WORCESTER POLYTECHNIC INSTITUTE

3-in-1 Saw

Major Qualifying Project

AY 2012, 2013

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Design and prototyping of a carpenter's saw to perform the functions of three different saws; slide-compound miter saw, table saw, and handheld circular saw.

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Background Information

Glossary of Terms

Angle Cut – A cut made at an angle other than 90 degrees to the cut fence.

Base Plate / Depth Guard / Shoe – A fixture on a circular saw which can be adjusted to control the cut depth.

Bevel Cut – A cut which results in an incline angle other than 90 degrees between the table of the miter saw and the work piece.

Binding – stoppage of the cutting tool caused by excessive forces on the blade which exceed the power output of the motor. Common causes include excessive cut speed.

Category II Saws – A type of multi-use saw which employs a table fixed atop the blade of the chop saw to allow for rip cutting.

Chatter – deviation from the intended cut path characterized by small raised sections along the cut face of a work piece usually caused by vibration or movement of the tool during a cutting operation.

Chop Saw – A saw on a fixed base which is used to cross-cut or chop lumber or other building materials. Please note: although the base is fixed, the blade may move along a rail or on an armature to expand the cutting capacity of the saw.

Circular Saw – A handheld power saw with a rotating blade.

Combination Saw – See multi-use saw.

Compound Miter Cut – A cut which involves a bevel and angle adjustment to create an angle which is other than perpendicular with the grain of the work piece.

Cross-cut (Chop) – A cut made perpendicular or at some other angle except parallel to the grain in lumber.

Cut Fence – A low wall on the miter saw table against which the work piece is placed in order to orient the piece with respect to the blade throughout the cut.

Damp / damping – Prevention or reduction of uncontrolled or excessive movement by mechanical means.

Flip-over saws- A category of multi-use saw which is converted between modes by rotating the table about an axis.

Miter – An angled cut made in a work piece to fit the end to the end of another piece.

Multi-use saw – any saw designed to perform the functions of two or more conventional saws.

Radial Arm – The beam on a compound miter saw on which the work piece is rested.

Rip – A cut made parallel to the grain in a piece of lumber.

Rip Fence – A component of a table saw which is fixable at variable distance from the blade and serves to guide the work piece linearly for a uniform cut.

Ripping Capacity – The maximum size of a work piece which can fit between the blade and the rip fence at its most extreme position on the table.

Scissor Jack – A class of jack which uses a horizontal screw to move members of a linkage in order to lift weight.

Slide Compound Miter Saw – A chop saw which uses a blade riding on rails (slides) to achieve a greater cutting capacity and provides adjustment for compound miter cuts.

Table Saw – A saw which uses a blade protruding from a fixed table to make rip cuts.

Worm gear – A cylindrical gear with an axial tooth used in conjunction with a conventional gear to transmit torque.

Types of Saws

Circular Saw

A circular saw is a handheld power saw with a rotating blade. Figure 1 below shows a circular saw.

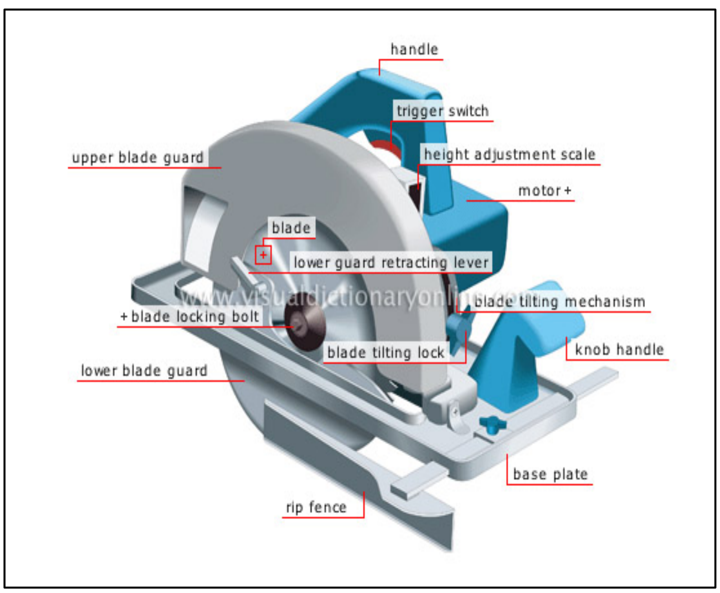


Figure 1: Circular Saw (Circular Saw)

Chop Saw

A chop saw is a saw on a fixed base which is used to cross-cut or chop lumber or other building materials. Although the base is fixed, the blade may move along a rail or on an armature to expand the cutting capacity of the saw. Figure 2 shows a chop saw, also known as a miter saw.

Figure 2: Miter Saw (Dewalt Miter Saw)

Table Saw

A table saw is a saw which uses a blade protruding from a fixed table to make rip cuts. Figure 3 shows a table saw.

Figure 3: Table Saw (Craftsman)

Background Research

In this section the reader will gain knowledge of research that was used for the 3 in 1 combination saw.

Overview

Results of the research into existing multi-use saw designs have shown that a saw which combines the functionality of a chop saw and a table saw has been explored by multiple parties. The designs for these saws fall into two general categories: flip-over saws and saws with a table saw atop the chop saw (herein referred to as “category II saws”). See Figure 4 and Figure 5 on the next page. There are two US patents concerning category II saws which are not available to US consumers, although Bosch offers a model in the European market (Bosch Model # GTM 12 Professional). Saws of the flip-over category are also available in the European market by manufacturers; DeWalt (sub. of Black & Decker) and Makita (a Japanese tool company). A US patent for a flip-over saw is owned by the Black & Decker Corporation. Each of the designs are shown in Figure 6 through Figure 9 on the following page.

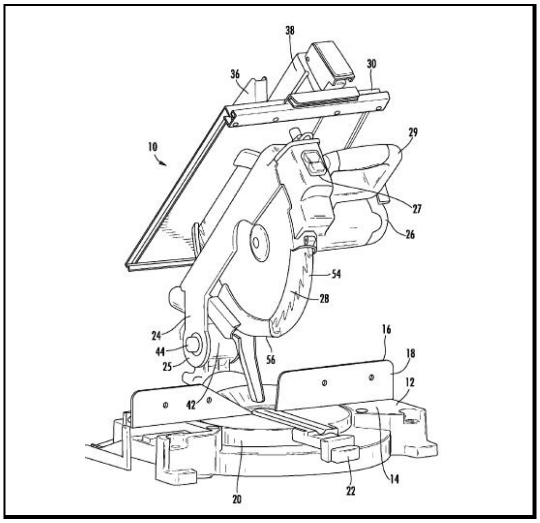
Figure 4: DeWalt DW743 Flip-Over Saw – Left (DW743N-QS)

Figure 5: Bosch GTM 12 Professional Category II Saw – Right (Bosch Table Saw)

Although each design has its particular strengths and weaknesses, it is helpful to explore the advantages and disadvantages of the two general categories of saws. The analysis of these designs is set forth below.

Flip-Over Saws

Flip-over saws, like those available on the European market, are similar in design to each other and convert between functional modes by rotating part of the table about a horizontal axis. The concept is fairly simple and the saws functions well in usability. One issue with these saws is the limited cutting capacity of the table saw. This limitation is brought upon by the size of the table whereby the rip fence cannot be extended beyond the edge of the table. The second, but more important issue, is that these saws require parts that are removed during the use of the saw as a chop saw and must be attached to convert the saw into a table saw. In practical terms, this creates the possibility for the operator to lose parts which are necessary for the functionality of the tool, thus rendering the tool unusable.



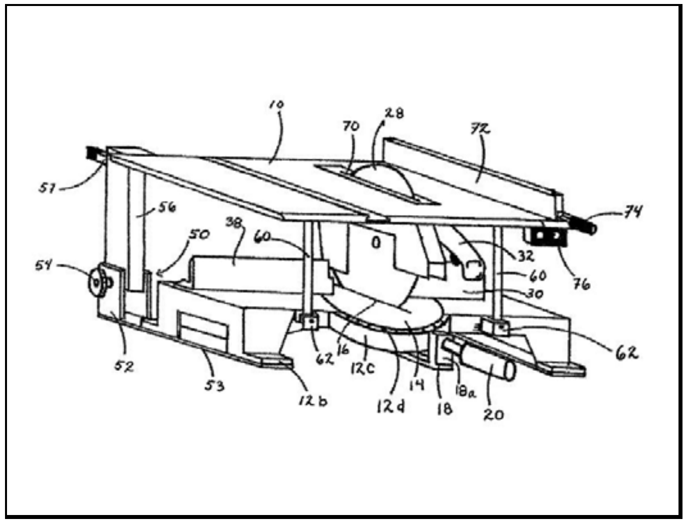


Figure 6: Patent US 20100269660 A1 Category II Saw – Left (Patent US20100269660)

Figure 7: Patent US 7891277 B2 Category II Saw – Right (Patent US7891277)

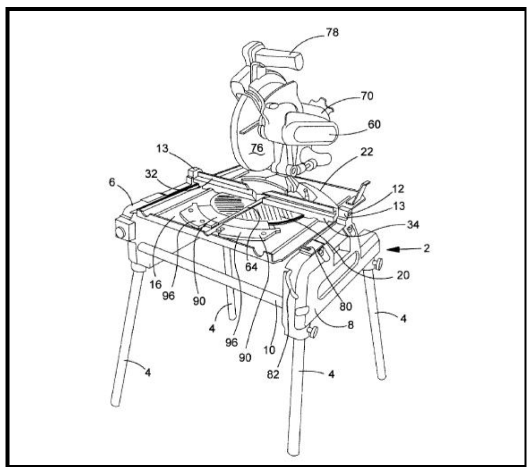


Figure 8: Makita LF1000 Flip-Over Saw – Left (Makita)

Figure 9: Patent US 20070234864 Flip-Over Saw – Right (Patent US20070234864)

Category II Saws

Category II saws achieve the functionality of both a chop saw and a table saw by utilizing a table on top of the chop saw which can be used as a table saw when the chop saw is in the locked down position. This concept is also very simple and it seems that less work is required to convert between operation modes. Unfortunately, with some models it is still necessary to remove and install some parts during conversion. Like the flip-over saws, the table saw ripping capacity is limited by the size of the table. Due to the particular design of this type of saw, the size of the table itself is limited more so than with the flip-over design. The lack of capability to make an angled cut with the table saw, due to the table being fixed to the top of the chop saw, further limits the functionality of the table saw.

Conclusions

Research into the existing concepts for combination saws has shown several important points. Firstly, none of the designs encountered in US patents or on the European market include a handheld circular saw capability; something which will be a unique goal for this project. Furthermore, the particular limitations of the combination saw designs should be addressed if a viable product is to be marketed to consumers. In order to make the product useful for working with material like sheets of plywood, which requires a larger ripping capacity, the table saw limitations need to be expanded. Also of concern is the removal and attachment of parts during conversion which should be minimized or, ideally, eliminated. A product that includes no removable parts and has the capability to handle the majority of construction related materials is the initial design goal.

Design Process

In this section the reader will be demonstrated the process involved for designing multiple prototypes of the 3 in 1 combination saw. The task and design specifications for the 3 in 1 combination saw can be seen below. These specifications were used to guide the prototype design.

Task Specifications:

1. One person should be able to carry the system. So, it should weigh less than 75 lbs.
2. Should convert between modes in less than 30 seconds. (This to be made more specific depending on design.)
3. Should incorporate industry standard safety guards for all three modes.
4. Stand should hold 300lbs. for miter saw use.
5. Should hold 300lbs. for table saw use.
6. Should make cuts to a precision of .001” with an 1/8” blade.
7. Working surface should be at an industry standard height or adjustable.
8. Should fold for portability/storage.
9. Should separate into no more than two major component groups (circular saw as one group, table/miter as the other group).
10. Should run on 120 V single phase power.
11. Should draw no more than 20 A current.
12. Should cost less than $1,000.
13. Circular saw should be able to withstand a fall from a two-story roof. (24 ft.)
14. Should be able to set-up from storage mode in less than 5 minutes.
15. Electrical components should be weather resistant.
16. Should be made with non-flammable materials.

17. Should be designed for the do-it-yourself market.
18. Moving mechanisms must be protected from debris and sawdust to a reasonable extent.

Design Specifications:

1. Circular saw should have bevel adjustment in both directions.
2. Circular saw should be adjustable between 60 degrees
3. Miter saw must be able to cut 2 x 12.
4. Table saw must have a ripping capacity of 25”.
5. Must accept a standard 10 ¼” blade.
6. Miter should be adjustable from 0-55 degrees left and 0-55 degrees right.
7. Miter saw should have bevel adjustable from 0 to 55 degrees in both directions.
8. Table saw should have a bevel adjustment from 0 to 55.
9. Table saw should have a 2.5” depth cut capacity.
10. Circular saw and miter saw should have a 3 ¾” cutting capacity.
11. Should have a laser guide for the miter saw with an accuracy of .001 in.
12. Table saw blade height needs to be adjustable to within 1/16”.

General Schematic Design

Figure 10 through Figure 12 demonstrate the final prototype of the 3 in 1 combination saw.

Figure 10: Device in Circular Saw Mode

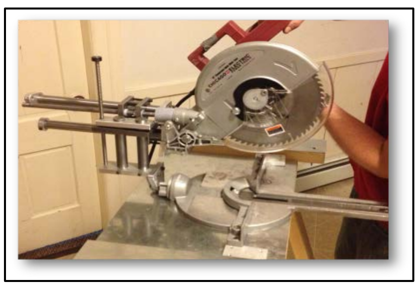


Figure 11: Device in Miter Saw Mode

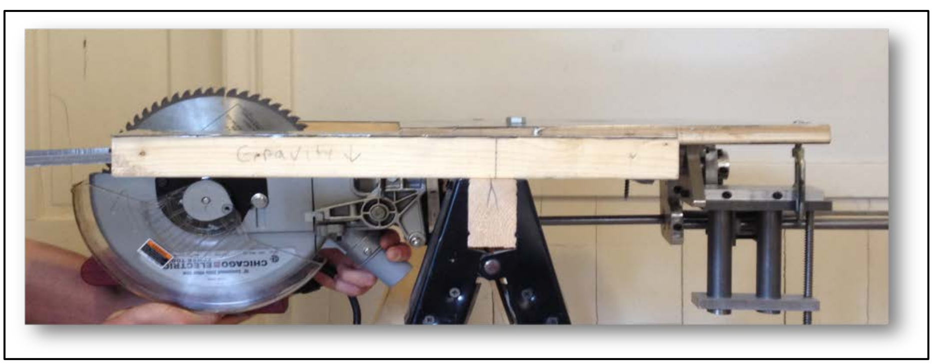


Figure 12: Device in Table Saw Mode

Introduction

The design process began by deciding which component of the system to focus on. The group decided that the system by which the circular saw would be attached to the miter saw armature was a logical starting point because the functionality of both the miter saw and the table saw depended on this fixture.

Circular Saw Attachment Design Progression

The primary consideration for fixing the circular saw to the miter saw armature is restricting the motion of the circular saw in a horizontal plane. It is desirable also to limit vertical motion of the saw. However, while some chatter in a vertical direction may be forgiven, horizontal movement of the saw during cutting operations would cause a combination of problems including inaccurate cuts, work piece binding, and destructive collisions with the base portion of the miter saw.

Aligning the Circular Saw

Initially, the aim of the design process was to limit motion in all directions. To this end, the system which was devised was to use three or more steel pins on the armature onto which the circular saw would be placed. The pins would fit into reliefs in the housing of the circular saw establishing the spatial relationship between the circular saw and the miter saw armature. Once the circular saw was located on the pins, a locking device consisting of either a cam locking device or latches would be used to hold the saw in place during use. Refer to Figure 13 below for a visual of the alignment pin concept for the circular saw.

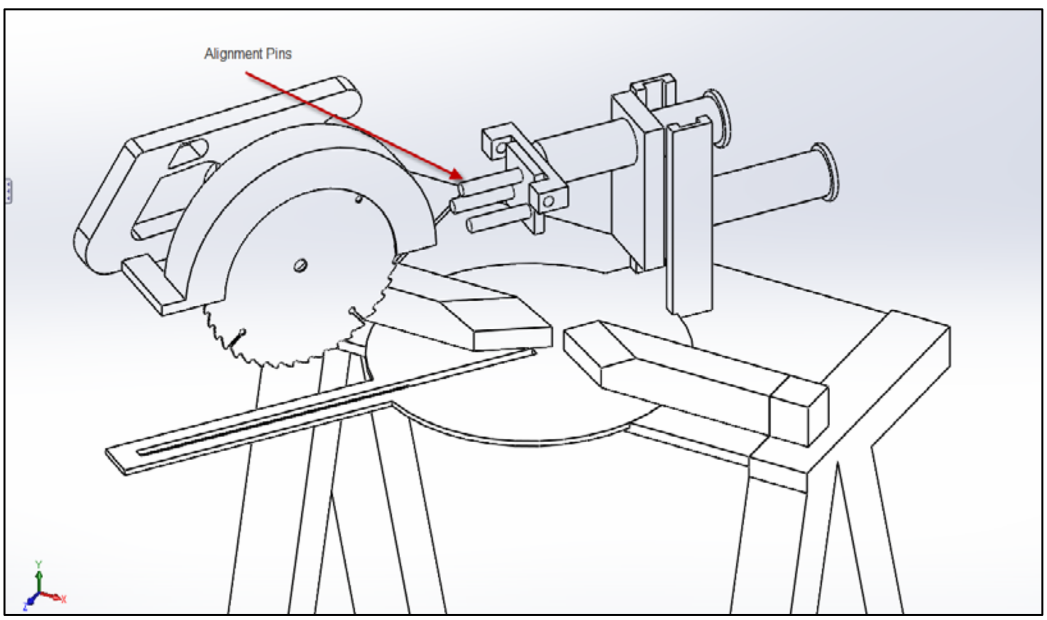


Figure 13: Alignment Pins for Circular Saw

A few issues were immediately apparent with this design. Firstly, precision of the locating pins would not only require tight tolerances, it would require a clean working environment in order to function properly on a consistent basis lest debris cause a clearance issue between the pins and the reliefs. This alone was enough to exclude the concept of precision locating pins when the working environment was considered. The idea of locating pins was not completely abandoned, however. Reliefs in either the circular saw base plate or the miter saw armature are to be used to help locate the saw on the armature. This carries an important provision: that the reliefs continue through the component forming a hole through which debris might be pushed instead of a well into which debris can be packed. Alternately, raised portions on the armature can be used to locate the base plate on the circular saw for proper alignment. This can be seen in below.

Locking Devices

Further complicating the concept was the need for an appropriate locking device. The original mounting method would require a separate locking device to hold the circular saw on the pins. Realizing that a separate locking device would add another step in the process of attaching the circular saw to the miter saw armature, the advantages of using the locking device to locate the saw became apparent. In order to facilitate this new approach, the system of locating pins was exchanged for a plate on which the base plate of the circular saw would rest while the locking mechanism secured the saw and prevented movement.

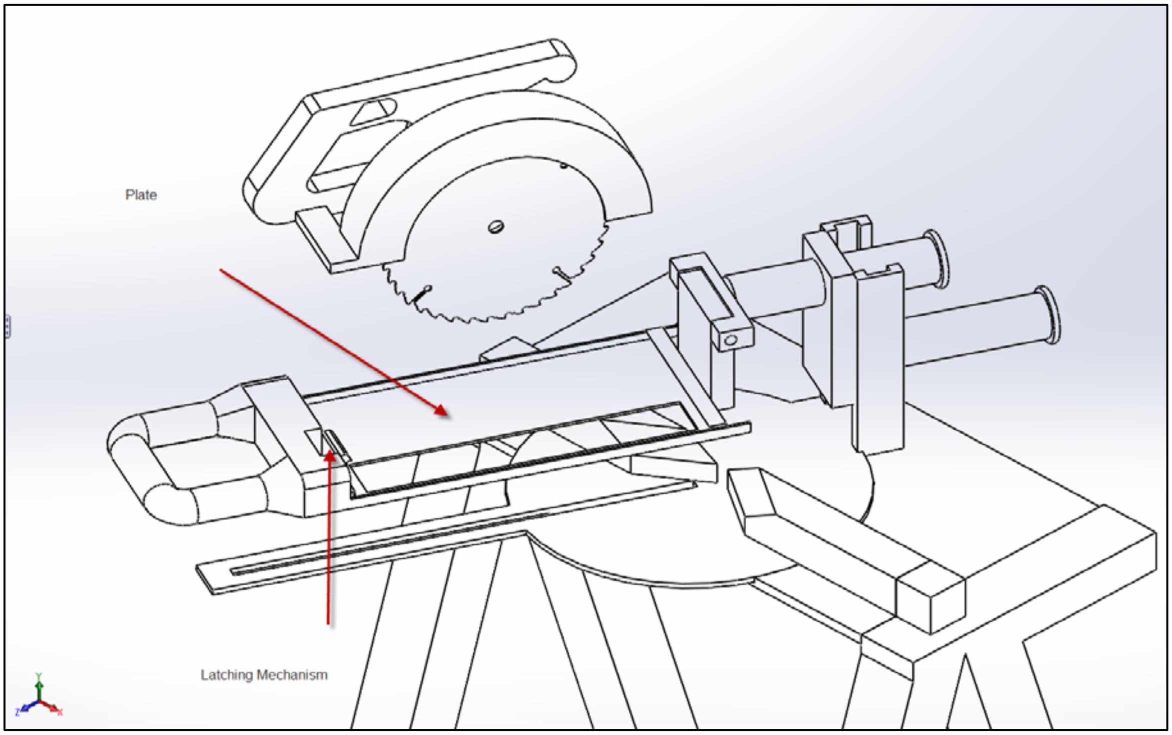


Figure 14: Latching Mechanism for Circular Saw

After moving away from locating pins and pursuing a plate mounted solution, the first ideas for locking mechanisms involved using the handle which would operate the miter saw to activate the locking system in order to simplify the apparatus for the sake of operational ease. This concept took two distinct forms. One of these forms involved using the miter saw handle to operate a cam lock or latch to hold the circular saw in place. The other used the miter saw handle to close a form-fitted cage around the housing of the circular saw effectively capturing the saw between the mounting plate and the cage. After considering the complications involved in this method, and the likelihood of creating a large and cumbersome apparatus, another approach was taken by referring to the locking mechanism section of *Ingenious Mechanisms*. (Jones, F. D) One particular mechanism used a linkage to lock two halves of the mechanism together with one motion of a lever. This device might be adapted in some form to attach the circular saw to the miter saw armature. However, the device itself is somewhat complicated and there is concern for whether it would hold up under the demanding operating conditions of the saw.

The final and most attractive solution is pictured in Figure 14 above. In this solution, the front of the circular saw base plate or a purpose built appendage is placed under a ledge at the front of a mounting plate on the miter saw armature. The rear of the circular saw is then pressed downward onto a wedged portion of a spring loaded arm which captures the housing of the circular saw and binds the saw in place on the mounting plate. By placing the catch for this mechanism on the housing of the circular saw, it will force the operator to place the base plate on the circular saw in the uppermost position in order to attach the saw to the miter saw fixture. This addresses one of two important issues with converting a circular saw into a miter saw. The second issue is retracting the blade guard on the saw automatically as is standard procedure on miter saws. This will be achieved by attaching a lever to the miter saw armature which will catch the thumb lever when the miter saw is pressed down.

Finally, in order to operate the saw using a trigger on the miter saw armature, an electrical contact will need to connect the trigger to the trigger circuit within the circular saw. A receptacle on the circular saw will receive a plug from the miter saw armature completing the electrical connection automatically when the circular saw is placed in the fixture. Additionally, a plastic wire clip on the opposite end of the armature will be provided in which to place the power cable for the circular saw so that it stays out of the way while the miter saw is operated.

Converting the Miter Saw to a Table Saw

The next logical component of the saw system to focus on is the conversion of the miter saw to the table saw and back to the miter saw mode. The considerations for this conversion are locking the saw in both the miter saw mode and table saw modes and allowing for safe, effective, and efficient conversion. Also of importance is a mechanism for raising and lowering the saw blade in the table saw mode.

General Conversion Concept

Research into current designs for combination saws suggests two primary methods for combining the functionality of the miter saw and table saw. The particulars of these designs have been discussed previously in the Background Research section of this report. Weighing the merits and disadvantages of the two types of design, the flip-over type design was pursued. The flip over concept can be seen in Figure 15 and Figure 16 below.

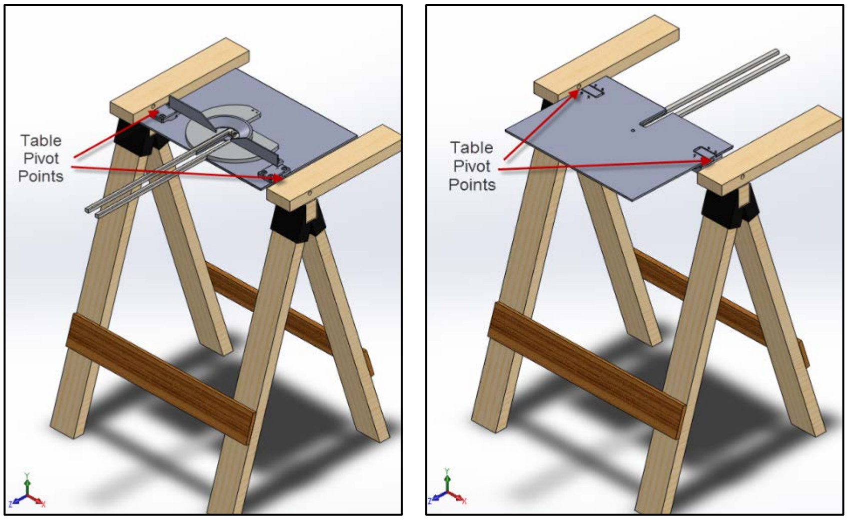


Figure 16: Table Flipped to Chop Saw Mode – left

Figure 16: Table Flipped to Table Saw Mode – right

Locking Mechanisms

In order for the saw to operate safely in both modes, the table must be locked into place so that it doesn't rotate inadvertently while in use. The first locking mechanism proposed was a spring-loaded pin on the stand which would fit into a hole in the rotating table and prevent rotation. This locking method would require the operator to pull one or more pins out to rotate the table. If the pins are spring-loaded, they must also be pulled out and reset in order to lock the table back into place once it has been flipped over. If the pins are not spring loaded, they may become loose during operation. So, for a safer solution, it was decided that the locking mechanism should lock automatically when the table is placed in either location. The mechanism must also require only one hand to unlock so that the table can be flipped with the other hand.

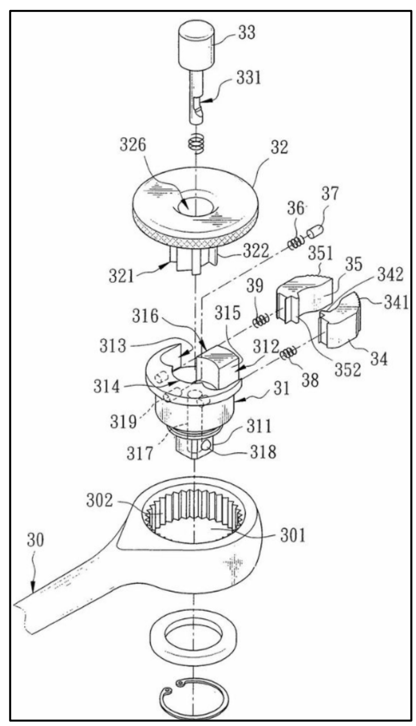


Figure 17: Ball Detent Ratchet Wrench Mechanism (FIELD OF THE INVENTION)

To accomplish automatic locking and one hand operation, a ball detent mechanism similar to that found in a ratchet wrench (used to hold the socket to the post and released with a button) will be used to hold the table in place. Two balls operated by a single button or lever will hold the table into place. The design of the spring-loaded detent mechanism will allow the table to lock into place automatically when the table reaches one of the two positions. The cavity for each of the two balls will be located on the rotating table equidistant from the axis of rotation. The mechanism which holds the balls in place and pushes them into the cavities will be located on the stand. This will allow a single stationary button or handle to operate the table release. The ball detent concept is similar to a ratchet wrench ball detent mechanism which can be seen to the right in Figure 17.

Controlling Table Motion

The rotation of the table with heavy components attached to it presents a possibly hazardous situation which must be addressed. The rotation of the table should be controlled in order to prevent injuries from pinch hazards and tip-overs. The suggested solution to this problem is to use a gas shock or two gas shocks to damp the motion of the table. With proper damping, the operator will be able to lift the saw past the tipping point and release the table which will then be lowered in a controlled fashion by gravity damped with the gas shock. So, using gas shocks not only prevents uncontrolled rotation of the table. But, it will allow for conversion of the saw without having to lean over the table. An image of a gas shock can be seen to the right in Figure 18.

Figure 18: Gas Shock (PPL Motor Homes)

Raising and Lowering the Table Saw Blade

Once the saw has been converted from the miter saw mode into a table saw, the operator should be able to raise and lower the blade in order to set a safe blade height for the cut to be made. To provide this function, the design will use two separate tables which will move relative to each other; effectively allowing more or less of the blade to be exposed through the table. The armature of the miter saw will need to be locked in the downward position using the locking mechanism which is standard for a miter saw. Figure 19 to the right shows the raising and lowering of the table saw. The table which will function as the table saw table will be attached to the stand by the rotation pin and the ball detent locking mechanism described above. A rack and pinion with a handle attached to the pinion will be used to raise and lower

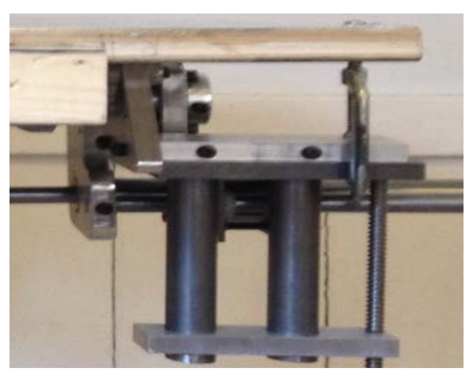


Figure 19: Raising and Lowering Table Saw Blade Mechanism

the miter saw relative to the table which will expose more or less of the blade as required by the task.

Design Details

This section details the overall design of the 3 in 1 combination saw.

Circular Saw Details

The circular saw being the primary component used in all three modes of the combination saw, was put to careful consideration. For the purposes of simplifying design and keeping costs under control, a standard circular saw adapted to the purposes of the combination saw is the most sensible approach. Of course, some components would have to be modified or redesigned and some new components may need to be added to the circular saw to meet the needs of the project. The only real decision, then, was which size circular saw to start with. Circular saws can be classified by blade size and this is how they will be classified within this report. If some specialty tools are included in the count, the sizes of circular saws range between 3 and 16 inches. However, the most common sizes of circular saws are 5 3/8”, 7 1/4”, and 10 ¼”. Blades for each of these three saws are readily available from tool suppliers and most major tool manufacturers offer a circular saw in each of these sizes. Compound miter saws (both simple and sliding models) generally come in three sizes as well: 8”, 10”, and 12” (also classified by blade size). Typically compound miter saws with smaller blades are limited in their capacity to make angled cuts in larger pieces of stock with 8” saws reaching the bounds of their limitations when angled cuts are required in 6” stock. The compromise to consider is between weight and safety of the circular saw and functionality and reasonable operation of the compound miter saw. Considering the limitations of a smaller blade on a compound miter saw, a 10 ¼” circular saw should provide reasonable functionality as both a circular saw and the starting point for the compound miter saw.

Miter Saw Details

Dimensions and Specifications

The details of the miter saw were determined using a set of criteria from the practical application of the tool. The goal is to be able to use the saw to cut a 2x12 member at an angle of 55 degrees without a bevel and also to be able to cut 4” nominal stock. In order to cut 4x stock, the saw needs simply to have a cut depth of at least 3 ½” which is the actual width of 4” nominal stock. To make the desired cut in a 2x12 at 55 degrees, the cut length of the sliding compound miter saw must be 20 1/16”.

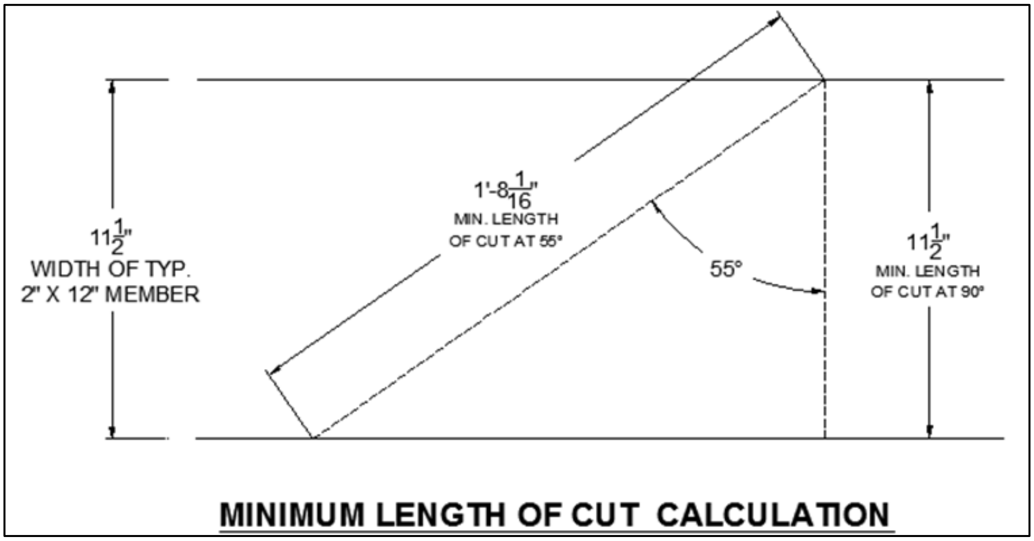


Figure 20: Length of Cut Diagram

Figure 20 shows the geometric methodology used to calculate the necessary cut length. The required cut length is the hypotenuse formed by a triangle with a side of 11 ½” (12” nominal stock) adjacent to a 55 degree angle. The cut length refers to the amount of material at the bottom of the work piece which must be removed by the blade. This means that the lane of the blade in contact with the bottom of the work piece must travel through a certain distance herein deemed the travel length in order to bring the blade in contact with the work piece along the entire cut length. Figure 21 below details the calculation of the travel length for the slide of the saw. In accordance with the design of the combination saw, the bottom of the blade will reach a depth of ½” below the table surface in order to accommodate some other features which will be explained in greater detail later in this report. By considering the length of the blade ½” from the bottom and the necessary cutting length of the saw, the required slide travel length was determined to be 15 5/8”.

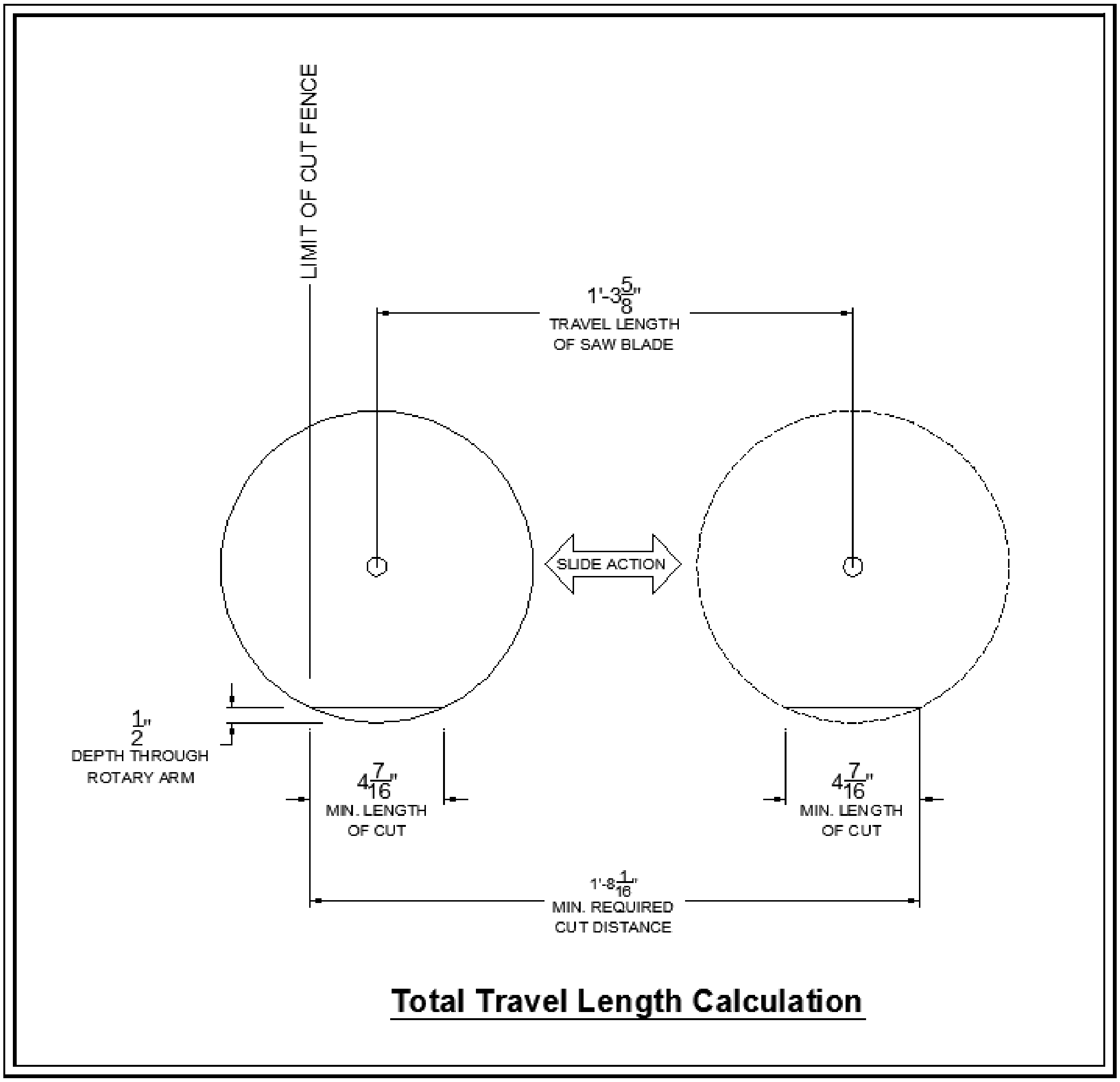


Figure 21: Travel Length Diagram

Bevel Adjustment

Another important feature of the miter saw is the pivot point for the bevel adjustment feature. In general, the mechanism consists of an axis (usually a pin or a bolt) around which the armature can rotate and a locking mechanism which allows the assembly to be locked into position at the desired bevel angle. Locking is typically accomplished by twisting a thumb screw and tightening a contact surface on the armature to a contact surface on the base. The critical feature of this mechanism in regards to designing the 3-in-1 saw is the placement of the pivot point. Ideally, the pivot point should be coaxial with the groove in the table in which the blade rides when cutting. This is necessary to prevent interference between the blade and the table by ensuring that the blade rides within the groove at all bevel angles. So, although this would present the ideal situation in a normal miter saw, due to the special limitations of the 3-in-1 saw, an alternative placement will be necessary. The specific problem with placing the pivot point coaxially with the table groove is that no part of the assembly may protrude past the plane of the table saw table in any bevel position. The proposed solution to this problem is to move the pivot point upward (in the positive y-direction) to the minimum distance such that no part of the armature assembly or the pivot assembly is beyond the plane of the table saw table in any bevel angle position. As long as the distance is minimal, some adjustment can be made in the width of the cutting groove to accommodate the blade at the most extreme bevel angle. The concept of the bevel angle can be seen in Figure 22 below.

Slide Arms

Another design consideration for the miter saw is the slide arms which carry the cutting assembly through the cut distance. A traditional slide compound miter saw uses two arms mounted side by side which are fixed to the cutting motor and blade and slide through linear bearings attached to the base of the saw. This configuration requires arms with a length equal to the desired cut length capacity of the saw. This would be unacceptable in conjunction with the flip-over table design as the sliding arms would protrude past the table saw table and pose a

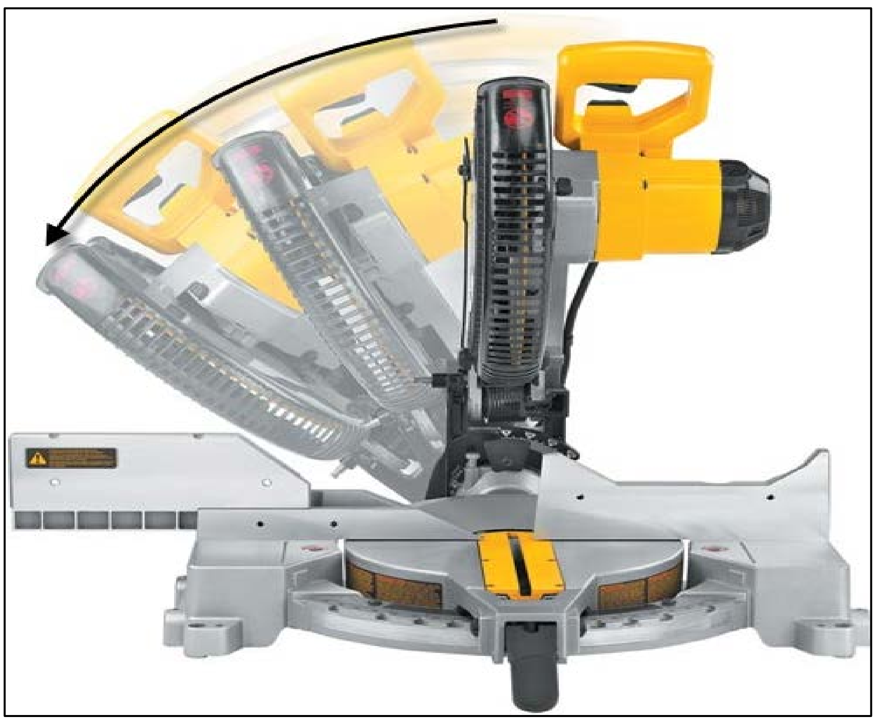
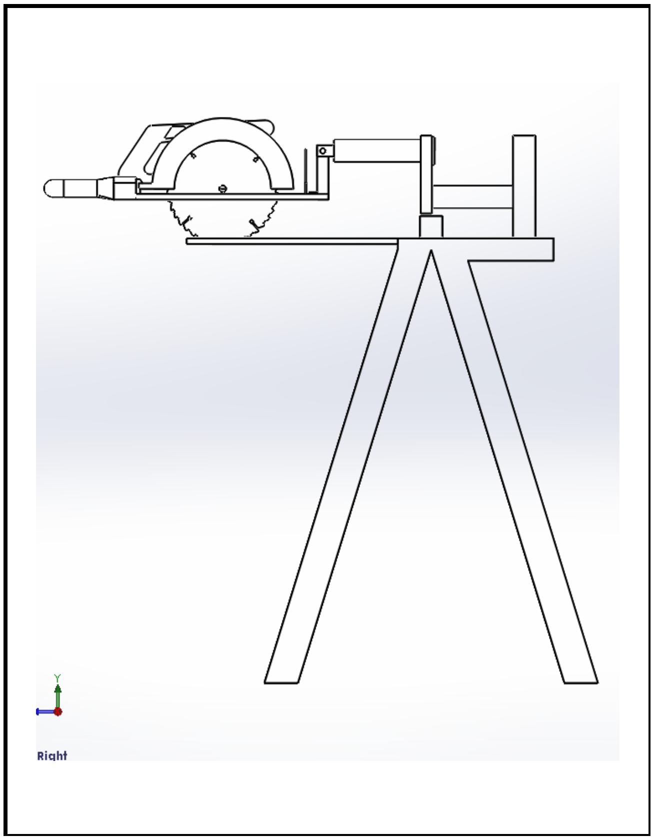


Figure 22: Bevel Adjustment of Chop Saw (Amazon.com)

tripping hazard to the operator or at least prevent comfortable and safe operation of the table saw by inhibiting the operators movement. To remedy this problem, the group proposes successive slides configuration in which two slides stacked vertically are allowed to slide independent of each other and through separate bearing surfaces in a way similar to the operation of drawer glides. Figure 23 and Figure 24 below illustrate the principal of successive slides. This configuration suits the needs of the 3-in-1 saw better by reducing the length of slides required.

Since the slides extend successively, each slide needs only be half of the length of the slides required to operate in a side by side configuration.



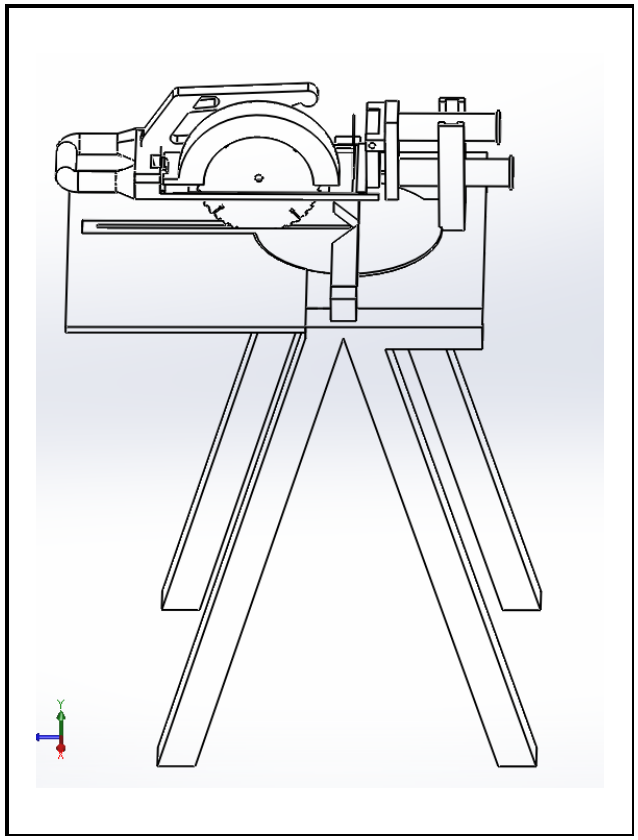
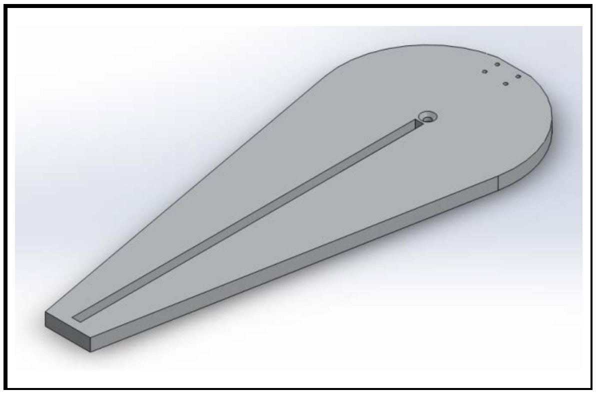


Figure 23: Successive Slides Illustration – Fully Extended (Left)

Figure 24: Successive Slides Illustration – Fully Collapsed (Right)

Structural Considerations

Because of the limitations on the thickness of the table, the structural integrity of the radial arm is of concern. Initially, the table was designed with a solid aluminum plate in a wedge shape protruding beyond the work piece table. See Figure 25 below. Analysis was done on a couple of different designs in order to determine the structural integrity of the table designs. Appendix A shows the MathCAD sheets used to calculate stresses in the table and determine the maximum allowable loading. The composite beam design is capable of withstanding a maximum loading of 45 lbf while a design using a solid steel beam will be capable of withstanding 90 lbf. See Figure 26 for the design of the steel reinforced turntable shown below.



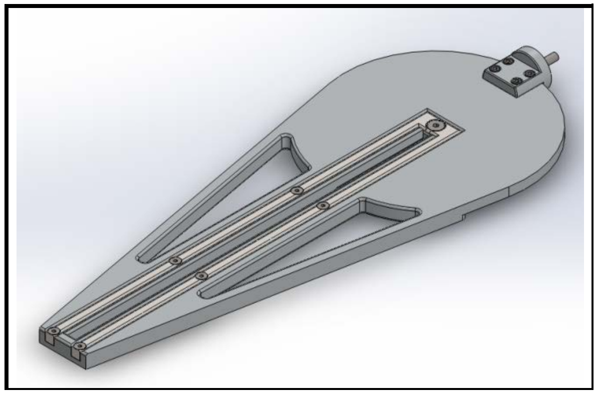


Figure 25: Solid Aluminum Turntable (Left)

Figure 26: Steel Reinforced Turntable (Right)

After all of the structural issues were considered, the solution that was proposed was to design the table for a reasonable factor of safety when 60 lb. are applied at the end of the radial arm and design the table such that if more than 60 lb. is applied at the end of the radial arm, the table will become unstable and fall over before yielding is caused in the radial arm. Secondly, the thickness of the radial arm affects the maximum cut depth of the table saw. The FBD of the radial arm is shown in Figure 27 and was used in the calculations of determining the thickness of the radial arm.

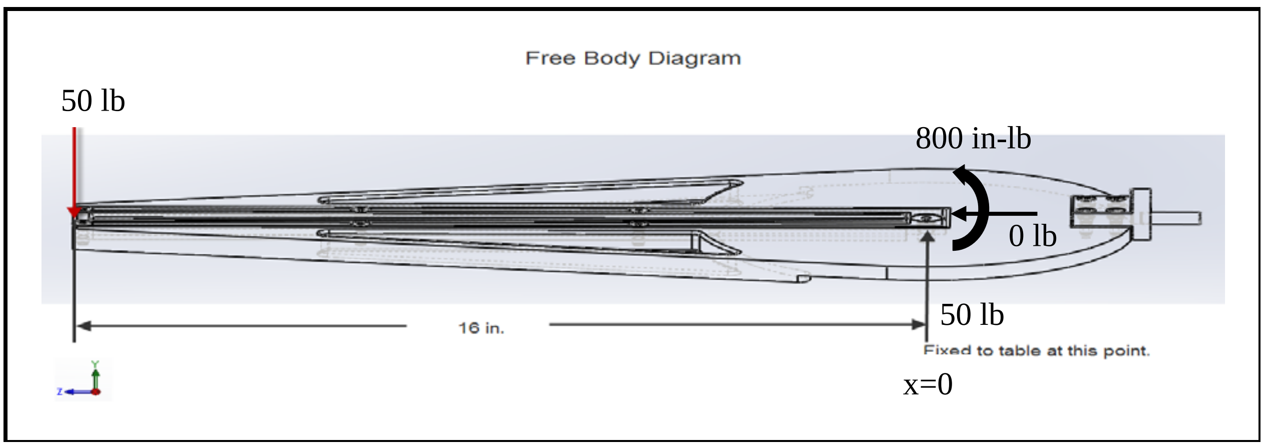


Figure 27: Radial Arm Free Body Diagram

Figure 28 shows an optimization graph used to help determine the optimal thickness of the table in order to maintain structural integrity and maximize the cut depth of the table saw. The thickness of the radial arm required a compromise between the deflection of the arm due to loading which will increase when thickness is decreased and the maximum cut depth of the table saw which will decrease as the radial arm thickness is increased. So, making the center section of the radial arm out of steel without an aluminum section and having a thickness of 0.5 in. through the radial arm will provide a factor of safety of about 6 when 50 lb. is applied while keeping a manageable thickness. Although 0.5 in is not the optimum value according to the optimization graphs, it is a standard stock size and choosing the optimal value will increase manufacturing costs by requiring custom parts. When the maximum allowable load is constrained by the stability of the table, there is a reasonable measure of confidence in this component. Also, since the steel radial arm will be a separate component attached with bolts, it will be fairly simple to replace if it is bent or broken.

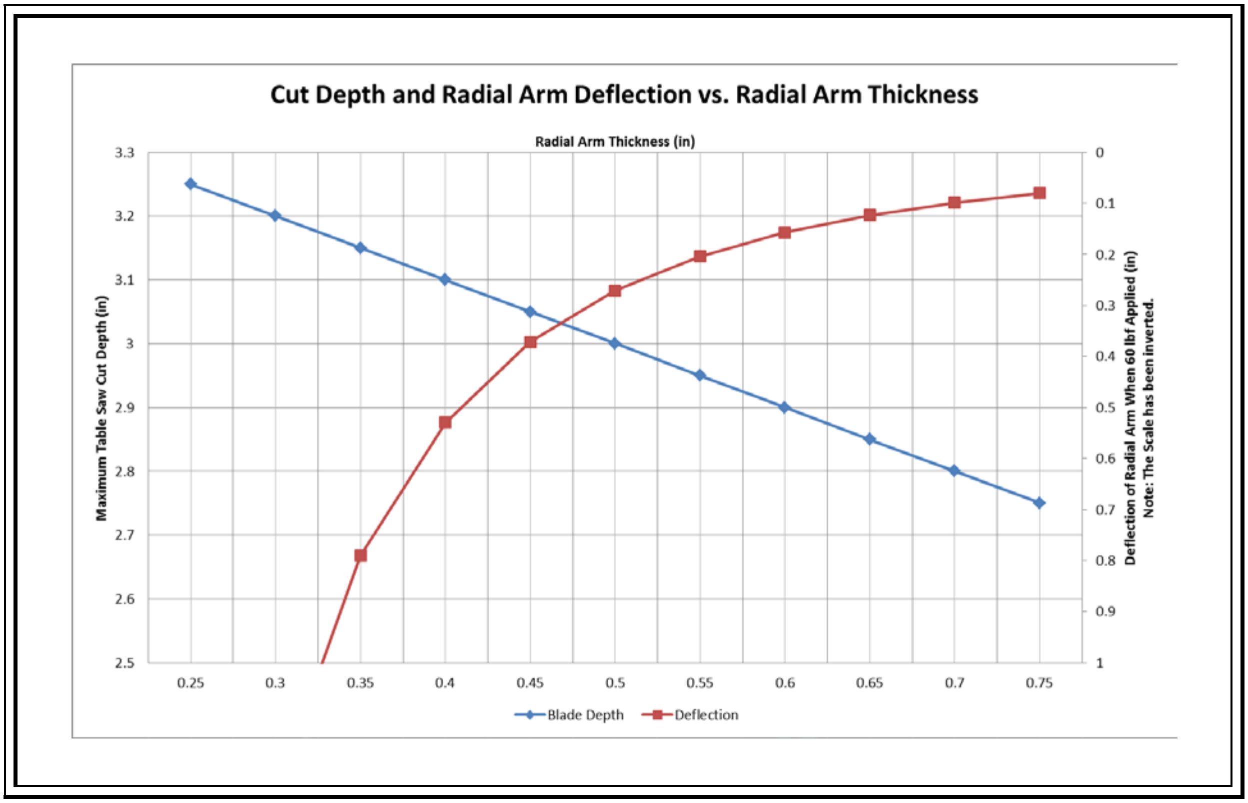


Figure 28: Table Saw Cut Depth and Deflection vs. Thickness

This graph was used to find the optimal compromise between deflection of the radial arm due to loading and the maximum cut depth of the table saw as the thickness of the radial arm is varied between ¼” and 3/4” as discussed above.

Table Saw Details

The first component of the table saw function approached is the mechanism by which the saw blade can be raised or lowered to accommodate a safe cutting height for the work piece. A few different ideas were considered including a worm gear and a rack and pinion. When these ideas were explored further and an attempt was made to model the system, there were issues with restricting the degrees of freedom of the mechanism. After several attempts to conceptualize a feasible system, some research was done into the mechanisms used in table saws which are already commercially available. The primary mechanism involved in each of the designs found during the research was a four bar linkage. Using the basis of a four bar linkage, a mechanism similar in operation to a scissor jack was created whereby the linkage carrying the saw is raised by moving a rocker link. The rocker link is moved by twisting a screw which is threaded through a block attached to the link. Figure 29 is a schematic representation of the proposed mechanism in the raised and lowered positions.

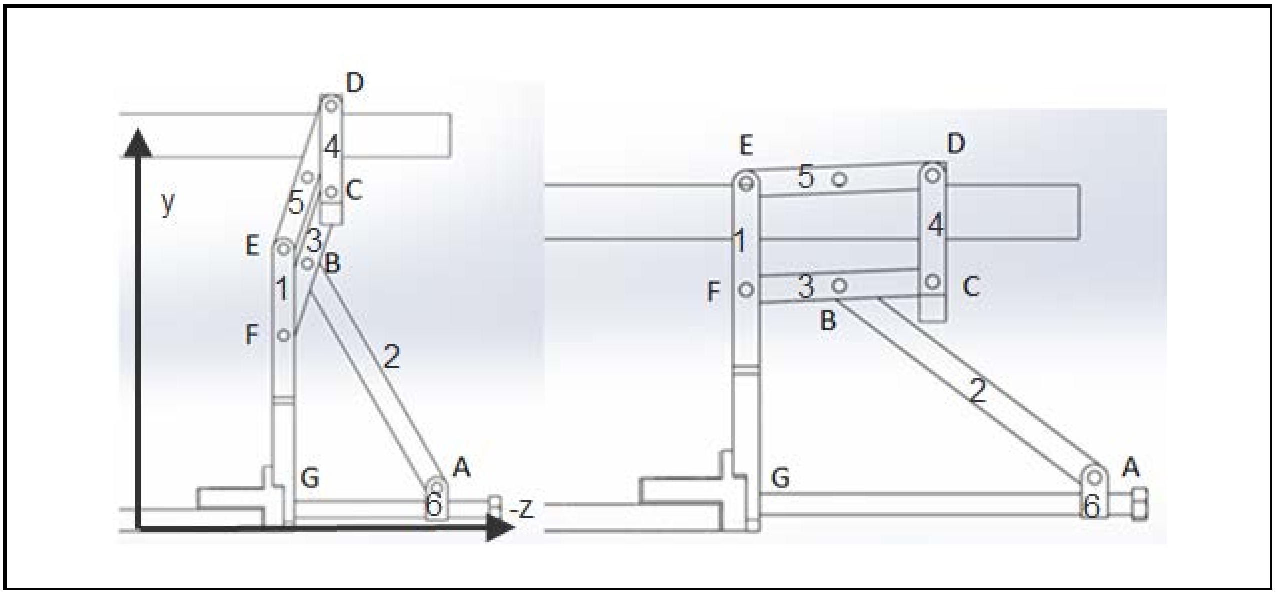


Figure 29: Mechanism to Raise and Lower Blade

Upward Position	
∠BAG	≈60°
∠AGF	≈90°
∠GFB	≈170°
∠FBA	≈40°
∠EFB	≈5°
∠BCD	≈175°
∠CDE	≈5°
∠DEF	≈175°
Downward Position	
∠BAG	≈45°
∠AGF	≈90°
∠GFB	≈95°
∠FBA	≈130°
∠EFB	≈85°
∠BCD	≈95°
∠CDE	≈85°
∠DEF	≈95°

Table 1: Linkage Internal Angles

The next step required dimensioning the mechanism and its respective members to obtain the proper amount of travel and minimize the screw length for packaging constraints. Variations on the linkage were examined using a simple CAD sketch and changing dimensions until a linkage which could be kept relatively small and still maintain an efficient transmission angle was developed. Figure 30 on the following page is the sketch used for development including the final dimensions of the linkage.

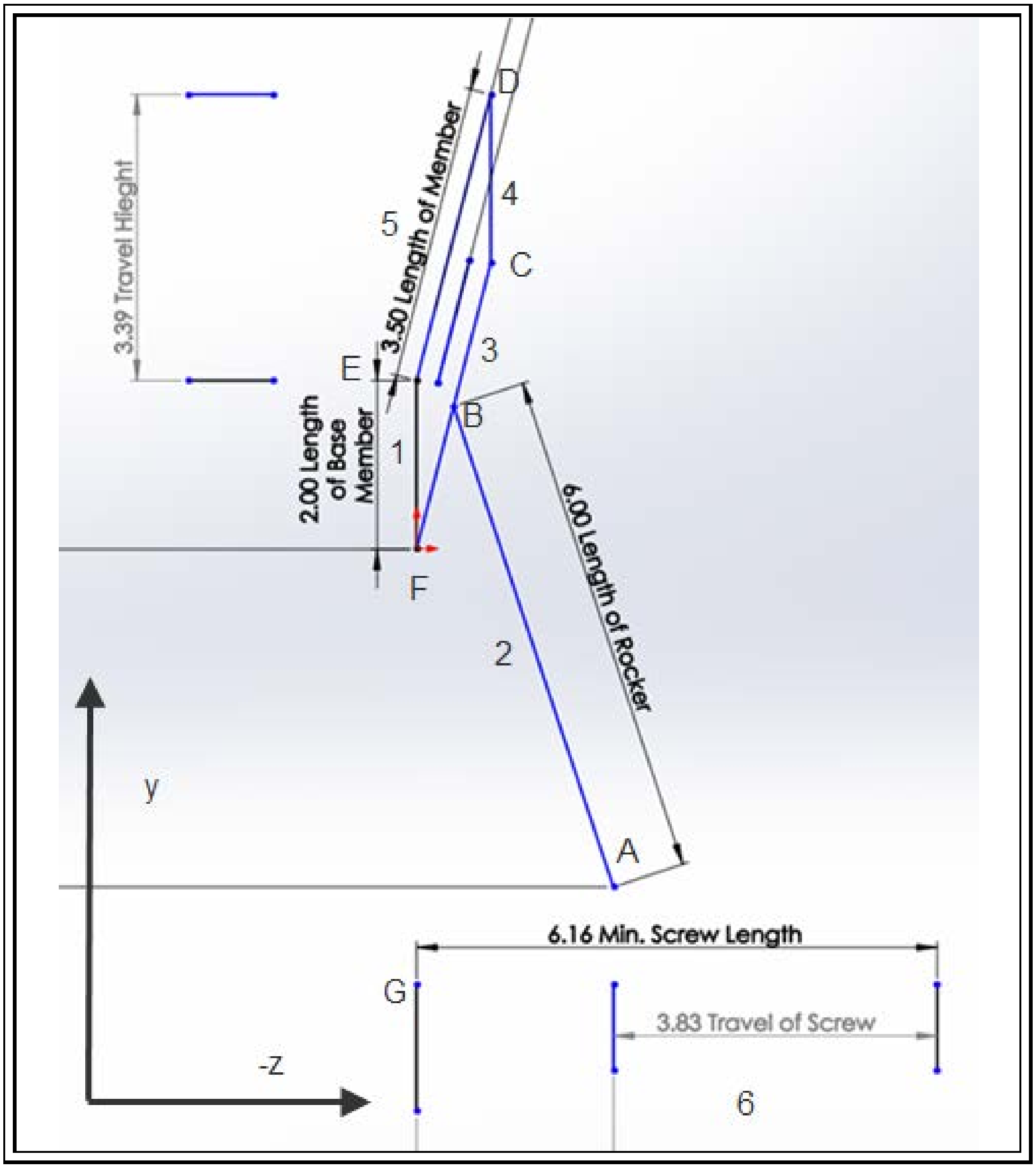


Figure 30: Linkage Development Sketch

Design of Blade Raising and Lowering Device

Three main considerations were made in designing the lifting mechanism: choosing a thread pitch and gear ratio combination which would allow for convenient raising and lowering with a compromise between minimizing rotations and allowing for fine adjustments, a non-back driving screw, and an appropriate bearing ratio to avoid jamming.

An acme threaded rod was chosen with a coarse pitch (1/2" – 8) and analyzed to assure that it would be non-back driving. The criteria used to make this determination was $\mu \geq (\frac{L}{\pi d_p})(cos\alpha)$ where μ is the coefficient of static friction, L is the lead of the thread, $d_p$is the pitch diameter, and α is the radial angle of the acme thread. According to this criteria, the screw will be non-back driving. Table 2 shows the values used in the calculation.

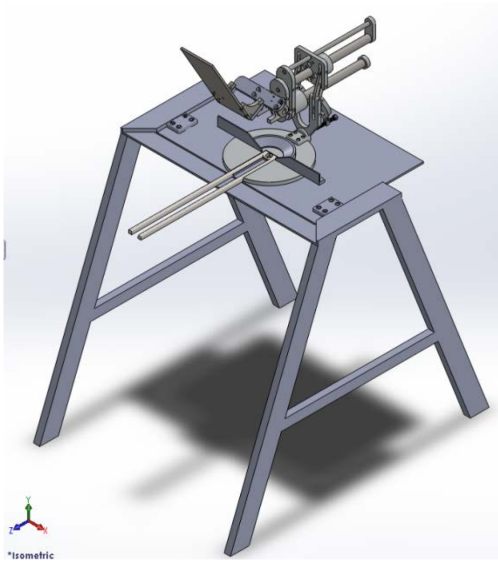
Variable	**Value**
Coefficient of Static Friction (μ)	0.16 (Steel on Steel Lubricated)
Lead of Thread (L)	0.125 in (Norton)
Pitch Diameter (d_p)	0.45 in (Norton)
Radial Angle (α)	14.5º

Table 2: Values Used to Analyze for Non-Back Driving Analysis

Once this determination was made, Norton's book, "Design of Machinery," was consulted to analyze the design to be sure that binding would not occur between the guide rod and the platform which carries the saw up and down (Norton, Robert L). The recommendation given in the book is that the ratio of the travel length of the rod to the distance between the rods is greater than 1.5. For smooth operation, a polymer sleeve may also be added between the rod and the platform to reduce friction at a fairly small cost.

Prototyping

At this point in the design process, the saw concept had accounted for all of the desired functions and CAD models had been created to detail each of the components. Figure 31 and Figure 32 on the next page show the CAD models at this stage of the design process. It was decided that prototyping should begin at this point in order to discover issues in the design which were not obvious in the CAD model. For prototyping purposes, most major components were made of wood because it is easy to work with and fairly inexpensive. Figure 33 and Figure 34 on the next page show the beginning stages of the prototype of the saw.



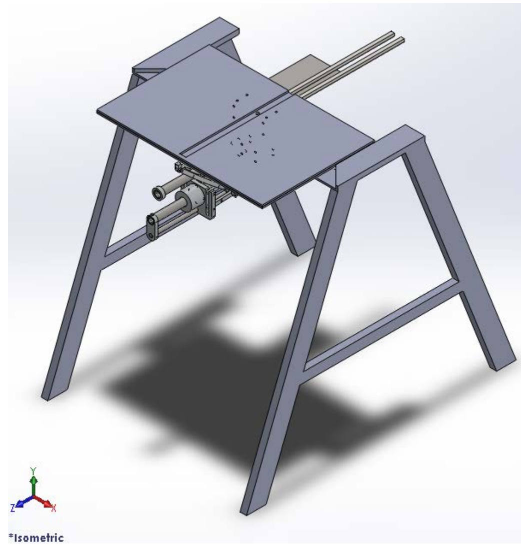


Figure 31: CAD Model in Miter Saw Mode – Top Left

Figure 32: CAD Model in Table Saw Mode – Top Right

Figure 33: Beveled and Mitered Prototype – Bottom Left

Figure 34: First Prototype in Miter Saw Mode – Bottom Right

When the task of building components for the linkage was approached, several difficulties and the complications of the system became apparent. Around the same time, some research was done in mechanisms already used for raising and lowering the blades on table saws. One design stood out as a particularly good fit for the 3-in-1 saw. Figure 35 shows the mechanism which was discovered. A decision was made to use a similar mechanism in the saw design which would eliminate the complicated linkage and many moving parts from the assembly. The new mechanism will raise and lower a platform which holds the slides and the saw and rides on a guide rail and a screw. The screw will be rotated in a threaded hole in the platform which will raise and lower the platform adjusting the blade height.

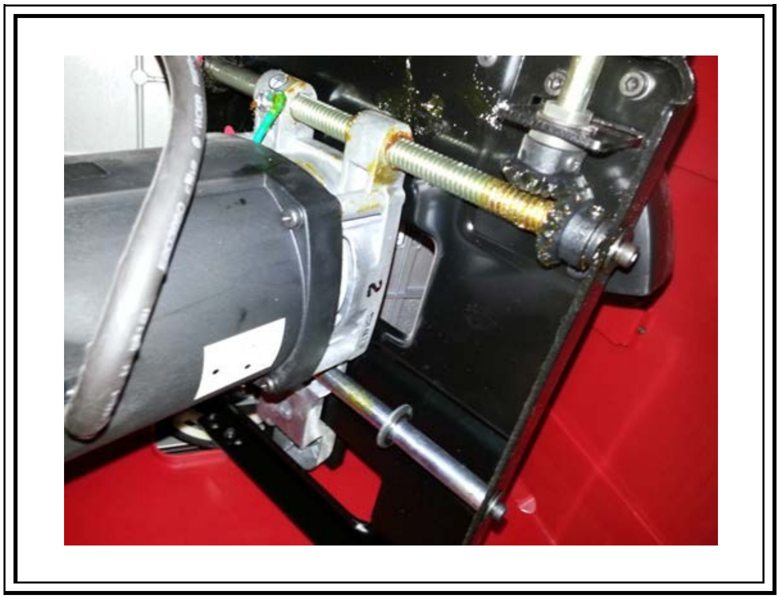


Figure 35: Blade Raising Mechanism

Evaluation

The final design was evaluated using the task and design specifications defined at the beginning of the project. It also evaluated on its feasibility as a consumer product. Most of the task specifications were met or exceeded by the design including the structural integrity of the design as described by the specifications and the time limit on mode conversions.

The specifics of the electrical system were largely neglected the design process and the electrical system from an existing saw was used for the prototype. The electrical system should be given more consideration. Similarly, tolerancing on some of the components of the mechanisms should take into account the limitations of cost effective manufacturing processes and the desired cut precision of .001”. Although there is reason to believe that the saw will fare well in durability, testing I this area would be desirable before it could be confidently stated that the durability specifications were met.

The design specifications were all met satisfactorily with the exception that a laser guide was not fitted to the prototype.

The prototype demonstrated feasibility of the mechanisms to achieve the desired goals. The idea was presented to several people during project presentation day and the interest expressed in the product may be an indication that the product could be marketed successfully. It is quite obvious, however, that although the saw is technologically feasible and the proposed mechanisms can achieve the goals, further testing and evaluation in the areas of manufacturability and marketability would be beneficial though they were somewhat beyond the scope of this project.

Recommendations

This section includes recommendations made from the designers for future design considerations of this project.

Safety Features

Up until now, safety features were not really considered because it was the designers’ goal to prove the concept of the device rather than to build a final production model. In order for this device to be marketable to consumers, it must first be safe. Most production saws on the market come with several safety features including guards and shut off switches; these features are recommended to be implemented within the device moving forward. The circular saw device used within the prototype has a blade guard but is limited in its performance. Circular saws typically have a guard that can be retracted by the user in order to line up the blade with the member before cutting for a more precise starting cut. This is done by rotating the lower guard retracting lever away from the user. It is recommended that a lower guard retracting lever be added to the circular saw device guard for ease of cut and precision. Please refer to

Figure 36 for a picture regarding the placement of guard bars on production circular saws.

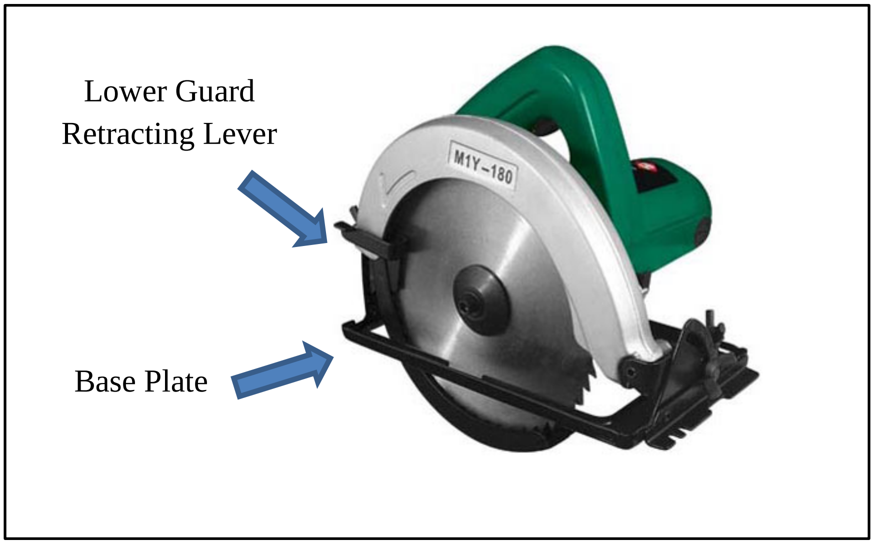


Figure 36: Typical Production Circular Saw

A base plate should also be designed for the circular saw device. The base plate allows the users to set a depth of cut while using the saw. It also assists the users with stability during a cut therefore increasing precision. This base plate shall be designed for a 10-inch blade and shall not be thicker than 0.125 inches or else it will affect the cutting capacity of the device in table saw mode. Please refer to

Figure 36 for an image depicting a production type base plate.

It is recommended that the circular saw device's power cord be redesigned. The placement of the power cord is located in the rear of the device and does not pose any problems while the device is being used as a circular saw. When the circular saw device is transitioned into miter saw mode, however, the power cord is in the way of the operator and the runs the risk of being cut while the device is in use. This would cause severe damage to the power cord and even the user. Options for this redesign may include a detachable power cord that has inputs on both the front and back of the circular saw or make the whole device cordless. These designs may require outside insight from an electrical engineer or manufacturer. It is important to note that cordless devices that are battery operated tend to be less powerful and require frequent charging.

When the prototype in transitioning between miter saw mode and table saw mode, as long as it is plugged in, it can be turned on. It is recommended that electrical contacts should be added within the table to prevent the saw from turning on during transition. The contacts shall be located on the stationary table supports and the rotational table and when they are not in contact with each other, the saw will not be able to operate. This will protect the user from the saw while he is transitioning between modes.

The prototype does not include a table saw guard for the device when it is in table saw mode. Production table saws include a blade guard that covers the exposed saw blade. The guard is typically angled so that the member being cut can force the guard upward allowing for the member to reach the blade while still protecting the user from the blade. This guard can be permanently attached the underside of the table as it will not interfere with any of the other saw modes. Please refer to Figure 37 for an image depicting a table saw guard.

Figure 37: Typical Table Saw with Guard

The final recommendation is to add a breaking component to the circular that dampens the saw rotation as soon as the trigger is released. Production miter saws and table saws include this break to stop the blade from rotating upon release of the trigger but circular saws do not. Since the circular saw is acting as both types of saw simultaneously in this device, the break works as a safety feature for device in miter saw mode and table saw mode, thus it should be included in the circular saw device.

Design Built-In Table Safety Specifications

Although the prototype is made from steel material, excess loading applied to the device, primarily to the rotational arm, can cause the material to yield. It is recommended that the entire device shall flip over if too much load is applied to the device. This will protect the device from yielding and other damages. The prototype was designed to withstand the weight of a package of shingles, so it is recommended that anything else heavier than that will cause the device to flip over. Static and moment analysis will need to be performed in order to determine the ultimate weight that will cause the device to flip.

Optimize for Weight and Material Selection

It was intended for the final designed product to be easily transported by a single user. The prototype was constructed from a combination of wood and steel material, making the device quite heavy and requires two people to move. It is recommended that a complete strength and material analysis be performed on every component to reduce the total weight of the device. There are multiple steel and wooden components used in the prototype that could be made from aluminum and other lighter materials that could still withstand the induced stresses. Using aluminum could serve as a major weight reducer and could still provide the structural integrity required for this device.

It is recommended to construct the reinforced beam style rotational arm as detailed in Design Details section of this paper. The constructed prototype was constructed solely from steel, due to lack of materials and funds, and adds unnecessary weight to the device. By including a composite arm made of aluminum and steel the device will weigh less and still maintain the ability to resist a 300 pound load before yielding.

Foldable aluminum table legs with wheels are also recommended in order to reduce weight and assist the user with transportation. The prototype takes up a large amount of room because it cannot be folded. Foldable legs will allow the user to minimize the device and conserve space.

Design for Manufacturability and Tolerances

It is highly recommended that a manufacturer be consulted in order to produce the device on a large scale. The intention of this project is to design a device that can be distributed on a large scale. The device contains numerous components and may be difficult to manufacture for this reason. Tolerances need to be considered due to flaws in manufacturing processes and the accuracy a manufacturer can achieve. Components may need to be redesigned due to the manufacturing processes selected for certain parts. Manufacturing processes such as casting or rapid prototyping need to be considered in the production of this device. Certain components are geared towards certain processes but manufacturability was not a major goal of this project, so these aspects need to be taken into consideration for consumer distribution.

Works Cited

Amazon.com. N.p., n.d. Web. 22 Apr. 2013. <http://g-ecx.images-amazon.com/images/G/01/th/content_26/Q1_2011/c26-B000ASBCK4-3-l.jpg>.

"Bosch Table Saw / Miter Saw Hybrid." *Tool Snob*. N.p., 7 Jan. 2009. Web. 22 Apr. 2013. <http://www.toolsnob.com/archives/2009/01/bosch_table_saw_miter_saw_hybr.php>.

Circular Saw. Visualdictionaryonline.com, n.d. Web. 8 Sept. 2012. <http://visual.merriam-webster.com/images/house/do-it-yourself/carpentry-sawing-tools/circular-saw.jpg>.

Craftsman, n.d. Web. 8 Sept. 2012. <http://imagethumbnails.milo.com/000/777/875/trimmed/777126_15826875_trimmed.jpg>.

Dewalt Miter Saw. N.p., n.d. Web. 8 Sept. 2012. <http://www.khonkaenbeestprice01.com/330x3305fdbe57B001AIX5OO/sale-DEWALT-DW717-Double-Bevel-Compound-Miter-Saw.jpg>.

DW743N-QS Dewalt Flip-Over Saw 250mm Induction Motor 2000W. A S Tools, 2013. Web. 22 Apr. 2013. <http://www.dewaltdirect.co.za/index.php?route=product/product&product_id=119>.

"FIELD OF THE INVENTION." *Tang and Ratchet Wrench with Rotating Disc Operated Direction Change of Drive and Ratcheting*. A.A.G. Industrial Co., LTD, 1 Jan. 2006. Web. 22 Apr. 2013. <http://www.freepatentsonline.com/7082860.html>.

Jones, F. D. *Ingenious Mechanisms*. New York: Industrial, 2001. Print.

"Makita Flip-Over Saw 260mm LF1000 110v." *Makita LF1000*. Kelvin Power Tools, 2013. Web. 22 Apr. 2013. <http://www.kelvinpowertools.com/makita-flip-over-saw-260mm-lf1000-110v-c-48-p-6140>.

Norton, Robert L. *Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines*. New York: McGraw-Hill, 1992. Print.

Norton, Robert L. *Machine Design: An Integrated Approach*. Upper Saddle River, NJ: Pearson Prentice Hall, 2006. Print.

"Patent US20070234864 - Flip Over Saw - Google Patents." *Google Books*. Black & Decker Inc., 11 Oct. 2007. Web. 22 Apr. 2013. <http://www.google.com/patents/US20070234864?pg=PA2>.

"Patent US20100269660 - Combination Table-miter Saw Safety System - Google Patents." *Google Books*. Credo Technology Corporation, 28 Oct. 2010. Web. 22 Apr. 2013. <http://www.google.com/patents/US20100269660?printsec=drawing>.

"Patent US7891277 - Convertible Circular Saw Apparatus Usable as Either a Miter Saw or a Table Saw - Google Patents." *Google Books*. Ouellette Normand, 22 Feb. 2011. Web. 22 Apr. 2013. <http://www.google.com/patents/US7891277?printsec=drawing>.

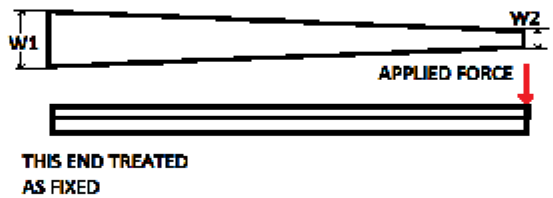
PPL Motor Homes. N.p., n.d. Web. 22 Apr. 2013. <http://www.pplmotorhomes.com/parts/rv-locks/gas-shocks-photo.jpg>.

"The Overflow Room." *Circular Saw Logic*. N.p., n.d. Web. 22 Apr. 2013. <http://theoverflowroom.wordpress.com/2010/08/23/circular-saw-logic/>.

"Wood Working Talk." *Table Saw Guards*. N.p., n.d. Web. 22 Apr. 2013. <http://www.woodworkingtalk.com/f7/how-many-actually-use-guard-table-saw-20201/>.

Appendix A: MathCad Calculations

For Composite Beam

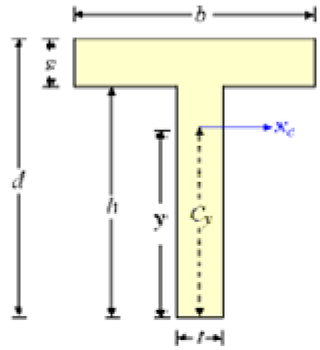


$b := 1\text{in} \quad s := .55\text{in} \quad h := .25\text{in} \quad d := s + h$

$L := 16\text{in}$ T beam constant dimensions

$E_2 := 10400\cdot\text{ksi} \qquad E_1 := 30000\cdot\text{ksi}$

E2 is for 6061 Heat Treated Aluminum Alloy
E1 is for Cold Rolled 1010 Steel
Values from Norton's Design of Machinery
Page 808-809



$F := 50\text{lbf} \quad n := \dfrac{E_2}{E_1}$ n is ratio of E for composite beams

$x := 0, 0.1\text{in}..L \quad w_1 := 9\text{in}\cdot n \quad w_2 := 2.2\text{in}\cdot n$

w1 and w2 are the width of the cantilever beam

$M(x) := F\cdot(L - x) \qquad t(x) := \left[w_1 - \left(\dfrac{w_1 - w_2}{L}\right)\cdot x\right]\cdot n$ Width varies along the length of the beam. t(x) is beam width at any location

$$c(x) := d - \frac{d^2\cdot t(x) + s^2\cdot(b - t(x))}{2(b\cdot s + h\cdot t(x))}$$

Centroid equation derived from integrating over the length of the beam.

$$I(x) := \frac{b\cdot s^3}{12} + b\cdot s\cdot\left(h - c(x) + \frac{s}{2}\right)^2 + \frac{t(x)\cdot h^3}{12} + \left(c(x) - \frac{h}{2}\right)^2\cdot t(x)\cdot h$$

Area second moment for a beam about Xc using parallel axis theorem

$\sigma_{st}(x) := \dfrac{M(x)\cdot c(x)}{I(x)} \qquad \sigma_{stmax} := \sigma_{st}(0) \qquad \sigma_{stmin} := \sigma_{st}(L)$

$\sigma_{stmin} = 0\cdot\text{ksi} \qquad \sigma_{almax} := \sigma_{stmax}\cdot n \qquad \sigma_{styd} := 44\text{ksi} \qquad \sigma_{alyd} := 40\text{ksi}$

Value from Norton's Design of Machinery Page 809

$Nst := \dfrac{\sigma_{styd}}{\sigma_{stmax}} \qquad N_{al} := \dfrac{\sigma_{alyd}}{\sigma_{almax}}$

Max Stress for Steel

$\sigma_{stmax} = 7.1\cdot\text{ksi}$

StaticSafetyFactor

$Nst = 6.2$

Max Stress for Aluminum

$\sigma_{almax} = 2.5\cdot\text{ksi}$

Static Safety Factor

$N_{al} = 16.2$

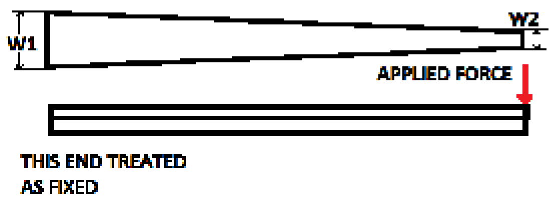
These are acceptable safety factors.

For Just Steel

$b := 1in \quad s := .5in \quad h := 0in \quad d := s + h$

$L := 16in$ T beam constant dimensions

FBD

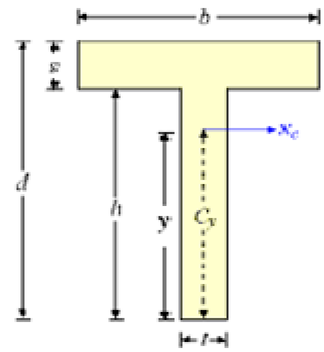


$E_2 := 10400 \cdot ksi \qquad E_1 := 30000 \cdot ksi$

E2 is for 6061 Heat Treated Aluminum Alloy
E1 is for Cold Rolled 1010 Steel
Values from Norton's Design of Machinery
Page 808-809

To approximate an all steel beam, the height of the aluminum section (h) was set to 0. Same result as using a rectangular section.

$F := 50lbf \quad n := \frac{E_2}{E_1}$ n is ratio of E for composite beams



$x := 0, 0.1in .. L \quad w_1 := 9in \cdot n \quad w_2 := 2.2in \cdot n$

w1 and w2 are the width of the cantilever beam

$M(x) := F \cdot (L - x) \qquad t(x) := \left[w_1 - \left(\frac{w_1 - w_2}{L}\right) \cdot x\right] \cdot n$

$$c(x) := d - \frac{d^2 \cdot t(x) + s^2 \cdot (b - t(x))}{2(b \cdot s + h \cdot t(x))}$$

Width varies along the length of the beam. t(x) is beam width at any location, x.

Centroid varies along the length of the beam also.

$$I(x) := \frac{b \cdot s^3}{12} + b \cdot s \left(h - c(x) + \frac{s}{2}\right)^2 + \frac{t(x) \cdot h^3}{12} + \left(c(x) - \frac{h}{2}\right)^2 \cdot t(x) \cdot h$$

Area second moment for a beam about Xc using parallel axis theorem.

$\sigma_x(x) := \frac{M(x) \cdot c(x)}{I(x)} \qquad \sigma_{xmax} := \sigma_x(0) \qquad \sigma_{xmin} := \sigma_x(L)$

$\sigma_{xmin} = 0 \cdot ksi \qquad \sigma_{yd} := 44ksi$ Value from Norton's Design of Machinery

$$N := \frac{\sigma_{yd}}{\sigma_{xmax}}$$

Max Stress

$\sigma_{xmax} = 19.2 \cdot ksi$

Static Safety Factor

$N = 2.3$ This result is acceptable under certain conditions.

Appendix B: Weekly Meeting Notes

August 29, 2012

Time: 12:00pm

- Make sure that project is correctly registered with the WPI registrar
- Provide pictures and background information on similar devices and explain how MQP will differ from what is already available to consumers
- Begin writing task specifications for device
- Investigate laser breaking as a possible safety mechanism
- Send weekly meeting reminder e-mails to all group members and advisors

September 5, 2012

Time: 12:00pm

- Explain what we like about available products and what we do not like
- Look into expandable dining room table designs for table saw
- Continue sketches and compare them to what is already available to consumers
- Patent citations do not necessarily mean that they are being used within the patented design
- Contact writing center in regards to citing specific patents

September 12, 2012

Time: 12:00pm

- Keep in mind that gradual wear of parts will occur and should be taken into account during design process
- Wedge system to reduce wear of parts
- Begin to investigate how we plan to release saw
- Try to reduce mechanical failure
- Where will possible kill switches need to be located on the saw
- Look into bell view springs for mechanisms
- Try to minimize the amount of costume parts (they need to be easily replaceable)
- Begin working on a solid model

September 18, 2012

Time: 12:00pm

- Should include a coordinate system on all submitted drawings
- Investigate electrical contacts between table so it does not turn on while transitioning between miter and table saw mode
- Determine pivot points of the table
- Construct models of adjustment mechanisms
- Investigate geometry of connections and physical hardware (more detailed parts)

September 26, 2012

Time: 12:00pm

- Increase degree of cut to 55º
- Indicate gravity on all figures
- Investigate telescoping slides (never been done before)
- Advantages vs. disadvantages of telescoping and typical slide rails
- Make sure to explain calculations in the report
- Determine overall dimensions of table and slides in accordance to task specifications

October 2, 2012

Time: 12:00pm

- Investigate telescoping slides more
- Define a slide stop for table saw mode (bump stop or pin)
- Maintain a list of issues that come up to deal with later
- On-off switch for table saw mode
- Contact Barbara Furhman about companies selling saws
- Talk to Neil about storage space in ME building

October 10, 2012

Time: 12:00pm

- Investigate drawer slides at Home Depot
- Determine pin lock position for table saw
- Determine location of rotation pins for table top
- Talk to Barbara Furhman about reimbursement of saw

October 30, 2012

Time: 12:00pm

- Go back and touch up task specifications
- Make decision on how much slides should impact our budget

- Make more detailed CAD drawings based off purchased miter saw

November 6, 2012

Time: 11:00am

- Investigate ball bearing slides (since we have 3 from purchased miter saw)
- Look back at old task specifications and make edits after designing for a few weeks
- Keep "quality over quantity" in mind
- Computer model finalization
- Provide an update on where the budget stands
- Calculate material strength required in radial arm
- Include cost of components and effectiveness in report
- Task specifications should mention that saw can withstand weight of shingles to be placed on table
- Investigate an I-beam for extension radial arm

November 14, 2012

Time: 11:00am

- Make use of Professor Norton's linkage program for saw linkage
- Investigate the combination of plastic and steel in the radial arm
- Begin to search around for scrap metal and prices
- Rapid prototype machine would not be an efficient use of materials and budget
- Keep in mind stress concentrations on key ways
- Look for standard parts for a 10-inch circular saw
- Look into Peterson's Stress Concentration book

November 20, 2012

Time: 11:00am

- Make sure that report takes significant figures into account when reporting number values
- Cite where material data comes from
- Account for variability in material dimensions due to manufacturing (tolerances)
- Perform truss analysis on table and linkage
- Question ME machine shop about the precision that they can achieve
- Only do analysis when needed
- Perform simple stress calculations on the table

November 27, 2012

Time: 11:00am

- Create cross section to scale of table and radial arm using actual materials
- Create the loads that the wood would exert on the saw
- Include FBD on Mathcad calculation
- Include cross sections of other parts

December 4, 2012

Time: 11:00am

- Investigate use of torsion bar vs. spring inside miter saw
- Provide a better view of spring component in miter saw
- Calculate deflection on turn table steel rods (ensure that saw does not penetrate table)
- Look into door latch mechanism for table locking
- Look for spring mechanism in Solid Works
- Deflection vs. Load curve for optimum radial arm thickness

December 11, 2012

Time: 11:00am

- Look into Solid Works visibility setting for countersunk holes
- Create an MQP status report and a to-do-list for C-term
- List out issues of the design that need to be taken care of
- Contact ME manufacturing lab for time to machine parts and take safety quiz
- Look into the cost of purchasing a table or saw horses
- Demonstrate plan for C-term
- It was decided to meet on Tuesdays at 11:00am during C-term

January 15, 2013

Time: 11:00am

- Contact Dave Blancher to see if Solid Works has a thread setting or command
- Metal saw horse clamps shall be used for prototype
- Contact Barbara Furman for steel manufacturers contact information
- Add the purchased miter saw into the cost sheet
- Construction progress photographs
- Begin MQP presentation day poster

January 22, 2013

Time: 11:00am

- Keep track of issues and include in report and explain resolutions
- Ask manufacturing lab for lab space to store prototype
- Look in Washburn for scrap metal that is not to be used anymore
- Explore various other scrap metal yards
- Leave rapid prototyping for after construction of prototype

January 29, 2013

Time: 11:00am

- Investigate worm gear as a non-back driving gear and price
- Catch up on the report
- Continue construction of prototype

February 5, 2013

Time: 11:00am

- Take report to be edited my writing center
- Perform binding calculations on vertical translator rods
- Check into linear bearings for vertical lift
- Investigate self-locking mechanisms
- Draw FBD on vertical motion

February 12, 2013

Time: 11:00am

- Possibly will still require a lock on non-back driving gear due to vibrations
- There should be a quick release stop on second vertical translator shaft like a bike seat lock
- Verify that 3/8-inch vertical rods is strong enough for translator shafts
- Order parts and correspond with Barbara Furman

February 19, 2013

Time: 11:00am

- Find center of gravity for different setups of slide rails
- Reconfirm stiffness of setups
- Cabinetry tolerance (0.005in)
- MQP tolerance (1/32” – 1/64”)

- Adjust geometry to get tolerance
- Remember that calculations to guide design
- Include test/evaluation section in paper and compare to goals

February 26, 2013

Time: 11:00am

- Include more figures and less words in report
- Include a definitions/glossary of terms section in report
- Edit composite beam calculation
- Include FBDs on calculations
- It was decided to meet on Tuesdays at 12:00pm during C-term

March 12, 2013

Time: 12:00pm

- Update the budget to see where we stand
- Check Peterson Steel Corporation for steel scrap

March 26, 2013

Time: 12:00pm

- Make sure to take photos of parts on white paper with a ruler next to it for scale
- Check with Washburn Labs to see if they have excess machine screws to sell
- Recommend to design for manufacturing in paper
- Update recommendations to show difference in prototype and final product
- Send advisors email corresponding to poster
- Begin to think about the 80 character eCDR

April 2, 2013

Time: 12:00pm

- Make changes to moment of inertia problem in paper
- Explain steps in calculations
- Keep an eye of significant digits within the paper and calculations
- Do not confuse moment of inertia with second moment area
- Continue to work on eCDR form

April 9, 2013

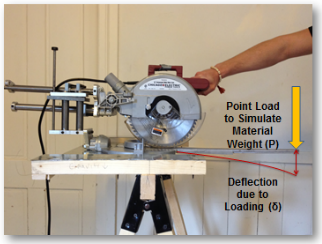
Time: 12:00pm

- Include an image of the device in table saw mode
- Think about preparing video or slideshow for project presentation day
- Explain the poster graph by including a free body diagram and equations
- Cut out some words in the poster
- Recommendation section could include optimization for weight and safety features

Appendix C: Poster Presentation

3-in-1 Combination Saw

Mathew Fredrick (ME), Edward Galvin (CEE), Timothy Moreau (ME)
Advisors: Professors Eben Cobb (ME), John Hall (CEE & ME)
AY 2012-2013



Free Body Diagram for Radial Arm Thickness Optimization

Abstract

Until now there has not been a multi-use tool that encompasses the functionality of a circular, miter, and table saw. The 3-in-1 Combination Saw combines these functionalities into a device that is mechanically and structurally safe to operate for the average do-it-yourselfer. Its ability to switch between operating modes in under 60 seconds makes the 3-in-1 Combination Saw truly unique.

Background

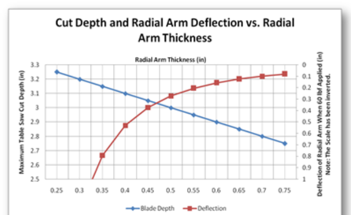
There is a multitude of different types and brands of saws currently available to consumers including combination saws. Circular, miter, and table saws are often sold individually while some combination saws combine the functionality of a miter and table saw. These combination saws are more popular in Europe, however, and are not sold in the U.S. There are no current patents that involve the combination of a circular saw with a miter or table saw setup.

Process

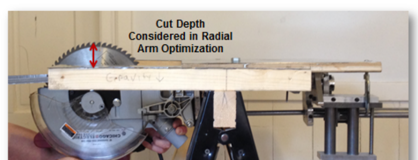
The early stages of design consisted of sketches and CAD models that took into consideration calculations that helped guide the project. An early prototype constructed of wood was created to confirm the design worked and to address problems which were not apparent in the CAD model. Once these issues were addressed, a working prototype was constructed with engineered and machined materials.

An example of maximum deflection of a cantilever beam with fixed support and end loading can be seen below that aided in the design of the radial arm thickness:

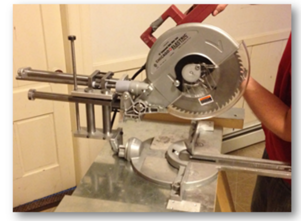
$$\delta = \frac{PL^3}{3EI}$$



Optimization Curve for Radial Arm Deflection and Table Saw Cut Depth



Device in Table Saw Mode



Device in Miter Saw Mode

Project Goals/Objectives

- To design a 3-in-1 saw that will have the ability to rip a 4'x8' sheet of plywood and cut a standard 2"x12" wooden member at a 55 degree angle;
- Switch between modes in under 60 seconds;
- Build a prototype;
- Plan for manufacturability and safety.

Device in Circular Saw Mode

Recommendations

- Optimize device for weight and portability;
- Add safety features;
- Additional testing for functionality and marketability;
- Consult manufacturing engineer for material selection and constructability.