Spring 2020

Composite Guitar

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Composite Guitar

By

Ryn Rollins

Contents

Introduction

Description

Traditional wood-bodied guitars can be easily chipped or cracked, which can compromise the desired sound of the guitar. The wood can also break down over time, which will lead to extra maintenance costs. These wooden guitar bodies can be replaced with materials that are stronger, cheaper, and easier to produce. Two of the most popular composite materials are carbon fiber and fiberglass.

Motivation

The CWU MET Program wants to prove the concept of making a composite guitar so that it might develop into a Lean Manufacturing lab. A wood bodied guitar can be easily damaged if not properly taken of. With composite material, the guitar will be more water resistant, able to withstand changes in temperature and humidity, and will even be able to stay in tune longer than a traditional guitar. Musicians will be able to feel better while traveling because a composite guitar will not be damaged as easily. Finally, if a part needs to be replaced, it is easier to replace composite parts than wood parts.

Function Statement

The composite guitar body is supposed to provide a shape that gives a desirable tone for the guitar. It must have space to connect the neck, bridge, electronics, and strings. The guitar body must also be designed to fit an appropriate sound and volume comparable to a traditional guitar.

Design Requirements

The guitar body needs:

- To be able to attach a neck with a 25.5 inch scale.

- Withstand the 10.5 lbs of force generated from the strings.
- To be 16.65 inches in length.
- 2 inches in depth.
- Unless otherwise specified all tolerances must be:

  X.XX = ± 0.02

  X.XXX = ± 0.015

Engineering Merit

The project will require an extensive amount of design. The composite guitar body will need to be shaped in a way that will give a desirable tone and volume. To achieve this, the composite body will be modeled after a wood-bodied guitar. Some dimensions will need to be altered since composite material will resonate sound differently than traditional wood. Since the neck will be detachable, the composite guitar will need to be engineered to have a space to connect the detachable neck.

Scope of Effort

The composite guitar body must first be compared to wood-bodied guitars and other composite guitars to ensure desirable size and shape. The size and shape will determine the sound that will be produced by the guitar. The guitar must also be shaped in a way that is comfortable for the player. A wood-bodied guitar will be used as a template for the carbon fiber guitar.

Success Criteria

For the project to be considered a success, the composite guitar body must provide a shape that gives a desirable tone, must have space to connect all required components, and must reach a volume that is suitable for the guitar. All dimensions must be within the given tolerances. Finally, the guitar must sound like a guitar when plugged into an amp.

Design & Analysis

Approach

One of the first steps in designing a guitar is deciding what the necessary dimensions will be. A wood-bodied cutout from the ESTC Woods Lab was used as a template. By basing the dimensions off of an already proven guitar template, there will be less of a “guessing game” when trying to determine if the size and shape will produce the required results.

Design Description

The guitar was designed similar to a traditional wood-bodied guitar. The overall length of the guitar body is 16.65 inches. The guitar has a Styrofoam core with carbon fiber outer layers.

To ensure the composite layer is strong enough, two layers of carbon fiber were used for each part of the guitar. Epoxy resin and hardener was used to apply the carbon fiber to the foam core and allowed to harden overnight for each iteration to ensure the strength of the carbon fiber would be able to withstand the tension of the strings when played.

Benchmark

This guitar is within 10% of the size of the model guitar used in the Lean Manufacturing class. The guitar weight is also within 10% of the calculated weight.

Performance Predictions

The guitar body should allow a neck to be bolted onto the neck block. Once the neck is attached, the sound of the composite guitar should be relatively similar to a wood-bodied guitar. Because this is an electric guitar, the guitar must sound like a traditional solid body electric guitar. The guitar must also be able to withstand the force created by the strings. The calculated shear stress created by the strings is 10.07 psi. The neck will be made out of maple wood, which has a max shear of 1495 psi. Using these calculations, the neck should easily be able to withstand the shear force created by the strings.

Description of Analyses

There will be 12 different analysis done during the design of the guitar. These analyses will vary from stress/strain at different locations on the guitar to an analysis on cutting the carbon fiber. An analysis was done using the Rule of Mixtures to find the modulus of elasticity for the carbon fiber after the epoxy had hardened.

Methods & Construction

Methods

The guitar was modeled after the “Flame” design that was provided by Professor Pringle and Professor Calahan. The core of the guitar is made out of Styrofoam and carbon fiber is used to reinforce the foam. The Styrofoam core was cut using a router in the Woods Lab. A router was used to ensure that the guitar was cut with the correct dimensions and also because the program for the router was readily available.

Initially, a vacuum sealer was going be used when doing the carbon fiber layup. Using a vacuum sealer will allow the carbon fiber to be molded more tightly to the Styrofoam core and ensure a better finish. After using the vacuum sealer for the test guitar, it was found that the corners were posing a problem. The carbon fiber was not able to get a good finish when trying to vacuum seal around the different shapes of the guitar. To fix this problem, the carbon fiber was applied using a simple wet layup and allowed to harden using gravity and the weight of the mixture to form around the corners of the guitar.

One layer of carbon fiber was done at a time to try and sure a nice even finish each time. A vacuum bag was used to try and remove all the air and get as good of a finish as possible. The cure time took around 6 hours which is close to the recommended cure time of 5 to 5.5 hours. When the vacuum bagging process finished, the guitar was pulled out and found to have deformations around the neck attachment area. The Styrofoam was too thin around that area and the cutout was bent and crushed when being vacuum bagged. A wooden block was placed into the cutout to try and return the foam to the correct shape. All other vacuum bagging processes will be done with support either from a wooden block or some other form of support.

Construction

The model for the composite guitar was given by Professor Pringle. The composite guitar was modeled after the "Flame" style guitar that is made in the Lean Manufacturing class. The guitar material was changed to Styrofoam in Solidworks. A shell was then created to mimic the layers of carbon fiber being added to the guitar body.

The Styrofoam core was cut with a router and the edges were sanded down to create a rounded shape rather than sharp corners. The carbon fiber was cut into strips so it could be laid onto the foam core more easily. After laying the first strips of carbon fiber, it was found that the fabric was not adhering to the foam core as well as it needed to. It was decided to add a generous layer of resin to the Styrofoam first before laying the carbon fiber. This was able to help with bonding the fabric to the core. Instead of using a vacuum bag, the guitar was placed into a makeshift vice with the newly applied carbon fiber facing upwards. It was then allowed to harden overnight to ensure enough time for the epoxy mixture to harden.

After this was done, the excess carbon fiber was cut off and sanded down using a Dremel to get the best finish possible. This was done for each section of the guitar. The larger holes and cutouts were cut out using the Dremel. For the smaller holes, toothpicks were placed before applying the carbon fiber to locate the holes more easily. Once the fiber had hardened, the toothpicks were removed, and the holes were re-drilled out with the corresponding drill bit size.

Testing

The most important test to the composite guitar is making sure the carbon fiber adheres to the foam core. After the first layup, the carbon fiber had a hard time getting an even finish on the core. This was due to the vacuum bag not molding well enough to the shape. For future layups, a simple wet layup was done to try and get a more form fit which resulted in a better finish.

One of the easier ways to see if the carbon fiber molded well to the core is a visual test. If there are no visible deformations or inconsistencies in the layup, the carbon fiber most likely was able to get a good finish. During the first layup, it was clearly visible that the carbon fiber had inconsistencies in the finish and the resin was not able to adhere to the foam core. For all future layups, the resin was be applied to the foam core first, and then to the carbon fiber strips.

Another test that will be done is physically feeling the carbon fiber to see if it has hardened enough to give the strength needed. Certain parts of the initial layup had reached the desired hardness, but others had not. These sections correlated with the spots that did not adhere to the foam core. This was fixed by applying the resin mixture to the foam core first, and then applying the carbon fiber strips to the guitar. This allowed the carbon fiber to adhere to the foam better than it had with the resin only on the strips.

Once all of the carbon fiber has adhered to the foam core and the guitar body is complete, the next step is to attach the neck to the body. If the neck does not fit, then either the guitar or the neck needs to be modified to fit in the neck cutout. The neck will be attached with four screws and a neck mounting plate. The plate will go on the back of the neck with the screws going all the way through the guitar body and into the neck. If the neck lines up correctly with the guitar, this process will only take a few minutes to complete. The resources needed are the guitar body, the neck, and the neck mounting plate with screws. A screwdriver or power drill will work although a power drill will most likely be the best and easiest method. As of now, all testing will take place at home.

After conducting the first test, it was found that the neck was able to fit smoothly into the neck cutout on the guitar body. The neck cutout did not deform as much as was originally thought during the vacuum bagging process. These deformities in the foam were able to be fixed to their original size when the carbon fiber had been applied and hardened to the foam. Once the neck mounting plate arrives, the neck will be attached to the guitar body and more realistic testing can be done.

The neck was able to be attached to the guitar with no issues. The holes in plate, guitar body, and neck all lined up correctly and the screws were able to go in with relative ease. The carbon fiber was a bit difficult to drill through, but pilot holes were made, and that solved the issue. Once the neck was firmly attached to the guitar, testing could be done. This testing includes pushing, pulling, and bending the neck and guitar body at multiple locations to see if the guitar could withstand the simulated forces of being played. These simple tests were done due to at home restrictions and limited availability of testing resources.

The testing procedure was done by starting at one location, applying different forces such as pushing, pulling, or bending, and the results recorded in the testing spreadsheet with a pass/fail grade. Extra bending tests were done near the neck cutout since that is the critical location on the guitar.

Both the neck and guitar body were able to handle all the testing loads that were applied. The neck cutout was especially looked at since that is where the neck is attached and also where the least amount of carbon fiber is. The neck cutout was able to withstand each test that was applied with no movement from the neck or screws.

Budget

The total cost of the project is $252.0. This is 137% over budget. The biggest reason for the cost increase was the need to buy a Dremel tool kit that was not originally taken into consideration when estimating the cost of the project. This tool kit alone was 81% of the total estimated cost of the whole project. There were a few extra purchases that were not included in the original budget including a can of foam sealant and the neck mounting plate with screws. Even though the foam sealant cost was minimal at $7.32 after taxes, it is still considered a cost overrun. The mounting plate and screws were about $27 after tax. This was not considered into the budget because the original plan was to receive all guitar attachments and electrical components from the guitar building program as discussed with Professor Calahan. When the testing quarter changed to remote, some of the parts needed to be purchased out of pocket. While it does increase the total cost of the project, the neck mounting plate is considered an essential part of the testing and was required to attach the neck to the guitar body.

There was one item that was initially estimated into the cost but was never purchased. The 3M sandpaper in the estimated cost ended up not being needed as there was already sandpaper available in the composite's lab. This saved roughly $25 to the actual cost. There may be a need to purchase extra carbon fiber depending on whether or not there are any issues when doing the vacuum bagging process.

One way to resolve future issues of extra costs is to factor in "extra expenditures" when doing the initial estimated cost. Most projects will have issues when it comes to budget, so if there was already a buffer zone in that cost, that would allow for extra purchases without going too far over budget.

See budget spreadsheet in Appendix C.

Schedule

There have been a few changes to the composite guitar during the manufacturing process. Initially, the guitar edges were going to be sharp 90° corners to make the machining process easier. After talking to Dr. Johnson, it was decided to put rounded edges on the guitar. This was done by sanding down the edges by hand to create a rounded radius. This will make the carbon fiber layup process easier as the carbon fiber will be able to lay over a rounded edge more easily than a sharp corner.

The next issue was deciding whether to use a test guitar or not. Dr. Johnson was able to find a smaller wooden guitar that will be used to test the vacuum bagging process. Another material other than carbon fiber will be used to preserve the fabric for the real guitar body. This testing process will be done over the course of this week and next week. If the test guitar comes out with a clean layup, the carbon fiber will be laid on the composite guitar and vacuum bagged.

The final issue with scheduling was waiting for the correct vacuum bagging equipment and foam sealant to arrive. After the equipment arrived, a test was done on the test guitar to see if vacuum bagging was the best way to lay the carbon fiber. Fiberglass was used instead of carbon fiber in order to save on material that would be needed for the actual guitar. The lay up process was the same, and the test guitar was placed in the vacuum bag and allowed to sit overnight. While the fiberglass adhered to the flat parts of the front and back of the guitar, the fiberglass ended up not being able to form around the edges of the guitar as well as it needed to, and the resin mixture pooled around the excess fiberglass. Even though it was decided to not use the vacuum bagging equipment, it was a good test and showed that the equipment works well for certain applications.

The construction of the guitar body and applying the carbon fiber was able to be completed on schedule. Testing the guitar and neck took a bit longer than expected. In order to test the guitar, the neck needed to be attached to the body using a neck mounting plate and screws. These parts took longer than expected to arrive due to delayed shipping. Once the plate arrived, the neck was able to be successfully attached to the body and testing could begin. Because of the lock down, the guitar was unable to be completed and the strings were not able to be attached. This required the testing methods to be changed and changed the schedule as well. Instead of testing the guitar by playing it, simulated tests were done on the neck and guitar body to mimic the forces of the strings. This allowed for the testing to be sped up and finished ahead of the previous scheduled device evaluation. This also allowed for more time to work on other aspects of the project such as the report and the PowerPoint presentation.

See schedule spreadsheet in appendix D.

Discussion

The first issue that came up during the manufacturing process was deciding whether to put a rounded edge on the guitar body or to keep the edges 90° angles. It was decided to add a rounded edge to the guitar because it will help with laying the carbon fiber during the vacuum bagging process and also will be more comfortable while playing. The desired radius was 1/8”, which is common on guitars. The edges were sanded down by hand with sandpaper so the radius may not be exact, but still close enough for the carbon fiber to be draped over and vacuum bagged.

The next issue was figuring out a way lay the carbon fiber without it covering up the screw holes and electrical cut-outs. This issue was resolved with help from Dr. Johnson and Professor Calahan. The first idea was to put the guitar back in the router after the carbon fiber layup had finished and recut the holes and electrical cut-outs using the guitar program already used in the ESTC guitar building class. Although this seemed like the best method, the guitar would have to be kept in the original cut-out to fit correctly into the router. This would not be possible since the guitar needed to be cut free during the vacuum bagging process. The next best solution seems to be to cut out all of the holes manually. The biggest issue with this is cutting in incorrect locations. The best method seemed to be placing inserts or something similar into the holes before applying the carbon fiber. This will allow for easier hole location once the carbon fiber has hardened.

After doing the first iteration of the vacuum bagging process, it was found that the carbon fiber did not adhere to the foam core as well as it needed to. About half of the carbon fiber was not adhered correctly. Because of this, the carbon fiber did not have the strength that would be needed to support the foam core under the stress of the strings. The carbon fiber strips had to be removed and the process had to be re-evaluated to figure out a better method to laying up the fabric. Instead of using the Torr vacuum bags, it was decided to just do a wet layup without vacuum bagging the guitar. The guitar was placed on its side and the carbon fiber was laid one side at a time. By using gravity and the weight of the carbon fiber/epoxy mixture, the fabric was able to get a much better finish with all parts of the carbon fiber adhering to the foam core. This process was repeated with all sides. The front and back of the guitar were done with the same methods as the sides. After the carbon fiber had hardened, the larger holes were cut out using the Dremel. For the smaller holes, toothpicks were inserted before the carbon fiber was laid down to help locate the holes after it had hardened. The toothpicks were pulled out and the holes were drilled out using the correct drill bit size.

While the toothpick method seemed to work well enough, it is most likely not the most ideal solution. The best solution seems to be to apply the carbon fiber to a blank rectangular piece of Styrofoam. Once the fabric has adhered to the foam, place the foam into the router and use the premade program to cut out the guitar with all the needed holes and cutout. This will ensure that the holes are cut to the correct size and in the correct location. This was discussed with both Professor Calahan and Ted Bramble, who run the woods lab and machine shop, respectively. They both stated that while this solution would most likely work, they were not allowed to do the process. The carbon fiber chips would pose a hazard to both the classrooms and the ventilation system. If this solution wanted to be implemented, it would need to be off site at a location that specializes in cutting composite materials like carbon fiber.

After all of the carbon fiber was applied to the guitar, the next step is attaching the neck. This will be done using a neck mounting plate and screws. The plate will go onto the back of the neck cutout and the screws will go through the pre-cut holes in both the guitar and the neck. To do this correctly, the holes in both the neck and the neck cutout must line up in the correct spots. If they do not, the screws may not be able to fit, and the neck will not be attached properly. Another problem that could arise is the strength of the neck cutout may not be able to handle the neck being attached when the strings are installed on the guitar. During the initial design calculations, the force of the strings was much less than the max allowable stress of the carbon fiber/foam mixture. Since the neck cutout was a bit warped while being vacuum bagged, this could have an effect on the strength of the neck cutout. One way to modify this is to add some sort of added strength to the neck cutout, such as a wooden block. This may not be possible due to the carbon fiber already being applied to the guitar but could have been done during the initial construction phase.

Once the neck was successfully attached to the guitar, testing of the neck strength was able to begin. Simple tests of pushing, pulling, and bending of both the body and the neck were done to try and simulate the forces the guitar would feel when the strings were attached. Since the neck cutout had the least amount of strength, most of the tests were focused on and around that location. Extra attention was given to checking whether or not the neck would move or become detached from the neck cutout.

The tests were done on multiple locations on both the body and the neck. After each test was done, all parts of the guitar were examined to see if any changes occurred during the test. If all parts did not move or break, the result was recorded on an Excel spreadsheet with a Pass/Fail grade. Since there is limited or no access to proper testing equipment, all tests were needed to be a simple pass or fail grade with careful observations on both the body and neck. If the neck was able to stay attached to the body without movement or breaking at the neck cutout, then the test was considered a pass. If there was movement or the screws did not hold, the test was considered a fail.

Both the neck and the guitar body passed all the tests that were applied. The screws held the neck in place during the testing and there was no bending or breaking at the neck cutout. Overall, the tests were a success because they showed that the neck and guitar body would be able to withstand the forces of the strings while being played.

Conclusion

Even though there were multiple changes to the design and the construction of the guitar, the finished product turned out successful. The carbon fiber adhered to the foam core fairly well with only a few small mistakes. There is a bit of a gap between the carbon fiber at some spots where they were done on separate days. A small piece of carbon fiber will be placed in the gap to try and fix this problem. The strength of the carbon fiber seems sturdy enough at first glance and will be tested in the future. Luckily, none of the gaps in the carbon fiber are in critical stress locations and should not have an effect on the overall strength of the guitar.

The neck will be made from the material in the woods shop and attached to the composite guitar with four screws and a backplate. Electrical components will be placed into the correct locations and the testing will finish with plugging in the guitar to see if it will play when connected to an amp.

Acknowledgements

Dr Johnson for his extensive knowledge in materials and composites.

Professor Pringle for his help with designing and cutting out the foam core of the guitar.

Professor Calahan for his sound advice and access to the woods lab whenever needed.

Appendix A - Analyses

PROJECT

TITLE

Continued from Page

Given:

Rule of Mixtures: $E_c = E_m V_m + E_f V_f$

$E_m = 36 \times 10^4$ psi $\quad V_m = 0.5$

$E_f = 33 \times 10^6$ psi $\quad V_f = 0.5$

Find:

Modulus for Compostie

Solution:

$E_c = E_m V_m + E_f V_f$

$= (36 \times 10^4 \text{ psi} (0.5)) + (33 \times 10^6 \text{ psi} (0.5))$

$E_c = 16.7 \times 10^6$ psi => 17 Msi

SIGNATURE

DATE

Continued to Page

DISCLOSED TO AND UNDERSTOOD BY

DATE

Continued from Page

Given:

Tension for each string $\tau_{max} = 1495$ psi

Angle for each string

Dimensions for neck, $r = 0.82$ in

Find:

Shear stress on neck

Solution:

$$A = \frac{\pi (0.82 \text{ in})^2}{2}$$

$$A = 1.05 \text{ in}^2$$

$$P = -T_1 \sin(\theta_1) - T_2 \sin(\theta_2) - T_3 \sin(\theta_3) - T_4 \sin(\theta_4) - T_5 \sin(\theta_5) - T_6 \sin(\theta_6) = 0$$

$$P = 16.22 \sin(7.54) + 15.39 \sin(3.2) + 16.58 \sin(4.02) + 14.3 \sin(5.14) + 16.55 \sin(6.88) + 16.83 \sin(1$$

$$P = 10.58 \text{ lb}$$

$$\tau < \tau_{max}$$

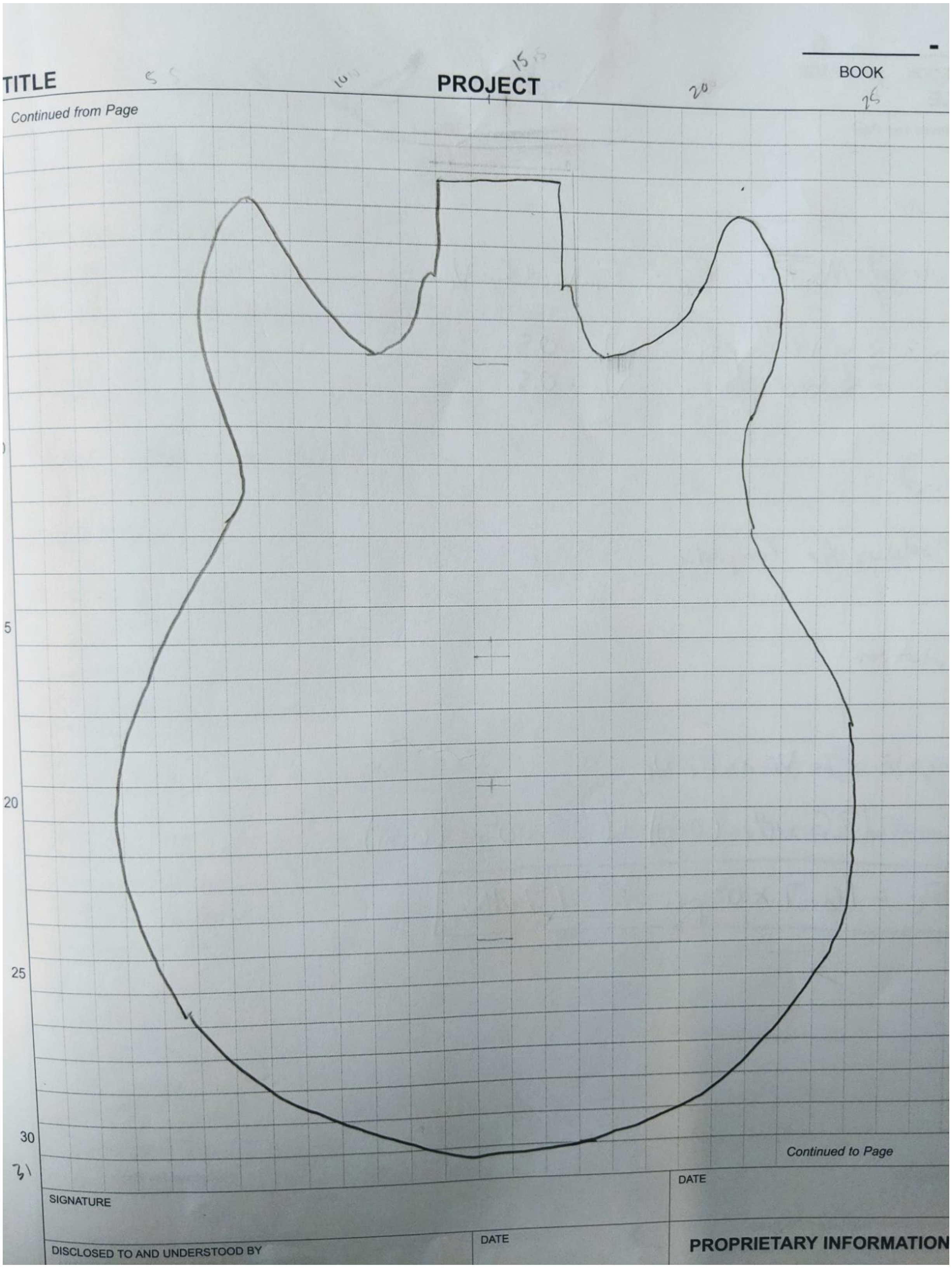
$$10.07 \text{ psi} < 1495 \text{ psi} \checkmark$$

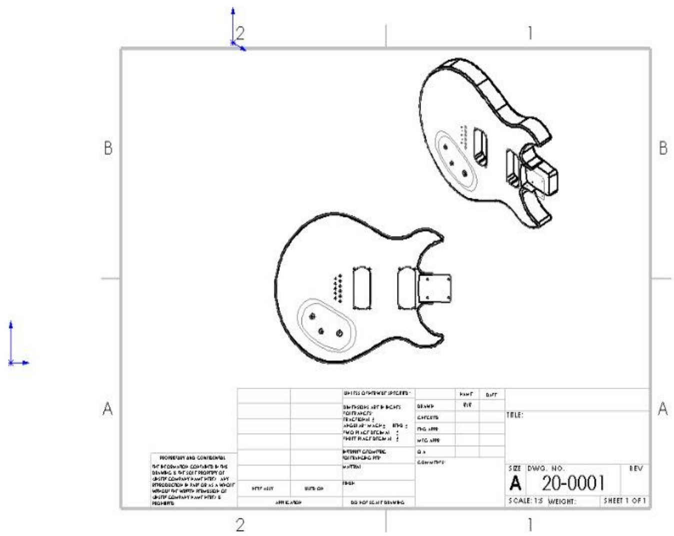
$$\tau = \frac{P}{A} = \frac{10.58 \text{ lb}}{1.05 \text{ in}^2}$$

$$\tau = 10.07 \text{ psi}$$

Continued to Page

Appendix B - Drawings





Appendix C – Parts List & Budget

Double click spreadsheet to open

PARTS LIST AND BUDGET		**This is a running document and will be updated throughout the entire project.**					
SENIOR PROJECT TITLE: Composite Guitar Body							
ITEM ID	**DESCRIPTION**	**SOURCE**	**BRAND INFO**	**MODEL/SN**	**PRICE**	**QUANTITY**	**SUB**
1	Carbon Fiber Fabric - 3k 2x2 Twill Weave	Protech Composites	Protech	1431990	$35.99	1	$
2	Marine Epoxy A-Side Resin 314	TAPPlastics.com	TAP Plastics	8746	$28.75	1	$
3	Medium B-Side Hardener 109	TAPPlastics.com	TAP Plastics	8716	$16.75	1	$
4	3M SandBlaster Sandpaper	Amazon	3M	11080-G	$24.74	1	$
5	Dap Tex Plus Foam Sealant	Amazon	DAP	18836	$6.78	1	$
6	Dremel Tool w/ Attachment Kit	Amazon	Dremel	8220-1/28	$79.99	1	$
7	Neck Mounting Plate w/ Screws	StewMac.com	Stew Mac	0131-B	$14.64	1	$

Appendix D – Schedule

Double click spreadsheet to open

DEFINE HOW THE STUDENTS SHOULD INDICATE STARTING EARLY/LATE AND FINISHING EARLY/LATE
X to indicate work

EXAMPLE SCHEDULE FOR SENIOR PROJECT:
NOTE: STUDENTS MUST MAKE THEIR OWN SCHEDULE!!!!!!!!!!!!!
PROJECT TITLE: Composite Guitar
Principal Investigator: Ryn Rollins

TASK: ID	Description	Duration Est. (hrs)	Actual (hrs)	%Comp.	S / October / November / Dec / January / February / Marc	
1	Proposal*					
1a	Outline	2	1	100%		
1b	Intro	2	4	100%		
1c	Methods	2	3	100%		
1d	Analysis	12		100%		
1e	Discussion	3	3	100%		
1f	Parts and Budget	1	2	100%	X X X X X	Started on time endec
1g	Drawings	15		100%	X X X X	Started on time endec
1h	Schedule	2	3	100%	X X X	Started late ended late
1i	Summary & Appx	3		100%	X X X	Started early ended ea
	subtotal:	42	16			
2	Analyses					
2a	Rule of Mixtures	1	3	100%		
2b	Shear Stress on Neck	1	3	100%		
	subtotal:	2	6			
3	Documentation					
3a	Initial Part Drawing (AutoCAD)	2	3			
3b	Initial Part Drawing (SolidWorks)	2	5			
	subtotal:	4	8			
4	Proposal Mods					
4a						
4b						
4c						
	subtotal:	0	0			
7	Part Construction					
7a	Make Guitar Neck	5				
7b	Make Fret Board	2				
7c	Make Neck Nut	2				
7d	Buy Tuning Knobs	2				
7e	Buy Electrical Components	5				
7f	Buy Screws	1				
7g	Buy Back Plate for Neck	1				
7h						
7i	Update Website	2				
	subtotal:	20	0			
9	Device Construct					
9a	Cut Styrofoam	1	1	100%	X	
9b	Lay Carbon Fiber Test Strips	1	1	100%	X	
9c	Lay Carbon Fiber Strips	25	30	100%	X X X X X X X	
9d	Vacuum Bag the Test Guitar	15	8	100%	X X	
9e	Clean Up Test Guitar	3	2	100%	X	
9f	Update Website	3	5	50%	X X X X X	
	subtotal:	48	47			
10	Device Evaluation					
10a	List Parameters	2	2			
10b	Design Test&Scope	2	1			
10c	Obtain Resources	2	1			
10d	Plan Analyses	2	3			
10e	Make Testing Procedures & Spreadsheet	1	1			
10f	Test Neck Size	1	1			
10g	Record Testing Video	1	1			
10h	Attach Neck to Body	1	2			
10i	Perform Evaluation	2	2			
10j	Take Testing Pictures	1	1			
10k	Update Website	3	5			

Appendix E - Resume

Ryn Rollins

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Objective

- Highly motivated and hardworking new graduate seeking a position that will incorporate my undergraduate coursework as well as my previous work experience.

Education

MECHANICAL ENGINEERING TECHNOLOGY | JUNE 2020 | CENTRAL WASHINGTON UNIVERSITY

- Gained experience in several aspects of mechanical engineering including thermo/fluids/heat transfer, mechanical design, FEA, energy systems, machining, metallurgy, and 2D/3D modeling.
- Experience in programs such as AutoCAD, SolidWorks, NASTRAN, and LabVIEW.

Experience

PROJECT ENGINEER INTERN | ATS AUTOMATION | MAY 2019 – SEPTEMBER 2019

- Duties include: Designing floor plans and drawing sheets for building controls and HVAC systems. Performing start-up functions, point-to-point verification, and troubleshooting for all HVAC DDC controlled devices.

PACKAGING TECHNICIAN | IRON HORSE BREWERY | AUGUST 2018 – JUNE 2019

- Duties include: Packaging cans, bottles, and kegs on a daily basis. Troubleshooting and resolving mechanical issues on multiple machines. In charge of nightly cleaning of machines and beer lines to ensure clean and safe packaging for the following day.

UNIT SUPPLY SPECIALIST | 2ND RANGER BATTALION, US ARMY | AUGUST 2011 – DECEMBER 2015

- Duties include: Receiving, inspecting, inventories, and issuing of company equipment. In charge of the unit's primary hand receipt. Maintained automated supply system for accounting of organizational and installation supplies and equipment. Managed up to 3 employees at a time.
- Accomplishments include: Army Commendation Medal (x2), Army Achievement Medal (x2), Army Good Conduct Medal, Airborne School, and Ranger Assessment and Selection Program (RASP). Three combat deployments to Afghanistan and one training deployment to Oman.

Skills & Abilities

ADAPTABILITY

- Able to adapt and accomplish any situation while keeping a level head.

WORK ETHIC

- Always strive to be the hardest worker in the room.

LEADERSHIP

- Led 3 employees through multiple military training exercises both stationed at home and while deployed overseas.