Mechanically Assisted log splitter

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by

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**ABSTRACT**

My project was stemmed from the need to help my dad split wood. When I left for college in 2008 he was left to do everything himself. What he encountered was an increase in time required to split wood, to heat our house, because he couldn’t lift the logs anymore which in turn made him spend more time cutting and more time in the cold. Because he was having difficulty spending more time in the cold and difficulty lifting logs he was being much less efficient at gathering enough wood to heat our house in the winter. This lead me to come up with a hybrid log splitter that used the industry’s best ideas in my own unique design to help increase efficiency and ease the burden of splitting wood alone. The scope of the project is to be able to lift a 24” piece of hickory to the splitting surface and split the wood into multiple pieces at a time. For my calculations I would need a splitting force of roughly 15,000 lbs to split a piece of hickory. I also wanted to keep to my efficiency guidelines so I designed my system to be roughly an 11 second cycle. My project was able to demonstrate the desired requirements based on material properties and hydraulic properties and hydraulic calculations. I was able to conclude the project was a success after a few hours of testing. I would however recommend being more frugal when ordering metals, hydraulics, and components. The splitter was above anticipated budget but below goal budget.
PROBLEM DEFINITION AND RESEARCH

Problem Statement
You’re a farmer who has grown up heating during the winter with natural wood heat, you thoroughly enjoy being in the woods, cutting down trees, splitting wood, and using the wood you processed to heat your home. But, you’re tired of wasting time cutting big logs into quarters so you can pick them up or your back isn’t strong enough to lift the logs to the splitter. What do you do? Most people don’t bother cutting down big trees anymore or they resort to buying preprocessed firewood which can be extremely expensive.

This solution can be found in a 3 point hitch wood splitter with an assisted lift. It has the design capabilities to split the toughest wood, up to 24” in diameter, easy to use hydraulic controls, an easy lift wood hoist to lift the bigger logs without wasting time quartering them up and it runs off of the tractor’s power take off, which is not only quiet but efficient.

Interviews
Jeff Michael, owner of a traditional landscaping business and outdoorsman, has been running a successful lawn care and landscaping business and was my resource for the voice of the customer. Consulting landscape jobs that require tree removal in the city of Columbus is actually cheaper to just chip the trees and not worry about splitting for firewood use. After learning of this I decided to gear my design more towards farm use. Jeff helped determine some of the criteria to build towards; speed, power, ease of use. The full interview notes can be found in Appendix A (Ref. 1).

Bob Fralick, is a lifelong farmer and has operated a successful timber and logging company during the winters since the early 80s. He was able to give me insight from a farmer’s perspective. His back is also not what it used to be and was adamant that the system utilize a lift to help get the logs from the ground to the splitter. The full interview notes can be found in Appendix A (Ref. 2).

Bogdan Kozul is a hydraulics expert and was able to help with the hydraulic system design. He was insightful when it came to the complexity of a hydraulic system and ultimately helped me choose my final design path for my project.
CURRENT PRODUCTS

Built Rite Splitters

Built Rite is a company that makes various farm equipment and has a line of wood splitters as well. Shown in Figure 1 is their 11hp splitter with an assist and a 4 way wedge. I studied this system because it had several components that were appealing to my design but there were drawbacks for my customer requirements with this design. This model is a pull behind so it has versatility but because of this it also requires a separate vehicle to pull it. This model has a great flow and it very easy to use. All of the controls are easy to access and it has a nice system layout. It also has a wood catch so you don’t have to bend over to pick up a piece that needs split again. I was able to use concepts from this to generate my final design. Altogether this model is nice to reference but is lacking power and the convenience of mounting it to a tractor. (Ref. 4).

Figure 1- Built rite 11hp Splitter
Trailer Hitch Hoist

Sherwood is a manufacturer of 3 point hitch wood splitters, Figure 2, which is run off of the tractors current hydraulic system. This has the advantage of saving quite a lot of cost due to the elimination of an engine, hydraulic pump, and hydraulic tank. The drawbacks to this design are that it tends to be slower than a pull behind, the power depends on the tractors hydraulic system and there is no lift to assist with hoisting the logs. This design gave me an understanding of the 3 point hitch only focus design. From this and the other design I was able to design my hybrid splitter. (Ref. 5).

Figure 2 – 3 Point hitch wood splitter

For more current products that aided in the design of the solution please reference the Appendix A.
CUSTOMER FEEDBACK AND OBJECTIVES

Survey Analysis

The features put into the survey were the ones most desirable to customers once research was conducted on the most requested qualities and characteristics of log splitters. The purpose of the survey was to find the importance of each feature in the design of mechanically assisted log splitter. The survey was distributed to friends, family, and industry experts. They were to rate the characteristics on a scale of 1 - 5, 1 being low importance and 5 being high importance. I also asked if they were going to replace their current splitter what cost would be reasonable to them. I did this to see if the time required and cost to build this system would be worth it.

The survey results were taken and used to determine which features were needed and which were unnecessary and finally used to come up with a design to satisfy customer needs. Purchasing the cylinders, pump and fluid tank ensured that the variance in the hydraulic system was to a minimum and that my force, speed and splitting capability is consistent. The results created a need for force over speed, due to the uncertainty of knotty wood, which lead me to redesign my splitting wedge. Given the need for force I was able to find a cylinder, pump and engine requirement that I think would satisfy most customers. Additionally the need for cost drove me to get rid of the external engine, axle, wheels, and expensive hydraulics pump and choose the power take off driven system. For more information on the survey see Appendix C.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Importance (out of 5)</th>
<th>Relative Weight</th>
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</thead>
<tbody>
<tr>
<td>Speed</td>
<td>4.25</td>
<td>15.4%</td>
</tr>
<tr>
<td>Force</td>
<td>4.50</td>
<td>17.1%</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>4.03</td>
<td>15.3%</td>
</tr>
<tr>
<td>Price</td>
<td>3.90</td>
<td>13.5%</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>3.40</td>
<td>12.6%</td>
</tr>
<tr>
<td>Compact Size</td>
<td>2.90</td>
<td>11.3%</td>
</tr>
<tr>
<td>Splitting Capability</td>
<td>4.00</td>
<td>14.8%</td>
</tr>
</tbody>
</table>

Table 1 – Survey Analysis
Product Features and Objectives

Based on the results from the survey, the product objectives were made to reflect features to keep in mind. The product objectives are listed below from most important to least important and come from the customer features and have been converted into measurable variables.

1. Splitting Force (17.1%)
   a. Based on calculations the splitter needs a splitting force of at least 11,231 lbs and 56,540 with a factor of safety of 5. A high safety factor is critical here due to logs having knots.

2. Speed (15.4%)
   a. The splitter should have a cycle of 15 seconds or less
   b. The splitter should have a single stage pump to keep the speed constant regardless of wood type or size

3. Ease of use (15.3%)
   a. The controls should be easy to learn and straight forward

4. Splitting Capability (14.8%)
   a. The splitter should be able to split a piece of hickory up to 24” in diameter 8 ways
   b. The splitter should be able to split in 8 ways or 2 ways for smaller/medium sized pieces

5. Price (13.5%)
   a. The splitter should be budget friendly to the average farmer
   b. The splitter should fall within the industry average for price, somewhere between $800 - $3000

6. Power Requirements (12.6%)
   a. The splitter should be able to run with a medium sized farm tractor ~45hp

7. Compact Size (11.3%)
   a. Should fit a standard 3 point hitch
   b. Should be able to drive farm wood plot to wood plot without hitting obstructions
Engineering Characteristics

This QFD will visually show the weighted importance of each aspect of the design or the engineering characteristics. These engineering characteristics were based on aspects which play a critical role in the fulfillment of the objectives and customer satisfaction.

<table>
<thead>
<tr>
<th>Engineering Characteristic</th>
<th>Importance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splitting Cycle (seconds)</td>
<td>23.00%</td>
</tr>
<tr>
<td>Splitting Force (lbs)</td>
<td>26.00%</td>
</tr>
<tr>
<td>Material Strength (PSI)</td>
<td>21.00%</td>
</tr>
<tr>
<td>Material Cost ($)</td>
<td>14.00%</td>
</tr>
<tr>
<td>Lifting Capacity (lbs)</td>
<td>16.00%</td>
</tr>
</tbody>
</table>

Table 2 – Engineering Characteristics/ Relative Weight
DESIGN

Design Alternatives - Concepts

In order to determine the best design that included the most desirable components and features of the system, three concepts were created and analyzed. Each concept took the features which potential customers saw as desirable and rearranged them in different layouts. Below are the three finalized concepts.

Pull Behind Assisted Concept

![Pull Behind Assisted Concept Side View](image)

This concept focused on the ability to pull and transport the splitter behind a vehicle. It had strengths in force, ease of use, and its ability to assist in lifting logs but it lacked in cost and practicality for a farm based customer. For these reasons I only used concepts from the design and deemed the entire design unfit for my application and customer demands.
This concept had high marks in cost and ease of use but low marks in assistance, power and speed. Because this system runs off of the tractor's current hydraulics it is limited in speed and power. The average tractor has a hydraulic pump capacity of 15 gallons per minute which causes a slow cycle time. This design also doesn’t have the assist mechanism, which is one of the requirements, so for these reasons this concept is unfit for my design.
This final concept took into account the positives from both of the previous designs and combined them into 1 hybrid design. The main focus was on speed and splitting force. By running a hydraulic pump off of the power takeoff and adding my own hydraulic fluid tank I was able to utilize the power and efficiency of the diesel engine, while keeping high forces and quick cycle times. I also added the mechanical assist and redesigned the 8 way wedge in order to gain versatility and ease of use. This system combines a middle of the road cost with a 10 second cycle time, roughly 20 tons of splitting force and an assisted log lift. This is the design that fits the customer and engineering characteristics the best.
**Design Selection**

I used the weighted rating method to select the design that met the customer needs the most. Below is a table that shows the weight given to each characteristic. A grade was given to the specific design based on how it fulfilled that characteristic, these grades ranged from zero to four. The grade was then multiplied by the corresponding weight assigned to that and design with the highest weighted sum was chosen.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Weight</th>
<th>Pull Behind Concept</th>
<th>3 Point Hitch Concept</th>
<th>Hybrid 3 Point Hitch Assist Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splitting Force</td>
<td>0.25</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>0.2</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>0.15</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>0.15</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Splitting Capability</td>
<td>0.16</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Compact Size</td>
<td>0.09</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>Weighted Total</strong></td>
<td>1</td>
<td>3.76</td>
<td>3.39</td>
<td>3.91</td>
</tr>
</tbody>
</table>

Table 3 – Weighted Rating Method
Mechanically Assisted Log Splitter

Cody Fralick

3-D Model

Full Splitter Assembly

The assembly can be seen in this view. The hydraulic cylinders are not exact spec because parker is working on exact drawings but everything else is the proper size. In this view you can also see the multi-way wedge. This wedge was a driving factor because of the force required to split a piece of wood. To decrease required force you can see I have the splitting edges offset. By doing this I was able to ensure that there would be no more than 6 points of contact at a time. This also allowed me to increase my factor of safety in case there was a piece of wood with large knots. The log lift will be able to hold 2 of the largest pieces of wood at a time or a stack of smaller pieces for convenience. I designed the hydraulic system is key to the design and in order to keep running at an acceptable operating temperature I designed the hydraulic tank to hold 30% extra fluid and to compensate for thermal expansion I designed the tank ~12% larger than needed. A big concern for this project was the strength of the material and required thickness for most of the materials so to compensate for this I used A36 steel, 3/8” tubing, and a w8x40 H-beam. For ease of use I incorporated a 3 way spool valve to give the operator full control over the splitter, wedge and lift.
Loading Conditions

Full Assembly with Loads

Figure 7 – Splitter Loading Conditions

Loading conditions for the splitter were applied by calculating the weights of fluids and materials on the assembly. I took into account the hydraulic fluid, wood, and material. Designing the 3 point hitch and hydraulic cylinder connection points, to be much stronger than needed, was critical for operator safety because failure at these points could be fatal or cause serious injury.
Loading conditions on the lift and beam for the wood were analyzed by finding the average weight of the densest wood. I also added an extra piece to simulate the highest possible loading conditions. For a 24”D 20”L piece of oak the weight came out to around 250lbs. After running analysis the loading conditions for the beam were not stressed and the lift arm was only seeing small amounts of stress at the connection points.
Design Analysis

Design analysis was performed on the splitter by using Engineering Toolbox to find properties for H-Beams (55,000 – 80,000 psi), finding the properties of grade 2 1.5” bolts (36,000 lbs) The heaviest load due to gravity that the splitter should see is around 3500lbs, which is well below the rated grade 2 1.5” bolt failure.

Figure 9 – Distributed Load Conditions Analysis

A test of the Finite Element Analysis (FEA) can be seen above. In order to accurately calculate the stresses on splitter mock pieces of wood were added to place forces in real life scenarios. The system will be supported fully at the 3 point hitch, represented by green arrows. The loads were applied in areas where the wood will be resting, on the plate holding the hydraulic tank/fluid, and a distributed load was placed over the beam to account for the cylinder and miscellaneous parts. The analysis was run and the results are above, the yield strength of the A36 Steel H-Beam is 2.500e+008 N/m^2 and, because the system components are designed with such stoutness, the max stress the system receives due to gravity doesn’t even register on the scale.
Above is the max displacement FEA test applied to the 3 point hitch. As you can see the colorations around the pins are barely changing colors, which shows that the materials are over designed for the forces applied.
Design Analysis on the push force from the hydraulic cylinder was conducted through the FEA software on SolidWorks as well as through hand calculations. Originally a 5 inch cylinder was specified but due to the strength of the beam and material and the desire for pushing force, from the customers, I was able to step up to a 6 inch cylinder. The results from the new analysis can be seen below beginning with the testing of the yield strength.

**Figure 11– Hydraulic Push Force Loading Conditions**

This hydraulic ram analysis is taking into account the 60,000lbs applied by the cylinder. The maximum force found during this Solid Works Simulation was 2.400e+007N/m^2 and the Yield Strength of the A36 Steel being used on this rack is 2.500e+008N/m^2 which means the max force applied by the hydraulic cylinder was almost 100% of the strength of the steel structure therefore I will consider adding some bracing to the push block and the connector block.
This is another view from the backside of the area where the cylinder is mounted and, while the colors are still green, it is still too close to failure and does not leave room for a factor of safety. This gives me reason to add material and support to decrease the chances of failure at this point.

Figure 12 – Hydraulic Push Force Loading Conditions Cont.
Component Selection

As stated previously I decided to purchase new components for as much of the hydraulics as I could. This included; cylinders, hoses, a pump, a hydraulic tank and control valve. The hydraulic system is crucial to proper operation so buying quality parts is necessary. Most of my hydraulic parts will be purchased from a Parker Hannifin dealer with the rest being purchased from northern tool. The rest of the splitter I will be able to manufacture out of scrap steel and purchased steel. The steel will be ASTM A36 because of its weldability and machinability. Most of the components will be welded and some will be bolted. This steel gives me the ability to have the characteristics desired for strength with the ease of manufacture. I will be using a H-beam, angle steel, tube steel and sheet steel. Most of the material will be purchased from various websites with some scraps used from the machine shop. I will purchase most of the material from metals depot.

Figure 13 – Parker 2H series Tie Rod Cylinder
Figure 14 - Prince 21gpm PTO Hydraulic Pump

Figure 15 - Parker Hydraulic Hoses

Figure 16 - 5ft3 Hydraulic Reservoir
Figure 17 - Prince 3 Spool Control Valve

Figure 18 – Structural Steel Angle

Figure 19 – Steel Flat Bar
Figure 20 - Steel H-Beam

Figure 21 - Steel Splitter Wedge
FABRICATION AND ASSEMBLY

Phase 1
This was my planning and picking up all of my materials. I had ordered from a lot of different places so this was mostly dedicated to getting everything I needed and starting to formulate a game plan of the best way to build. I had to be careful with how I built because a good portion of my fabrication was welding and I wouldn’t have enough to redo anything if I messed up. To help get a game plan together I consulted with my dad and a professional welder in order to figure out the best steps to take first.

Phase 2
For this phase I had decided, in order to practice my welding skills, to start with building the housing for my wedges. I used standard A-36 ½” steel to do this. I welded it just big enough to slide over a piece of A-36 2”x6” steel tubing. I had consulted with professor Conrad on how to properly weld this type of material and he suggested using a deep penetrating rod for the first passes and a more forgiving higher material placement rod for the second and third passes. This was actually the only part of my machine that had a failure during testing. I concluded that it was the welds that failed due to my inability to get the welding rod into the inside of the housing and weld the areas of high stress.

Figure 22 – Wedge broken at the weld
Phase 3

For this part of the build I had worked on my welding enough to feel confident to start working on and welding the more major components of the splitter. I next started working on the beam, the push plate, the anchor block, and the locations for the spool valves and hydraulic tank. This was by far the longest phase out of all of them due to the extensive welding, grinding, cutting, fitting, and adjustments that had to be made. This was also the part of the build where I learned the most. I was completely unaware of how much time actually went into fabrication, welding, machining and putting components of this nature together. This was also a reason I was behind schedule. I had accounted for 4 days to build and it actually took 7 – 8 days start to finish.

Figure 23 – Cutting pieces for the beam and wedge

Figure 24 – Measuring and cutting for the components on the end of the beam
Figure 25 – welding the components on the end of the beam

Figure 26 – Taking final measurements with my dad for the cylinder anchor block
Figure 27 – Final day, putting on the last of the components before hydraulics
Phase 4

This was the final phase of the build. I added all of the purchases components to the build; the hydraulic cylinders, the hydraulic tank, the 3-point-hitch lift pins, and bolted the wedge and lift arm up to their cylinders. Then I took the splitter to my hydraulics guy to get fitted for all of my hydraulic hoses. Once that was done I was able to add my hydraulic fluid and fit the pump to the tractor for testing.

Figure 28 – Hydraulic hoses and final components ready for testing
Figure 29 – second angle with all components and hydraulics on
Testing

In order to test the splitter I had to bleed the hydraulic lines and then the only other thing to do was split wood. While I was bleeding my hydraulic lines I had a failure with the chain that was keeping the pump steady. As the chain broke the pump rotated with the power take off and ripped 2 of my hydraulic hoses. This was a huge setback because the tech expo was approaching and I would not be able to get 2 new lines in time. So I presented my splitter at the tech expo with broken lines and it was not working. I was able to get the lines 2 days later and fix them in order to test. Once those were fixed and I solved my chain problem I was able to bleed the lines and test everything. I was able to split 3 pieces of wood before the weld broke on my wedge so I can conclude that my splitter design was successful but my welds were inadequate. My final steps are to redesign my wedge in order to reduce stress on it and make it easier to weld. Once that is complete my project will be functional and ready for the woods this winter.

Figure 30 – Successful testing with pieces of hickory
Conclusion

In conclusion I think this project was extremely fun and enjoyable while at the same time educational. I think that some of the professors at the tech expo were unimpressed with my project but my argument is that engineering is not just someone who designs stuff. An engineer is someone who finds a problem and solves it. My problem was my dad’s and other farmers inability to lift heavy logs and stay in the cold for a long time. My solution was to create a splitter that was not only cost effective but an easy fit for tractors they already had access to and would lift the logs for them while splitting in multiple sections to reduce time spent in the woods. I 100% think my project was a success and will give me the ability to enjoy splitting wood with my dad for many years to come. This project also helped me see the, often overlooked, correlation between design and manufacturing. As I designed it, everything made sense in my head but, when I started to manufacture I soon realized that things in the real world don’t ever go as planned and manufacturing takes longer than expected.
PROJECT MANAGEMENT

Bill of Materials

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<thead>
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<th>Item</th>
<th>Description</th>
<th>Vendor</th>
<th>Quantity</th>
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<th>Total Cost</th>
</tr>
</thead>
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<td>6&quot; bore, 3&quot; rod, 24&quot; stroke hydraulic cylinder</td>
<td>Prince Manufacturing Gladiator line</td>
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<td>815</td>
<td>815</td>
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<tr>
<td>3-Way Spool Valve</td>
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Table 4 – Bill of Materials
Mechanically Assisted Log Splitter

Cody Fralick

Budget, proposed/actual

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Total $2373.98

Table 5 – Preliminary Budget

For the actual budget see Table 4, Bill of Materials.
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Table 6 – Proposed Schedule
Plan to finish

Step 1: Submit Senior Design Report and receive feedback 1/14/15
Step 2: Make corrections regardless of receiving feedback after 1/14/15
Step 3: Begin creating presentation from the report
Step 4: Give presentation on 1/26/15
Step 5: Receive feedback from presentation
Step 6: Finalize design if needed
Step 7: Order parts so building phase can begin
Step 8: Figure out where to manufacture the system at
Step 9: Begin work on manufacturing parts
Step 10: Assemble parts and create first prototype
Step 11: Test prototype
Step 12: Fix or rebuild anything that needs done before spring break
Step 13: Do a live test the first weekend of spring break consisting of hauling meat for a long distance and raising and using the crane arm as well
Step 14: Make adjustments after live test if need be
Step 15: Maintain the system until Senior Tech Expo
REFERENCES
Properties of wood. [Online] [Cited: Oct 26, 14.]
https://books.google.com/books?id=NxUHAQAAAfAAJ&pg=PA578&lpg=PA578&dq=cleavability+of+wood&source=bl&ots=V7JYCh9Ry2&sig=dtQW2eoPWelgusVVLltE0iVm6g&hl=en&sa=X&ei=Xt_LVMbCBMvK5YATGioLwAg&ved=0CDQ6AEwBQ#v=onepage&q=cleavability&f=false.
Wood Splitter Parts. [Online] Northern Tool. [Cited: Jan 5, 15.]
## APPENDIX A - RESEARCH

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact Information</th>
</tr>
</thead>
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<tr>
<td>Jeff Michael</td>
<td>Hilliard Ohio 10/20/14&lt;br&gt;Owner of a traditional landscaping business and outdoorsman&lt;br&gt;Runs a successful lawn care and landscaping business&lt;br&gt;Voice of the customer.&lt;br&gt;Helped with showing cost of chipping vs splitting in city of Columbus&lt;br&gt;Steered me towards farm use&lt;br&gt;Gave input on criteria to build&lt;br&gt;Speed&lt;br&gt;Power&lt;br&gt; Ease of use.</td>
</tr>
<tr>
<td>Bob Fralick</td>
<td>1980 State Route 56 NW, Ohio, 43140&lt;br&gt;Lifelong farmer&lt;br&gt;Operated a successful timber and logging company during the winters since the early 80s.&lt;br&gt;Farmer’s perspective.&lt;br&gt;Easy on the back because farmers are so hard on their backs that when they get older they can’t lift heavy items&lt;br&gt;Mechanical assist&lt;br&gt;As you age winters get colder&lt;br&gt;Needs to be fast and efficient&lt;br&gt;Split a lot of hickory and oak&lt;br&gt;Design based on these trees because oak and hickory are 2 of the hardest to split</td>
</tr>
<tr>
<td>Bogdan Kozul</td>
<td>1/11/15&lt;br&gt;Hydraulics expert&lt;br&gt;Hydraulic system design.&lt;br&gt;Hydraulic systems are complex (heat, turbulence, debris, purity)&lt;br&gt;Need pressure regulator&lt;br&gt;10% room in hydraulic reservoir&lt;br&gt;20% extra oil over pump GPM requirements&lt;br&gt;Need a diffuser for return oil</td>
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## Built rite pull behind wood splitters

The built rite splitters are perfect for home use. They are pre-assembled and tested and can be purchased at almost any local equipment store. They have a high splitting capacity with a good cycle time. However, they are on the expensive side and are not practical for farmers looking for a splitter for the back of their tractor.

![Image of splitter](image)

### SPECIFICATIONS:

- Roughly 25 ton splitting force
- 10 second cycle time
- Quality materials
- Standard 2.5” ball hitch
- $6500

### Pros
- Pull behind
- Splits efficiently
- Has assist
- High splitting force
- Fast cycle

### Cons
- Expensive
- Not compatible with a farm tractor

[http://www.built-rite.com/woodsplitters.htm](http://www.built-rite.com/woodsplitters.htm)

10/1/14
Sherwood 3 Point Hitch Splitter
The Sherwood log splitter range allows for the splitting of firewood logs up to 20” long with a splitting force of up to 20 tons, using a 4” bore cylinder, and a stop/return detent valve which is standard on some models. These are very simple and easy units to buy and go for the average farmer. However, they are lacking the assist and cycle time desired by an older farmer.

SPECIFICATIONS:

- Up to 20 ton splitting force
- Standard 3 point hitch connection
- Stop/return valve
- 4” cylinder
- ~$1500

Pros
- Simple to use
- Cheaper
- Good splitting force

Cons
- Slower cycle time
- Doesn’t have an assist
- Isn’t as efficient
- Only splits 2 ways

APPENDIX B – OBJECTIVES

1. Splitting Force (16.7%)
   a. Based on calculations the splitter needs a splitting force of at least 11,231 lbs and 56,540 with a factor of safety of 5. A high safety factor is critical here due to logs having knots.

2. Speed (15.8%)
   a. The splitter should have a cycle of 15 seconds or less
   b. The splitter should have a single stage pump to keep the speed constant regardless of wood type or size

3. Ease of use (14.9%)
   a. The controls should be easy to learn and straightforward

4. Splitting Capability (14.8%)
   a. The splitter should be able to split a piece of hickory up to 24” in diameter 8 ways
   b. The splitter should be able to split in 8 ways or 2 ways for smaller/medium sized pieces

5. Price (14.5%)
   a. The splitter should be budget friendly to the average farmer
   b. The splitter should fall within the industry average for price, somewhere between $800 - $3000

6. Power Requirements (12.6%)
   a. The splitter should be able to run with a medium sized farm tractor ~45hp

7. Compact Size (10.7%)
   a. Should fit a standard 3 point hitch
   b. Should be able to drive farm wood plot to wood plot without hitting obstructions
Mechanically assisted wood splitter

The goal of this solution is to design wood splitter that will appeal to farmers of all kinds and meet their needs when it comes to a quality wood splitter for a decent price.

**How important is each feature to you for the design of the mechanically assisted wood splitter?**

**Please circle the appropriate answer.**

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</table>
# APPENDIX D – SCHEDULE

|------------------------------------|----------------|------------|------------|------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
## APPENDIX F – BUDGET

### PRELIMINARY BUDGET

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Company</th>
<th>Estimated Cost</th>
<th>Actual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic cylinders</td>
<td>1 6” cylinder 2 2” cylinders</td>
<td>Northern Tool Eq.</td>
<td>$600.00</td>
<td>-</td>
</tr>
<tr>
<td>Spool valve</td>
<td>3 – way spool valve</td>
<td>Northern Tool Eq.</td>
<td>$300.00</td>
<td>-</td>
</tr>
<tr>
<td>Hydraulic hose</td>
<td>Standard 3000psi hose</td>
<td>Northern tool/parker</td>
<td>$100.00</td>
<td>-</td>
</tr>
<tr>
<td>Hydraulic pump</td>
<td>21 GPM PTO pump</td>
<td>Prince</td>
<td>$529.99</td>
<td>-</td>
</tr>
<tr>
<td>Hydraulic fluid</td>
<td>Synthetic Cold weather fluid</td>
<td>Mag 1</td>
<td>$319.99</td>
<td>-</td>
</tr>
<tr>
<td>Hydraulic reservoir</td>
<td>25-30 Gal</td>
<td>Buyers</td>
<td>$224.00</td>
<td>-</td>
</tr>
<tr>
<td>Hydraulic regulators and fittings</td>
<td>Pressure regulator, diffuser and hose fittings</td>
<td>Northern tool</td>
<td>$200.00</td>
<td>-</td>
</tr>
<tr>
<td>steel</td>
<td>Misc angle iron, steel tubing, and sheet metel</td>
<td>Metals depot</td>
<td>$100.00</td>
<td>-</td>
</tr>
<tr>
<td>labor</td>
<td>Self built</td>
<td>$free</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>$2373.98</td>
<td>-</td>
</tr>
</tbody>
</table>
APPENDIX G – CONCEPT DESIGN DRAWINGS

Figure 31 - Pull Behind Assisted Concept Side View

Figure 32 – 3 Point Hitch With no Assist Concept Top View
Figure 33 – Hybrid 3 Point Hitch With Assist Design Concept Top View
APPENDIX H – HAND CALCULATIONS

• Required to split hickory
  • \( F = \text{Area} \times \text{cleavability factor} \times \text{number of wedges} \)
  • \( F = (3\text{mm} \times 8\text{”}) \times 2650 \times 4 \)
  • \( F = 10,015\text{lbs} \)

• Push force total
  • \( F_2 = \left(\pi \frac{d^2}{4}\right) P_2 \)
  • \( F_2 = (\pi \left(5\text{”}\right)^2 / 4) \times 2000 \)
  • \( F_2 = 39,270 \approx 20 \text{ tons} \)

• Elastic Section Modulus
  • \( \text{ESM} = \left(\frac{\text{push force} \times \text{wedge height}}{21,600}\right) \)
  • \( \text{ESM} = \left(39,270 \times 12\text{”}\right)/21,600 \)
  • \( \text{ESM} = 21.8 \)

• Cycle Time
  • Given 5\” bore, 24\” stroke, 21gpm pump
  • 11 second total cycle
  • calculated on http://internationalhydraulicsus.com/logsplitter-speed-calculator

• Required to split hickory – calculated above
  • \( F = 10,015\text{lbs} \)
  • \( F = 39,270 \)
  • Factor of safety of almost 4

• Elastic Section Modulus (concern)
  • \( \text{ESM} = 21.8 \)
  • Without 1.5 factor of safety
  • If calculated with only required force to split hickory
    • \( \text{ESM} = 5.56 \)
    • My beam is 10.2
  • Factor of safety of roughly 2
APPENDIX I – SHOP DRAWINGS AND FINAL ASSEMBLY

[Diagrams of mechanical components and assembly plans]