminum. The following aluminum parts susceptible to failure were tested: the aluminum lever and the aluminum pole.

![Image of lever with stress analysis](image.jpg)

Figure 22

Figure 22 contains the lever; the broached square keyway was grounded, and the small hole on the left was subject to a force of 20 lbf, equal to that of the maximum cable pulling force that would be pulling on it. The minimum stress is seen at the rounded bottom of the lever and the maximum stress is seen at the corners of the square keyway. The resulting factor of safety was 11.1831; this would indicate that this lever could withstand a maximum pulling force of 223.662 lbf applied to the hole before failing at the keyway.
The trimmer head weighs 7 lbs. 20 lbf (over twice the force created by the weight of the head) was applied to the pole in the worst direction possible; parallel to the bolt holes. With the pole fixed to the base end face and bolt holes, 20 lbf applied to the opposite end caused the bolt holes to fail. The factor of safety with 20 lbf applied was 0.8216; this shows that under the worst circumstances the pole will fail at the bolt holes with more than 16.43 lbf applied at the opposite end (trimmer head end). Taking into consideration that the base will distribute loads over a much broader area on the base end of the pole, and the user will be holding the pole mid section, this is an unrealistic, extreme test of the structural integrity. However, this determines that this pole can be longer than the intended 6 feet which is important because this proves that all of the weight reduction done in the trimming mechanism by using aluminum was successful.

**FIELD TESTING METHODS**

Simulated testing cannot prove that this product will serve its intended purpose, only prove that it will work conceptually. So this product was built and tested in a real environment. The final assembly is displayed in figure 24. The device was tested on branches of various sizes, shapes, and heights. It needed to be able to be laid on the ground after each use as it would in the real world, and was tested again and again on any reachable branches. Then the jaw was opened and closed repeatedly to make sure it functioned well before, and after each test. It needed to be stored away in a cluttered garage which will also give information on its ease of storage. These tests were not carried out in one day but over the course of several days. Shortcomings and potential failures will be noted and solutions to them will be devised. The testing would prove determine how effective the device was, how easy it was to handle, how clean of a cut it could make, but most importantly whether it even worked properly.
The prototype trimmer was a great success; the crab apple tree on which the device was tested was not only partially trimmed exclusively for testing, but was eventually fully pruned with this device after testing was completed. Each attempt was equally successful on small and large branches, providing clean cuts in all cases. Figure 25 shows the largest branch cut with this device: a 3 inch diameter limb, cut off in just 6 seconds. The device was handled by multiple people; all had the same successful results and agreed that it was easy to use. Wood chips during the cutting process flew out of the housing at relatively high velocity in the opposite direction of the user, which was an unexpected but positive result.

The device only had one failure; the chain for the chainsaw was too loose and fell off during the first attempted cut. This was corrected by moving the saw frame further out from the chain gear by 1/8”. All other components functioned as were designed, and testing on 15
branches of several sizes, ranging from 1-3 inches in diameter, were successfully removed. Repeated placement on the ground was successful, being done after every 3 cuts. Storage for the most part was successful; the saw was able to be leaned against the wall in a garage. It was able to fit between the front of a car parked in the garage and a wall (1 ft 3 inches) with ease. Indoor storage was different however; this device was not meant to be stored in a basement (where it was stored during manufacturing). Wood chips would fall out of the housing all over the floor and maneuvering down an enclosed stairwell with a landing was difficult but could be done. Overall, its intended storage was very successful. It stores well in a garage in the upright position, or could even be mounted on a wall horizontally with wall hooks.

**BILL OF MATERIALS**

This bill of materials (BOM) serves as the list of purchasable items, their cost, who sells them, how many are needed, and how many parts come with one order.

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<tr>
<th>Description</th>
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<th>Quantity Purchased</th>
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**Table 4**

**TOTAL**  $728.35
The housing and handle are going to be made with ABS plastic. In mass production these parts would be created with injection molding. Creating injection molding dies for these parts would be economical in large scale manufacturing, but for this project the cost for dies would exceed the budget many times over. Therefore, these parts will be made with a 3D printer. Other parts such as the aluminum support components would normally have been cast, stamped, drilled, and one broached. But again mass production is not a factor in the creation of one prototype and cost to obtain those resources would be too great. So they must be milled in a machine shop out of a 0.5” thick 6061 aluminum plate. The 3D prints which take place of the ABS plastic housing pushed the design over the initial budget.

WORKS CITED

APPENDIX A

Heavy-duty Bypass pruner

This is the latest version of a professional-quality bypass pruner introduced 30 years ago. The Swiss-made tool has relatively straight, forged aluminum handles that are rubber-dipped for a nonslip comfortable grip. It comes right out of the package with a razor-sharp blade. The lower jaw has a sap groove - this space allows the sticky material to drain away so that it doesn't stick the blade and jaw together. Another professional-quality feature is the small notch in the lower jaw that allows the tool to cut the thin, comparatively soft wire that is used in plant packaging. The entire tool can be disassembled for cleaning, sharpening and repair. It costs $45.95 postpaid from Lee Valley Tools.

Lee Valley Tools, P.O. Box 1780, Ogdensburg, NY 13669; 800-871-8158.

Figure 4

The best pole saw can be defined as an elongated yet portable machine used for pruning and tree landscaping. It is made up of a pole with a saw attached on one end. The best pole is made from high quality material that can withstand the weight of the saw and does not bend on exertion of pressure when in use. It comes in sections and its length is adjusted by addition or removal of sections. There are three different kinds of pole saws depending on the energy required to run them. These are: gas-powered saws, electric pole saws and cordless pole saws. The electric pole saws require electricity to function and are attached to an external power supply. The cordless saws run on rechargeable batteries made of Lithium-Ion or Ni-Cad. The gas-powered ones are powerfully built to use up combustible gas in a pack on the saw.

Advantages of using the Pole Saw

- **Adjustability** - the cord lengths can be increased or reduced accordingly depending on the height of the branches and your height.
- **Easy maneuver** - you can easily walk around the tree while pruning the tree
- **Pole weight** - the pole is light and versatile
- **Quality of materials** - the pole is made of good quality metals that resist tension and pressure forces. The saw is equally made of steel that is durable.
- **Safety** - you do not require to use ladders hence reduced chances of encounter with the dangers of ladder-climbing.

**Electric Pole Saws**

The corded poles are easy to maintain and operate. They are light at about 10 pounds. The cord lengths vary but are commonly 100 feet.

: It is suitable for maintaining a small yard regularly.

**Pros:**

- It is very light
- It is less noisier than the Gas-powered saw
• It is more powerful than the cordless saw
• It is easily maintained and operated

Cons:
• The distance is limited by the cord
• It is not as powerful as the gas saw

3. Gas Powered Pole Saws
These are powerful saws equipped with more chains and heavy-duty bars. They are heavier, more pricey and noisier than the aforementioned types.

: These types of saws are suitable for professionals.

Pros:
• They are the most powerful in terms of performance
• They work as long as there is gas in the tank
• They last long when maintained properly
• They are easy to operate

Cons:
• They are heavier than the electric and cordless types
• They are very noisy
• They are costly to purchase
• They are pricey in terms of maintenance

What to consider before buying A Best Pole Saw
There are several factors to consider when buying a pole saw. These factors determine how long the machine will serve you, how well it will do and how you will maintain it.

• An appropriate pole saw should be able to reach the branches that are to be pruned. It should be able to cut through the branches and make quick and clean cuts.
• It should have enough power for the kind of work to be done and the right size of blades too.
• The saw should be light enough to be lifted up to the branches and should be strong enough to withstand the weight of the saw without bending or breaking.
• The connection between the saw and the pole should be durable to prevent kickbacks from occurring.
• The energy requirements of the saw should be affordable such that it can be maintained appropriately.
• A pole saw that meets this criteria should be deemed suitable for use.
The type of energy it uses - This in turn will determine the power of the machine, the size of the blades and the use of the machine.

The brand of the machine - This will determine the quality of the blades, the length of the pole and the price of the pole saw.

Power of Pole Saw

Gas-powered saws - The Husqvarna is arguably the most powerful in its kind. It uses a 2-stroke, 24.5 cc gas engine and a horse power of 1.2 which is rather high. This machine translates to quicker chain speed and faster cutting when compared to others. Cordless saws - The least powerful cordless ones average 18-20 –volts. Electric-powered saws - An example is the Remington RM1015SPS which provides a 1.5 horsepower from 8 amperes. The cordless and electric saws are therefore less powerful.

Height of Pole

The long poles reach maximum extensions at 11 feet with the longest one yet being 13 feet long. They can be re-adjusted to 6 and a half feet long when the trees aren’t very high. The pole reach can be obtained from adding your height to the maximum extension of the pole. It is useful to know the difference between the two when purchasing because the maximum extension is a more useful variant to you than the pole reach.

Weight of Pole Saw

The weights of the poles depend on the company’s preference of material and the length of the pole. With regard to the saws, the battery-operated ones are heavier than the electric ones with cords because of the difference in the weight of the battery. A Black and Decker cordless LPP120 weighs 6.3 pounds. Gas pole saws are heaviest because they have bigger blades and chains for their heavy use. One Husqvarna weighs 16.1 pounds.

The big Size of Branches You Want to Cut

The size of branches to be cut depend on the power of the machine as well as the size of the blades. The cordless saws are useful for gardening since they cut branches of around 6 inches in diameter comfortably while the gas-powered saws can cut through most big branches with bars as long as 12 inches.
The Practical Black and Decker Alligator Lopper

SEPTEMBER 25, 2014 BY MAIL@GIOSASSO.COM

If you’ve never heard of the Black and Decker Alligator lopper my only question is: Where have you been? When I stumbled upon this tool I have to be honest, I was somewhat in awe of it. Why? Because this tool is exceptional at what it does is fill a need that consumers yearn for – an easier way to cut wood, and in this case, it safely cuts wood under 4 inches.

In fact, the Black and Decker Alligator lopper is so good that you don’t need a chainsaw if your yard work doesn’t require cutting wood any larger than 4 inches. Some customers claim that it can cut wood up to 5 inches in diameter. Even better. Manufacturers are typically conservative when it comes to their recommendations, and in this case, to your advantage.
Work Safer with the Black and Decker Alligator

It’s far too common for people to think that a chainsaw is the only tool available for cutting branches, logs, twigs, vines or even small trees. But let’s face it; chainsaws can be very intimidating, especially if you’re a first time user. Chainsaws are highly effective and useful for cutting wood but they do require a certain degree of skill; forcing you to learn the nuances of chainsaw operation and have knowledge of proper safety procedures.

Another big advantage of the Black and Decker Alligator lopper is the fact that it’s safer to use than a chainsaw due to its advanced design. See the video in this article to see how it works and you’ll quickly understand why. Plus it’s much lighter than a chainsaw.

I certainly wouldn’t recommend a chainsaw for everyone and in all honesty, in some cases they’re completely unnecessary and would be considered overkill. They are a dangerous tool especially for people who treat them like any other power tool. For people who aren’t comfortable using a chainsaw there are alternatives and I’m here to introduce you to a great one: the Black and Decker Alligator lopper.

So, if you’re someone who needs to do some light cleanup work around your home, which might include: cutting branches (limbing) around your yard, cutting small logs or even felling a very small tree, you’re in luck. Yup, Black and Decker has come up with a fantastic tool to help you to tackle these projects for cutting wood up to 4” in diameter, and even slightly larger. Perhaps closer to 5” according to customers.

The tool we’re spotlighting here is the Black and Decker Alligator lopper. There are three models for you to choose from; which you can see in the comparison chart included in this article.

Watch the Alligator Lopper cutting wood:

I love choices but sometimes I wish they just made one version of a tool so I don’t have to sift through all the data. They say that too many options actually degrades our level of happiness because as humans we tend to over-analyze and strive to make the best decision. So even after we make a decision we still wonder, “Did I make the best decision?” I’m genuinely impressed or I wouldn’t be spending the time to write this article.

Features:

- Heavy-duty 6 inch cutting bar and chain
- 4” maximum cutting capacity
- Grab and cut in one simple motion
- Accidental starting prevention with dual-hand switches that need to be activated to initiate cutting
The Alligator Lopper™ is **ideal for tree pruning and clearing brush** and is a great alternative to chainsaws, manual loppers, handsaws and clippers

- Powerful. Fast cutting
- **Patented clamping jaws** grab and cut limbs, logs and brush safely in one easy motion.
- Cuts limbs too big for manual loppers
- Innovative clamping jaws

Generally, all three of these models are the same tool with the main difference being in the power source: Electric vs Lithium Ion vs NiCad (Nickel-cadmium) but there are a few other differences that I want to point out here.

*I use a Husqvarna 18" inch chainsaw for cutting larger trees and branches and was looking for something that was smaller and easy to carry around for the small jobs such as pruning and cutting up downed tree limbs. This tool fit the bill perfectly. It can easily cut 4 to 5 inch trees and branches and is light enough that my wife can use it. It holds a charge for a decent amount of time and cuts really well. I was actually surprised by how much power it has for a battery powered tool and was also surprised at how quiet it is*

*I am a 65 year old woman. My doctor forbids me to use my chainsaw. I need kindling, the Gator works very well. My 25 year old son even used it and was surprised that it worked so well. I bought 2 batteries and the charger. It charges quickly and the charge lasts as advertised.*

*This is an awesome tool that was purchased for cutting up pallets/skids a manufacturing company making it easier to dispose of. It was easy to follow the directions and safer than a regular chain saw because you have to compress both handles at the same time. Oiling it was not a problem.*

*The B/D Alligator Lopper is awesome – it is SO much easier to use than a regular chain saw. I’ve been going through a pile of brush/tree limbs that has piled up on our property for years. This tool has made it FUN! I’ve been dreading cutting all this up and once I saw this, I knew it was the answer. I have high expectations and have NOT been disappointed. I’ve used it on some large limbs and it cuts through w/great ease. Let the machine do the work – takes very little effort on my part. The cordless one is worth the extra cost to avoid having to deal w/cords.*

*This is a great tool! Easy to use and so much safer than a heavy chainsaw! We have used this hundreds of times around the yard, helping neighbors, and managing lots of different kinds of tasks— cutting up fallen tree limbs, cutting down weed trees, and lots of yard maintenance.*
Black & Decker LP1000: It’s electric so you don’t need to worry about batteries.

The Black & Decker Alligator lopper LP1000 is the corded version of the tool and also has the most reviews on Amazon with over 680 reviews at 4.7 out of 5 stars. That’s very impressive. What I’m trying to say is that customers who actually purchased this saw absolutely love it so there’s nothing more that I can really add to that. True validation comes from customers who use the device on a regular basis.

If you don’t mind dealing with an extension cord and you need to do a lot of cutting then this is certainly the model to buy. You can use this model all day long without ever having to worry about when the battery will die on you, which is makes yard work more pleasant and less stressful. If you don’t already have one, don’t forget to buy the right extension cord, and I’ve created a guide that goes into detail on how to decide: Extension Cord Buying Guide.

What’s included in the box?

- Oil Bottle
- Wrench

Perfect for:

- Pruning branches up to 4” in diameter
- Cutting branches into manageable pieces
- Cleaning up after a storm
- Cutting for extended periods of time

What Amazon customers say:

Appears safer. The blade is almost entirely enclosed. When you put the saw down, you don’t need to worry about the blade hitting anything. The light weight (6 pounds) is also less tiring.
I have a small gas-powered chain saw and also a gas-powered pole saw. The chain saw is heavy to hold up and I didn’t need to use the pole saw for most of my pruning. Based on the reviews, I decided to give this product a try. This tool works really great! It’s not super heavy and you don’t have to mess with gas since its electric powered. I’ve been using mine to trim oleanders with some branches 4” thick with no problems. Even with ratchet loppers, it’s not always possible to cut the thicker branches and the Alligator Lopper solves this problem. You do have to put oil into a small covered hole but you have to oil and chain saw device. The jaws shield the cutters while closed so it’s pretty safe to use.

Finally a lopper/chain saw that a woman can safely and comfortably handle for yard work trimming. I highly recommend this. Easy to handle and simple to maintain the chain.
APPENDIX B

Trimmer exploded view

Pole trimmer assembly
Right hand housing with right hand bracket

Left hand housing with left hand bracket and ring assembly
Right hand bracket in assembly

Left hand bracket in assembly
Jaw and shield with brackets
Ring assembly around motor

Inside view (right hand side)
Trimmer head right hand side view

Handle assembly (minus cable and push button switch)
Trimmer head left hand side view

Right hand spacer
Spacer left hand

Saw frame interior
Saw frame (x2)

Ring support clamp
Ring support base
Chain pinion

Chain Gear
Motor cap

Aluminum tube

Saw shield
Lever
Motor
Gearbox housing right hand side
Gearbox housing left hand side
Gearbox gear (connected to chainsaw gear)
Bracket right hand side
Bracket left hand side
Housing left hand side

Housing right hand side
Trigger body (no lever or cable)
Base handle

2 piece jaw right hand side
2 piece jaw left hand side
STRESS TEST SAMPLES
APPENDIX C

PRODUCTION DRAWINGS

Base PD (view 1)
Base PD (view 2)
Lever PD
Right side housing PD view 1 (this is labeled “LEFT” because of the orientation it was modeled in while building the trimmer)
Right side housing PD view 2
Left side housing PD view 1 (this is labeled “RIGHT” because of the orientation it was modeled in while building the trimmer)
Left side housing PD view 2
Right bracket PD 1 (this is labeled "LEFT" because of the orientation it was modeled in while building the trimmer)
Right bracket PD 2
Right bracket PD 3
Left bracket PD 1 (this is labeled “RIGHT” because of the orientation it was modeled in while building the trimmer)
Ring mount PD 1 (view 1)
Ring mount PD 2 (view 1)
Ring mount PD 3 (view 2)
RING MOUNT BASE

ring 2

Ring Clamp PD
Right side spacer PD
**APPENDIX D**

Customer Survey
Extended Power Trimmer
This survey will be used to prioritize features of this product to maximize customer satisfaction. The device will address the issue of high reach limb trimming. This should allow the user to trim with ease and accuracy without the issue of backlash during trimming.

**How important is each feature to you in a pole trimming device?**

Please select the appropriate answer. **1= Low importance  5= High importance**

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**How satisfied are you with your current pole trimming technology?**

Please select the appropriate answer. **1= Very unsatisfied  5= Very satisfied**

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<tr>
<td>Load/Capacity</td>
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<tr>
<td>Maneuverability</td>
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<tr>
<td>Overall Size (length)</td>
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<tr>
<td>Cutting Accuracy</td>
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**How much would you be willing to invest in this technology?**

$1000-$3000  $3000-$5000  $5000-$8000  $8000+