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Composite Recycler: Frame

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COMPOSITE RECYCLING

Alfonso Olivera
CWU
Frame
Table of Contents

Introduction .................................................................................................................. 3
  Website: .................................................................................................................... 3
  Description: .............................................................................................................. 3
  Motivation: ............................................................................................................... 3
  Function Statement: ............................................................................................... 3
  Requirements: ......................................................................................................... 3
  Engineering Merit: ................................................................................................. 4
  Scope of Effort: ....................................................................................................... 4
  Success Criteria: ..................................................................................................... 4

Design and Analyses .................................................................................................. 5
  Design Description: ............................................................................................... 5
  Benchmark: ............................................................................................................ 5
  Performance Predictions: ...................................................................................... 5
  Description of Analyses: ....................................................................................... 6
  Scope of Testing and Evaluation: .......................................................................... 7
  Device: Parts, Shapes, and Conformation: ............................................................ 7
  Device Assembly and Attachments: ....................................................................... 8
  Tolerances, Kinematics, etc.: ................................................................................ 8
  Technical Risk Analysis, Failure Mode Analyses, Safety Factors, Operation
  Limits: .................................................................................................................... 8

Methods and Construction ....................................................................................... 9
  Description: ............................................................................................................ 9
  Drawing Tree and Drawing ID’s: ........................................................................... 9
  Parts list and labels: .............................................................................................. 10
  Manufacturing Issues: .......................................................................................... 10
  Assembly, Sub-assembly, Parts, Drawings: .......................................................... 11

Testing Method ......................................................................................................... 12
  Testing Method: Introduction .............................................................................. 12
  Method / Approach: ............................................................................................. 12
Test Procedures: .................................................................13
Deliverables: .........................................................................14
Budget / Schedule / Project Management ..................................14
  Cost and Budget: .................................................................14
  Schedule: ..............................................................................15
  Project Management: ...........................................................15
Discussion ..............................................................................15
  Project Progression: .............................................................15
  Successful Approach for the Project: .......................................16
  Accomplishments: ...............................................................16
Conclusion ..............................................................................17
Appendix A - Analyses ..........................................................18
Appendix B – Drawings ...........................................................32
Appendix C – Parts List ...........................................................39
Appendix D – Budget ..............................................................39
Appendix E - Schedule .............................................................40
Appendix F – Expertise & Resources .........................................41
Appendix G – Testing Data ........................................................42
Appendix H – Evaluation Sheet ................................................43
Appendix I – Testing Report ......................................................44
Appendix J – Job Hazard / Safety ..............................................48
Appendix K – Resume / Vita .......................................................49
Introduction

The purpose of the Composite Recycler is to be able to break down composites (carbon fiber) in pieces. The framework and feed rate would have to be able to pull the composites steadily with appropriate adjustments and a calculated control fashion. The frame would have to withstand the loads from material being fed into it and not get deformed in any way, so there’s no further problems. Along with the frame, the feed rate would use the same motor as a fixture to the frame. On the frame, a ram will be mounted on as well to delaminate the composites. There will be an attached vice on the bottom that is fit to the ram so that the composites can bend and break in the designed grooves.

Website:

Click Here
https://oliveraa4.wixsite.com/website

Description:

The recycler as a whole should be able to get fed the material (carbon fiber), the feed rate mechanism should control the feed rate, the frame should delaminate the carbon fiber into layers, and the shredder at the end will cut the material into pieces. When it’s in pieces, the recycled composite pieces will then get burned with fire for the resin to burn and disintegrate while the fiber will be left for reuse.

Motivation:

The motivation for this project started a year ago when two students chose to tackle this problem, breaking down composites “carbon fiber” for recycling, but were unfortunately unable to make it work efficiently. A determined team was gathered to take this challenge and make this mechanism work, to accomplish the end goal, recycle composites (carbon fiber).

Function Statement:

The purpose of the frame is to be able to withstand deflection when the material is getting fed into it. It will also be designed to delaminate the whole composites into layers to be broken down further.

Requirements:

The device will conform the following requirements:

• The feed should be controlled in a fashion where it won’t shoot out through the end.
• The frame should be able to withstand the material being fed into it while delaminating it.
• The composites should break down passing the frame.
• The shredder should cut the composites into pieces.
• Fire will be used to separate resin and fiber.

Engineering Merit:

Analysis of the frame will be able to withstand the forces that carbon fiber produce so that the frame won’t bend but be able to bend the composites for delamination.

Scope of Effort:

The mechanism is supposed to break down composites so they can be recycled for further use. This will be accomplished by having appropriate fixtures to hold and delaminate the material as it’s going through the frame. The frame will be adjustable to fit several of sizes of composites to breakdown, and the feed rate will be adjusted based off the thickness of the composites being fed into it.

Success Criteria:

The frame will be able to not deflect under loads produced from the gears and material being fed. The shafts, will also be able to do the same, so there’s no deformation.

Abstract

How can composites be recycled? The Composite Recycler is an ongoing project that started in September 2017. The purpose of this project was to create a machine that will delaminate the composites, chip them, and heat them up to separate the resin from the composites so they can be recycled. The delamination process uses a ram to press two saw tooth shaped devices together that bends and deforms the material in opposite directions. The chipper process uses counter rotating saw blades spaced 1/8” apart to produce small shredded material. An oven is used for the heating process. The existing base was used as well as the chipper and electrical motors. The upgrades included a housing to support the transport rollers and changing from a cam to a ram for delamination. The housing was designed to hold all the parts needed to contain and support the transport rollers as well as provide pressure on the composites as they travel through the rollers. The rollers were made with grooves for more grip on the composites. The group of three used a SOLIDWORKS assembly file to ensure all design components fit together properly. The finished housing supported the rollers and the springs maintained a force of 10 lbs on the material as it was transported through the housing. This provided enough grip to eliminate any slippage as the material is transported towards the chipper.
Design and Analyses

The first step into making this project possible, is by making sure it’s going to be designed to be safe and usable. In order to make this happen, analyses were created to prove the materials are going to be able to withstand the loads that are performed on the materials. The analyses that were wrote up can be found below in Appendix A.

Design Description:

The design of the frame should be able to make it possible to fit the composites that are going to be fed into through the front, while protecting the user from fragments that could fly out. The frame as a whole, is designed to look like this:

Benchmark:

The idea of the composite recycler came from students from the previous year that couldn’t make the project work. The plan for this design is to reconstruct the whole project as a whole that the previous year tried but actually make it work with the new designs.

Performance Predictions:

For the properties of the frame itself (excluding Rosy’s and Nathan’s parts):

Material = ANSI 1020 Steel
Mass = 104.45 pounds
Volume = 365.97 cubic inches
Surface area = 1391.19 square inches
The performance predictions have high expectations because the frame should be able to withstand all the forces applied to it while it’s running. It is predicted that the frame will be able to not deform with all the loads that act on the frame as a whole. The cost can be found in Appendix D where the Budget can be found. The timing can be found in Appendix E under Schedule.

**Description of Analyses:**

The following analyses can be found worked out step by step in Appendix A: Loads, deflections, Stress (bending, shear, torsional), Load bearing geometry.

**Loads: Appendix A1**
In this analysis, loads were calculated that were going to be acting on the beam. This was found, by finding the ram, mounted on the top of the frame, and the loads that the ram will perform on the frame.

**Deflection: Appendix A2**
In this analysis, the beam deflection formula was used which calculated the deflection that would act on the beam.

**Side Walls: Appendix A3**
In this analysis, an idea of what the side walls were envisioned to look like to incorporate how it was planned to be designed to fit all the parts to make the frame possible.

**Inner Shafts and Shaft Sleeves: Appendix A4**
In this analysis, a construction of what the shaft sleeves and inner shafts were envisioned to look so that they’re able to fit over each other so that they’re able to rotate with the contact of the composites pushing them.

**Torsional Deformation (Shafts): Appendix A5**
In this analysis, the torsional deformation formula was used. The values used were:
Torque=4 N*m, the Length= 6 inches, Modulus of Elasticity= 75 GPa, and Polar Moment of Inertia= 0.464 inches cubed.

**Torsional Shear Stress (Shafts): Appendix A6**
In this analysis, the torsion shear stress formula was used. Tmax= Tc/J. T= 4 N*m, c= 19.05mm, J=0.50 inches cubed.

**Composite Push Force: Appendix A7**
In this analysis, given dimensions were used of an average board length, widths, and thicknesses. Then the minimum push force was calculated to push the boards to make the vice work. The area of the boards was also found based off the given dimensions. Then, calculations were performed to determine if either steel or rubber would have a higher friction factor.
Breaking Torque: Appendix A8
   In this analysis, the shafts and RPMs were used of what the shafts would be rotating as so that the Mass Moment Inertia can be determine, the Required Deceleration, and the Breaking Torque.

Friction Force: Appendix A9
   In this analysis, rubber and steel was used to be able to find more precisely, which material would have a better (higher) Friction Force.

Base Plate Ram Analysis: Appendix A10
   In this analysis, the load that will take place in the base plate where the dye is going to be located was found by making appropriate calculations. Also, a V&M Diagram was created for a visual of the load.

Base Deflection Analysis: Appendix A11
   In this analysis, the base plate on the area was targeted where there will be the dye and then the deflection was then calculated at that area where 2000 pound force would be distributed to a 2.38 inch length, adding to a 9000 pound load.

Maximum Stress & Maximum Vertical Shear Stress: Appendix A12
   In this analysis, the maximum stress due to the bending joist and the maximum vertical shear stress was calculated. Many steps had to take place to make the numbers come out, which can be seen below in the Appendix.

Scope of Testing and Evaluation:

Testing that should be done will be on the material strength with the different thicknesses. The material will be strong and thick enough to withstand the loads applied.

Device: Parts, Shapes, and Conformation:

All the following parts can be found in Appendix B:
   • The Base will be a rectangular shape with a slot cut out to fit the dye.
   • There will be 2 rectangular Side Walls with fillet top edges with holes and hole slots to incorporate the shafts that will be going through them.
   • The Top will be rectangular and there will be a hole for the Ram to be able to go through and out, as well as cutouts to where hex screws will be able to be screwed down to the tops of the side walls.
   • There will be 1 cylinder Shaft that will be press fitted into the side walls for composite material guidance.
   • There will be 3 Inner Shafts that will fit in the hole slots so that they’re able to move to the thickness of the composites being fed into the machine.
   • There will be 3 Outer Shaft Sleeves to fit over the Inner Shafts so that they’re able to rotate when they come in contact with the composites and rotate freely.
   • There will be 6 Pins that will fit in the designated holes in on the ends of the Inner Shafts so that they can move up and down in a smooth fashion.
   • There will be 6 Springs that will go on the top half of the Inner Shafts, over the Pins to allow adjustability to the shafts based off the thickness of the composites.
- There will be 6 Big Hex Screws to screw down the Top Plate with the top of the side walls so that it’s able to stay in place.
- There will be 8 Small Hex Screws to screw down the wall guides for the Ram Guides.

**Device Assembly and Attachments:**

Here is how the assembly as a whole will look like including the parts that the team has provided to be assembled together. The individual parts can be found in Appendix B.

<table>
<thead>
<tr>
<th>Isometric View</th>
<th>Front View</th>
<th>Section View</th>
</tr>
</thead>
</table>

![Device assembly images]

**Tolerances, Kinematics, etc.:**

The tolerances of the parts that will be made are plus/minus five thousands of an inch. Kinematics will be done when the assembly is put together to see how the moving parts will be moving as well as what conflicts with their motion.

**Technical Risk Analysis, Failure Mode Analyses, Safety Factors, Operation Limits:**

There can be technical analysis that can be done if the parts have too much friction to move as they were designed to. Things like this can be fixed by reducing the size of the parts causing too much friction so that it can move freely as designed. Some other technical risks that can happen are misplacing of the added parts and them not lining up precisely how they are designed to fit. Further steps would have to be made in order to fix this problem if it occurs such as possible redesign.

There could be some technical risk analyses that could be done if the motor, pulley with belt, or shafts dysfunction and steps that could be taken to redo or fix. There should be a solution to any technical risk factor that could happen in the mechanism. Technical risk Analyses can be found in Appendix A9. A failure mode analyses is also conducted for the feed control mechanism and is found in Appendix A10. Although the technical risk and failure mode analyses can change, one will be set up to start off.
Methods and Construction

This project was an idea that some students the year prior (2017) didn’t quite accomplish. A team this year was given the opportunity to work on this project to help with the framework in regards to the project as an entirety.

Description:

The frame will be built in different sections. The parts will be ordered and parts needed to be manufactured will be manufactured to the calculated and designed dimensions in order to fit and function as supposed to. First, the base will be ordered and received and will be welded onto the existing frame that the motors are attached to. Second, the shafts and sleeves will be turned into the appropriate dimensions. Third, the walls will be cut wherever needed to, and appropriate holes will be added to where parts need to be screwed/attached to. Fourthly, 2 walls will be inserted to where the ram will be going down so that it can be guided. Fifth, the top will be machined with appropriate cuts. Sixth, pins will be cutout with springs to be added to the shafts to keep their place as well as providing force to push down on the material being fed. Seventh, the screws will be ordered and cut down to appropriate length to be able to screw the whole assembly together. The whole assembly as a whole will consist of 37 parts.

Drawing Tree and Drawing ID’s:

Assembly as a Whole: Appendix B Number 1
The assembly as a whole will be how the frame will be constructed and how the composites will enter the front of the frame and make its way through as the feed rate is adjusted.
Angle Iron Corner Wall: Appendix B Number 2 (4 Parts)
This piece will be the vertical support on the angle iron box frame structure.
Angle Iron Short Side: Appendix B Number 3 (4 Parts)
This piece will be to horizontal support on the angle iron structure.
Angle Iron Long Side: Appendix B Number 4 (4 Parts)
This piece will be the long side connecting the Angle Iron Corner Walls and the Angle Iron Short Side to put together the whole Angle Iron Structure.
Side Walls: Appendix B Number 5 (2 Parts)
The side walls will fit all the necessary parts to make the composites be able to be fed into the vice while safely covering all areas that could possibly let fragments out.
Top Plate: Appendix B Number 6 (1 Part)
The top plate will be placed on the top of the whole vice to protect the user from getting hit by fragments. The plate will also have a slot in which the ram will be going through to break down the composites by delaminating it.
Shaft With Extended Bushing (Top): Appendix B Number 7 (3 Parts)
The shafts will help guide the composites in a straight fashion. Due to not enough space to add bushings, spacer-like ends were turned on the shaft itself to help from sliding to the sides out of place. There were also grooves added for more friction on the composites.

Shaft Wider (Bottom): Appendix B Number 8 (1 Part)
The shafts will help guide the composites in a straight fashion. There were also grooves added for more friction on the composites. This shaft was made wider to extend to the bushing on the side and allow no movement once running.

Shaft Guide Box: Appendix B Number 9 (6 Parts)
This piece will be fixed on the Top Shafts to help guide them in a straight fashion. The Spring Pin will be fit on the top so that the shafts move straight.

Spring Pin: Appendix B Number 10 (6 Parts)
The spring pins will fit in the hole on the inner shafts and have a spring on the top in order to guide the shafts movement in a straight up and down fashion while being in place.

Frame Spacer: Appendix B Number 11 (2 Parts)
This piece was added to lift the frame as a whole to help bring centered with the cutter on the machine.

Top Bearing: Appendix B Number 12 (6 Parts)
This Bearing will be pressed on the Shaft Guide Box to fit the Shaft With Extended Bushing.

Bottom Bearing: Appendix B Number 13 (6 Parts)
This bearing will be pressed into the Side Walls to fit the Shaft Wider.

Parts list and labels:

Angle Iron, 2 Side Walls, Top Plate, 3 Shafts, 1 Shaft Wider, 6 Shaft Guides, 6 Spring Pins, 6 Pins, 6 Springs, 6 Big Hex Screws, 8 Bushings, and 24 Small Hex Screws.

These parts can also be found in Appendix B & C.

Manufacturing Issues:

Issues that can come up can be in the weldments. The weldments will be done in order to put together the frame walls with the base, all while most of the parts are in place with the frame walls where they need to be. Another issue would be the wearing of the added parts with things such as replacing screws or wall guides for the ram.

Construction Modifications:

There were modifications made for the week of 1/14/19 – 1/20/19. Some manufacturing modifications were made on the whole frame itself to reduce weight of the whole frame as well as provide a way to swap out wearing parts by attaching them to the angle iron box that was created. The frame will be able to be attached to an angle iron box, that the plates can be fitted onto them. The inside shafts will be adjusted to better fit
the extension of the width of the box. The design will remain mostly the same, but some adjustments have been made.

There were modifications made for the week of 1/21/19 – 1/27/19. There was a box constructed to hold the shafts with a bearing and a hole was placed on the top of the box. The hole on top of the box was created for a pin to be added to it to hold the spring in place. The top plate was also modified with holes toward the sides to fit the pins and allow them to slide through the holes as material widths vary, moving the pins up/down and having the springs compress/decompress.

There were modifications made for the week of 1/21/19 – 1/27/19. There was a box constructed to hold the shafts with a bearing and a hole was placed on the top of the box. The hole on top of the box was created for a pin to be added to it to hold the spring in place. The top plate was also modified with holes toward the sides to fit the pins and allow them to slide through the holes as material widths vary, moving the pins up/down and having the springs compress/decompress.

There were modifications made for the week of 2/11/19 – 2/17/19. There is a total of 8 individual drawn parts manufactured to total 28 individual parts including the bushings. There were some modifications on the holes on the side wall due to the screw interfering with the spring pin and springs that will be added soon. There was also a modification made on the slot where the Idler is at, the slot became an inch longer vertically and the original dimensions of cut out slot was taken into account for the new dimension needed to be added (another inch in length). These solutions allowed the parts already made to not have to be re-machined.

There were modifications made for the week of 2/25/19 – 3/3/19. As for the design manufacturing issues, there weren't any issues. A modification that was made was adding grooves to the shafts. As for the bottom single shaft, it was designed with 120 teeth. For the three shafts on top, it was designed to have 60 teeth so that the shafts won't mesh with the bottom shafts, by the teeth being bigger. The method used for adding the grooves was by using the CNC machine in the machine shop, and using a jig that would rotate the shaft after every cut in an almost perfect rotation allowing there to not be a problem with the grooves shearing into each other when cutting.

Assembly, Sub-assembly, Parts, Drawings:

First, the base will be mounted and welded onto the whole base fixture that was already created. Then, the dye created will be fitted and screwed down into the appropriate slot on the case to where the ram will meet with the dye. Then, the shafts, inner shafts, and shaft sleeves will be fitted into the frame walls so that they can be aligned and welded to the base of the frame. Then the pins and springs will be placed above the shafts. Then, the 2 ram wall guides will be placed and screwed with the small hex screws to the appropriate locations. Finally, the top plate will be placed on top, and the big hex screws will be added to fit snug at the appropriate location.
Testing Method

Testing Method: Introduction

In this testing procedure, the spring force will be tested on the Composite Recycler. The springs are located on the spring pins that are attached to the shaft guide, which have the shafts attached to them, allowing the shafts to move up and down on the material when in contact, while putting force on the material. The springs should have enough force to put down on the materials so that the cutter won’t pull the composites through, but will instead be controlled. In order to test for this, gauges will be used to see what force of springs will be needed for no slippage, the gauge will be put at an end of the composite to see at what force the springs slips, and multiple springs with different compression forces will be ordered and put on the spring pins and will be ran with composites to test the pull the cutter will have on the material being fed into the recycler. The sheet metal guards will have been put up to provide safety for users.

Method / Approach:

- Acquire different pairs of springs with different compression forces.
- Apply pair onto Recycler.
- Feed composite material.
- Observe how the material gets pulled in comparison to what the handle is being turned.
- Decide which spring forces show best control over feed.
- Acquire spring gauges.
- Use drill to drill hole in composites.
- Create data sheets to insert values gathered

Test Modifications:

There were modifications made for the week of 2/18/19 – 2/24/19. For the first test that will be done will be on the spring forces and determining how much spring force that will be needed in order to press down on the composites so that the material doesn't just rip through with the cutter. In order to test this, 2 springs at a time will be ordered, all with different compression forces to test which one puts enough force on the composites while not stopping to the rest of the process from happening. In other words, it'll be trial and error until a force works with the shaft guides and spring pins in corresponding to the shaft.

Tests were ran on 4/8/19. There weren't any testing issues when doing the three first tests that were done on the frame. There also weren't any modifications due to the testing plan being followed and met by the tests. The tests were meant to determine the initial spring rate and spring pressure on the existing springs on the frame. The tests also help figure out the resistance that would be needed for the composites not to slip.
Composites were also fed into all shafts with spring pressure on the shafts and there was a device attached to pull and measure the spring rate the springs have.

Test were ran on 4/22/19. For the second set of testing, springs were ordered with different spring rates from the original set of springs. These springs varied in strength but were stronger than the original springs placed onto the Recycler. The top plate was removed, then the original springs were removed and replaced by the first set of springs. The top plate was then closed and the composite material was placed through the shafts. Then a spring gauge was attached to the composite material and force was pulled in an increasing fashion until the material started to slip from the force, then the pounds were recorded. Then the process was repeated three more times with the same springs to gain an average slippage. Then the top plate was removed again and the springs were swapped out to the second set of new springs where the same process was done to gather another three samples of data. The springs both showed big improvements from the existing springs because they were able to withstand more pounds in the horizontal side, where the existing cutter will do the same, pull the composite material. For the smaller springs, the material slipped between 55-58 pounds. For the bigger springs, the material slipped between 52-54 pounds.

Test Procedures:

Test 1: Required Spring Force for no Slippage.
1. Detach top plate.
2. Remove springs.
3. Use two spring gauges and place them where springs would go.
4. Insert composite material.
5. Push down on spring gauges while person is attempting to pull out the material and figure the force needed and produced on the spring.
6. Repeat steps 3-5 two more times.

Test 2: Existing Spring Resistance
1. Acquire new composite material.
2. Drill hole towards the end of the composite material.
3. Attach spring gage to end where hole is located.
4. Insert material through all 3 rollers.
5. Pull on the material until slipping starts.
6. Record the pounds.
7. Repeat steps 1-6 two more times.

Test 3: Existing Spring Rate (Original)
1. Take springs off Recycler
2. Put springs stacked on compression tester
3. Acquire 3 compression lengths with pound-force
4. Calculate spring rate using spring rate equation.
Test 4: Which Springs Best Fit
1. Get multiple pairs of springs with different compressions.
2. Detach the top plate.
3. Place first pair of springs on spring pins.
4. Bolt down the top plate.
5. Turn on Recycler.
6. Feed material into Recycler.
7. Record observations, time, and distance material moved.
8. Repeat Steps 2-7 with different pair of springs.
9. Decide which springs work the best while having no slippage of the materials.

Deliverables:

The deliverables can be found in Appendix G under Testing Data.

Budget / Schedule / Project Management

This project has 4 people working on it to make it work in a designed fashion. As for the frame portion of the project, all the parts that will have to be fixed or fitted within it so that proper adjustments can be done on the frame, so that the recycler can do its job. Being able to complete the project the design is going to be able to be done, the risk to the project is that if the way the design is constructed will actually be an efficient way of handling the recycling process.

Cost and Budget:

A parts list can be found in Appendix C. In the appendix, the parts that are going to be needed are going to be labeled with an ID number, the item description, the item source, the item brand, the model number, the price/cost, and the quantity. The totals will then be added at the end as well as the actual total that includes the taxes. As of now, $388.17 is the actual cost that all the materials are summed up to be (will vary).

Modifications:
There were modifications made for the week of 2/4/19 – 2/10/19. For the budget, the cost reduced by a lot by making the material not as thick and adding angle iron, allowing some parts to not even be put in the project as a whole. There wasn't necessarily mistakes that changed the cost of the project, but there were adjustments made to help the frame become more stable with as little wear as we could get it to be. As to what the cost will be at the end is still unsure do to there being some possible changes to come still. The tax/shipping isn't of concern either due to the budget we have since we're still way under the amount given to us to use for the project.

5/17/2019. For the most part, there were no changes put into the Composite Recycler on all the frame parts, they all stayed the same. There were some additional springs ordered.
due to there being slippage with the composite material, the final springs that were ordered were around $60 including shipping and handling. These springs were a lot stronger than the ones that had been ordered previous. The springs had forces of 100 pounds, 65 pounds, and 50 pounds. They were put onto the Composite Recycler and adjusted onto the shafts until a correct placement of the springs allowed no slippage whatsoever while still moving as designed to with the feed control.

Schedule:

The Schedule can be found in Appendix E below. Here, the processes that need to be performed are labeled and will be filled in as the project progresses. As of now, the estimated time that each task will take it on the sheet and the actual ones will be updated after each task is updated. The schedule will show when the start of the task takes place as well as when the task is finished. Milestones will also be added when certain significant tasks have been completed.

Schedule Modifications:

There were modifications made for the week of 1/28/19 - 2/3/19. There has been quite a few changes made into design that has caused issues with being able to get started on the manufacturing of the project. This has thrown the schedule off due to the parts not being able to be ordered due to the redesigning of the project as a whole. Everything now is starting to get finalized and some parts have been ordered. Now we're just waiting to make the assembly on SolidWorks and have it completed so that everything in the project can be ordered and manufactured. Some methods to resolve the scheduling issue will be to make more time to manufacture more parts so that we can catch up and have the project completed by the end of the quarter.

Project Management:

The risks that the composite recycler can have is that it doesn’t work or it wears out faster than anticipated/calculated. Budget wise, there shouldn’t be a problem due to the funds provided to make this project possible. Scheduling is always a risk due to designs always changing and things having to be added to make the project function as needed to be. As of now, the resources being used are within one company Metals Depot, which have all the parts needed for the framework of the project. This project will succeed by getting the parts in and machined to specified dimensions.

Discussion

Project Progression:
The original design that was constructed the previous year, had flaws in the frame that was able to get taken care of with the design of this frame that was designed this year. This project progressed in a consistent fashion. Ideas were made and designed to make work through analyses and drawings. The project started with the base, the two side walls that’s will be welded to the base. The shafts that will be press fitted to help guide the composites in a straight fashion. The inner shafts with the sleeves were designed to be able to rotate under contact as well as move to the thickness of the material/composites that will be fed into. The pins to hold the inner shafts as well as the springs to allow adjustability to the inner shafts.

Testing Discussion:

4/16/2019. There weren't any testing issues when doing the three first tests that were done on the frame. There also weren't any modifications due to the testing plan being followed and met by the tests. The tests were meant to determine the initial spring rate and spring pressure on the existing springs on the frame. The tests also help figure out the resistance that would be needed for the composites not to slip. Composites were also fed into all shafts with spring pressure on the shafts and there was a device attached to pull and measure the spring rate the springs have.

5/1/2019. For the Design Testing, there were some minor issues with the composites slipping at random pounds. Therefore, each spring tested was ran three times with new sets of composite material so that there would be existing scratch marks for the previous trials from the shaft and the grooves that could be causing the material to slip at a smaller force than it should. There were modifications with the springs. Multiple springs were ordered with different spring rates in order to test them and see which best fits for the least amount of slippage with the composite material and the Composite Recycler.

Successful Approach for the Project:

There was a redesign at the beginning before anything started therefore all that was constructed and designed was straight forward and successful from then on. The drawings and analyses were appropriate and were able to work based off the calculations in the analysis and the fitment on Solidworks.

Accomplishments:

- Introduction
- Design and Analyses
- Methods and Construction
- Testing Method
- Budget / Schedule / Project Management
- Discussion
- Conclusion
- Proposal
- THE REST TO BE CONTINUED…
Conclusion

This project wouldn’t be able to be made possible if it wasn’t for the JCATI foundation and their support by providing the funds to make an idea possible. This project proposal is based truly on the Frame of the Composite Recycler. The team is excited to be able to work on this project with all the roles in the making of the project: The Frame, Ram, Feed Rate, and the Recycling of the composites. The team as a whole is dedicated and wants to make this project a success. As for what has been mainly talked about in this proposal, the Frame, and based off the calculations and drawings, it is certain that this project will be a success and function as designed to. The requirements for the frame portion are that the materials don’t deform in any way, shape, or form, all while keeping the user safe from potential flying fragments. All steps in the construction of this frame will be done in the designed fashion listed above to work as efficient as possible. The parts will be ordered and machined to the appropriate dimensions to run as intended and designed to. The team is looking forward to putting this project together with the help of the professors, and all other resources/people that are able to help put this project all together.
Appendix A - Analyses

1.
Analysis "Frame" 1

- There will be a horizontal force going through the frame, will be the forces applied by the feed.

- There will be a vertical force in the center of the frame on top, which is the forces applied by the ram machine.

- Ram Force $\approx 2000$ lbs
- Feed Force $\approx 20$ lbs

$A = (b)(h)(w) = (10')(12')(15') = 252 \text{ in}^3$

\[
\begin{align*}
2000\# & \uparrow & 0 \downarrow \\
A_x & \leftarrow & 20 \text{ lbs}
\end{align*}
\]

\[
\begin{align*}
ZFx = A_x - 20 \text{ lbs} & = 0 \\
A_x & = 20 \text{ lbs}
\end{align*}
\]

\[
\begin{align*}
ZMA & = -2000 \text{ lbs (7 in)} + B_y (14 \text{ in}) = 0 \\
B_y & = 1000 \text{ lbs}
\end{align*}
\]

\[
\begin{align*}
ZFY & = A_y - 2000 \text{ lbs} + 1000 \text{ lbs} \\
A_y & = 1000 \text{ lbs}
\end{align*}
\]
3.

Analysis "Frame" 2

Moments:

\[ M_b = \frac{PL}{8} = \frac{(2000 \text{ lb})(14\text{ in})}{8} \]
\[ M_a = M_c = -\frac{PL}{8} = -\frac{(2000 \text{ lb})(14\text{ in})}{8} \]
\[ M_e = 3500 \text{ lb-in} \]
\[ M_a = M_c = -3500 \text{ lb-in} \]

Deflections:

\[ y_e = y_{max} = \frac{-PL^3}{192EI} \]
\[ = \frac{-(2000 \text{ lb})(14\text{ in})^3}{(192)(200 \times 10^6)(2016)} = -7.089 \times 10^{-11} \]

\[ E = 200 \times 10^9 \]
\[ I = \frac{b h^3}{12} = \frac{(14\text{ in})(12\text{ in})^3}{12} = 2016 \]

Between A and B:

\[ y = -\frac{P(3L-x)^2}{48EI} = \frac{-(2000 \text{ lb})(3.5 \text{ in})^2}{(480)(200 \times 10^6)(2016)} (3(14\text{ in}) - 3.5) \]
\[ x = 3.5 \text{ in} = \text{center of A} \]
\[ x = -24500 \]
\[ 1.955 \times 10^{-10} \]
\[ y = -4.8738 \times 10^{-11} \]
New Design "Frame"
Shaft

Inner Shaft

Shaft Sleeve

\[ b = 45 \times 2 \]

[Dimensions and measurements depicted in the diagram]
Torsional Deformation (Shafts)

\[ \theta = \frac{TL}{GJ} \]

\[ T = 4 \text{ Nm} \]
\[ L = 6 \text{ in} \]
\[ G = 75 \text{ GPa} \]
\[ J = 1.46 \text{ in}^4 \]

\[ J = \frac{\pi}{32} (D^4 - d^4) \]
\[ = \frac{\pi}{32} (1.5\text{ in}^4 - 0.5\text{ in}^4) \]
\[ = \frac{8}{32} (1.728\text{ in}^4) \]
\[ J = 0.469\text{ in}^4 \]

\[ \theta = \frac{4 \times 10^3 \text{ N-m}^2}{75 \times 10^9 \text{ N-m}^2} \left( \frac{\text{in}}{2\text{ in}} \right) \left( \frac{\text{in}}{4\text{ in}^4} \right) \]

\[ \theta = 0.0011 \text{ rad} \]
\[ \theta = (0.0011 \text{ rad}) (180^\circ/\pi\text{ rad}) = 0.6^\circ = \theta \]
Torsional Shear Stress (Shafts)

Formula:

\[ T_{\text{max}} = \frac{T}{J} \]

\[ T = 4 \, \text{N} \cdot \text{m} \]
\[ c = 0.75 \, \text{in} = 19.05 \, \text{mm} \]
\[ D = 1.5 \, \text{in} = 38.1 \, \text{mm} \]
\[ J = 50 \, \text{in}^4 = 20651.03 \, \text{mm}^4 \]

\[ J = \frac{\pi D^4}{32} \]
\[ J = \frac{\pi (38.1)^4}{32} \]
\[ J = 20651.03 \, \text{mm}^4 \]

\[ J = \frac{1.5 \, \text{in} \left( \frac{25.4 \, \text{mm}}{1 \, \text{in}} \right)^4}{15 \, \text{in} \left( \frac{25.4 \, \text{mm}}{1 \, \text{in}} \right)} = 38.1 \, \text{mm}^4 \]

\[ J_{\text{max}} = \frac{(4 \, \text{N} \cdot \text{m}) \left( 19.05 \, \text{mm} \right)^4}{20651.03 \, \text{mm}^4} \, \text{in} \]
\[ = 306 \, \text{N} \cdot \text{mm}^2 \]

\[ T_{\text{max}} = 306 \, \text{N} \cdot \text{mm} \]
Composite Friction Force

Given:
- Dimensions: Width = 30 in, Thickness = 5 in, Length = 40 in

Find:
- Minimum force to push a board
- Area of the board
- Which friction factor is better

Solution:

\[ A = b \times h \times w \]
\[ A = (35 \text{ in})(40 \text{ in})(0.5 \text{ in}) \]
\[ A = 70 \text{ in}^2 \]

Friction:
- Steel Friction Factor = 0.7
- Rubber Friction Factor = 1.1

FBD:
\[ \tau \]
\[ F_{\text{Push}} = 2 \text{ lb}(15\text{ in}) + 2 \text{ lb}(23\text{ in}) - F_A(3\text{ in}) \]
\[ F_A(3\text{ in}) = \frac{30 \text{ lbs}}{3\text{ in}} \]
\[ F_A(3\text{ in}) = 10 \text{ lbs/in} \]
\[ F_A(3\text{ in}) = 20 \text{ lbs} \]

Area = 70 in²
Given:
The strings must be of appropriate size as well as have proper breaking within 1 second.

\[ \text{n} = 600 \text{ RPM} \]

Part 1:
Required deceleration at 1 second

Breaking Torque

Solution:

\[
\begin{array}{c}
\text{Length 1} = 6^\circ \\
\text{Diameter 1} = 1.5^\circ \\
\text{Length 2} = 2" \\
\text{Diameter 2} = 1.74" \\
\text{Length 3} = 2" \\
\text{Diameter 3} = .74" \\
\end{array}
\]

\[
\begin{array}{l}
\text{Mass} = \pi \text{r}^2 \text{(Density)} \\
\text{m}_1 = \pi (1.75)^2 \left( \frac{256}{180} \text{ kg/m}^3 \right) = 1248 \text{ lbs} \\
\text{m}_2 = \pi \left( \frac{1.37}{2} \right)^2 \left( \frac{285}{1000} \text{ lbs/in}^3 \right) = 1220 \text{ lbs} \\
\text{Inertia} = \frac{m_1 \cdot (60)}{2} = \frac{1248 \cdot 30}{2} = 5244 \text{ lb-in}^2 \\
\text{Inertia} = 9.552 \text{ lb-in}^2 \\
\text{Work} = 2 \pi \text{in} \cdot \text{lb} = \frac{2 \pi \text{in}}{60} \\
\text{WJ} = 52.44 \text{ ft-lb/s} \\
\text{Required Deceleration} \quad \alpha = \frac{WJ}{J} = \frac{52.44}{9.552} \text{ rad/s}^2 \\
\alpha = 5.5 \text{ rad/s}^2 \\
\text{Breaking Torque} \quad T = I \alpha = 9.552 \text{ lb-in}^2 \cdot 5.5 \text{ rad/s}^2 \\
T = 53.4 \text{ lb-in}
Friction Force

Given:
- Steel Friction Coefficient = \( \mu_s \)
- Rubber Friction Coefficient = \( \mu_r \)

Find:
Which of both materials has a better Friction Force (higher).

Solution:
\[
\begin{align*}
\text{Steel Friction Force} &= \mu_s \cdot F_r \\
\text{Rubber Friction Force} &= \mu_r \cdot F_r
\end{align*}
\]

Density Rubber = 0.2288 lb/in^3
\( \rho = \frac{m}{V} \) with \( m = 10 \) lb
\( V = 30 \) in^3

Nose Steel Shaft = 2.568 lb

Nose Rubber Tire:
\( m = \pi r^2 h \) with \( m = 0.0564 \) lb
\( h = 0.25 \) in

\( F_s = \mu_s \cdot F_r \) and \( F_r = \frac{1}{2} \cdot \frac{m g}{V} \)

\[
F_s = \mu_s \cdot \frac{1}{2} \cdot \frac{m g}{V} = 172.52 \text{ lb}
\]

\( F_r = \frac{1}{2} \cdot \frac{m g}{V} = 100.71 \text{ lb} \)
Given: 200 lb Load on a 2.5" by 4" plate.
Find: The load on the main portion to the base plate. V and M Diagram
Solution:
\[ F = 200 \text{lb} \]
\[ \text{F.E.D.} \]
\[ A_1 \]
\[ A_2 \]
\[ \beta_1 \]
\[ \beta_2 \]
\[ ZA_1 = 0 = -9000 + \beta_1 \times 3 \]
\[ \beta_1 = \frac{5000 - 3 \beta_2}{3} \]
\[ \beta_2 = 385.7 \text{lb/in} \]
\[ ZF_1 = A_1 - 9000 + 385.7 \]
\[ A_1 = 5412.8 \text{lb/in} \]
\[ ZF_x = 0 = A_1 = 0 \text{lb/in} \]

\[ M \]
\[ 3085 \text{lb/in} \]
Base Deflection Analysis

Given:

\[ \begin{align*}
A & \quad \text{12 in} \\
C & \quad 6 \text{ in} \\
E & \quad 8 \text{ in}
\end{align*} \]

Find: Deflection at C.

Solution:

\[ E = 200 \times 10^9 \]

\[ I = \frac{bh^3}{12} = \frac{(14)(6)^3}{12} \]

\[ I = .49 \]

\[ Y_b = \frac{P L^2}{8 (12) E I} \]

\[ = -\frac{(2000)(12)^2}{(12)(14)(6)^2(0.49)} \]

\[ Y_b = \text{Ymax} = -1.207 \times 10^{-5} \text{ in} \]
12. Continued
Reduced of Creepation
\[ \frac{c_y}{r} = \frac{b}{\sqrt{E}} = \frac{144}{172} \]
\[ c_y = 12.4 \text{ in} \]

Inertia
\[ c_y = \sqrt{I_y/A} \]
\[ I_y = G_y^{\text{el}} \]
\[ = (12.4)^2 \left( \frac{1}{12} \right) \]
\[ I_y = 1.5 \times 10^{-6} \text{ in}^4 \]

Slenderness Ratio
\[ \frac{h}{r} = \frac{h^{\text{el}}}{r^{\text{el}}} = 1.16 \]

Critical Load on Column
\[ P_c = \frac{\pi^2 EI}{k^2} \]
\[ = \frac{4.41 \times (29.7 \times 10^6) (540,346)}{141^2} \]
\[ P_c = 3.73 \times 10^6 \text{ lb} \]

Critical Load
\[ P_{\text{critical}} = \frac{P_c}{N} = \frac{3.73 \times 10^6}{3} \]
\[ = 1.28 \times 10^6 \text{ lb} \]
Appendix B – Drawings

1.
Appendix C – Parts List

<table>
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<tr>
<th>Item ID</th>
<th>Item Description</th>
<th>Function in Assembly</th>
<th>Item Source</th>
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<th>Model/SN</th>
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<th>Quantity</th>
<th>Cost Subtotals ($)</th>
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<td>1 in. Steel Plate 7x14</td>
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<td>A36 Steel Plate</td>
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<td>1/4 Steel Plate (Top) 6x14</td>
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<td>1/4 Steel Plate (Bottom) 6x14</td>
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<td>Shafts</td>
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<td>3/4” x 2” Heavy Hex Bolts 20 PKG</td>
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<td>1/4”-20 x 2” Alum Cap Screw 25 PKG</td>
<td>Side Wall Screws</td>
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Total List $ 517.66 $ 422.83

Appendix D – Budget

- Base Plate - $79.38
- 2 Side Walls - $194.64
- Top Plate - $20.12
- 1 Shaft - $19.98
- 3 Inner Shafts - Taken From Above (1 Shaft)
- 3 Outer Shaft Sleeves - Taken From Above (1 Shaft)
- 6 Pins - To be Found
- 6 Springs - To be Found
- 6 Big Hex Screws - Hardware Store
- 8 Small Hex Screws - Hardware Store

The JCATI Foundation provided funds to make this project possible, all in which, the assigned team will meet the given amount.
## Appendix E - Schedule

### SCHEDULE FOR SENIOR PROJECT
**PROJECT TITLE:** Composite Recycling "Frame"
**Principal Investigator:** Alfonso Olivera

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<td>Discussion</td>
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<td>Drawings</td>
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<td>Inner Shafts and Shaft Sleeves</td>
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<td>Buy Part Top Plate</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5f</td>
<td>Machine Top Plate</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5g</td>
<td>Buy Steel Cylinder</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5h</td>
<td>Cut Appropriate Dimension Lengths (6 cuts)</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5i</td>
<td>Machine Shafts/Sleeves</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>subtotal</strong></td>
<td>19</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

### Device Construction

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Est. (hrs)</th>
<th>Actual (hrs)</th>
<th>%Comp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6a</td>
<td>Assemble Walls With Shafts</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6b</td>
<td>Assemble Shaft Guide</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6c</td>
<td>Assemble Shaft Guides</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6d</td>
<td>Assemble Top Plate</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6e</td>
<td>Assemble Guards</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>subtotal</strong></td>
<td>11</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

### Device Evaluation

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Est. (hrs)</th>
<th>Actual (hrs)</th>
<th>%Comp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7a</td>
<td>List Parameters</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>7b</td>
<td>Design Test</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>7c</td>
<td>Test 2: Existing Spring Force for Slippage</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>7d</td>
<td>Test 3: Existing Spring Rate (Original)</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>7e</td>
<td>Test 4: Which Springs Best Fit</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>subtotal</strong></td>
<td>33</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

### H&S Deliverables

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Est. (hrs)</th>
<th>Actual (hrs)</th>
<th>%Comp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8a</td>
<td>Lab Report Guide</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8b</td>
<td>Make Rep Outline</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>8c</td>
<td>Initial Report</td>
<td>6</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>8d</td>
<td>Make Slide Outline</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>8e</td>
<td>Create Presentation</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>8f</td>
<td>Update Website</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>subtotal</strong></td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

**Total Est. Hours=** 157
**Total Actual Hrs=** 272

**Labor Costs: $100.00**
**$15,700.00**
**$27,200.00**

**Note:** Deliverables:
- Draft Proposal
- Analysis
- Document
- Final Proposal
- Part Construction
- Device Construct
- Device Evaluation
- H&S Deliverables
5/8/2019. For the Testing Schedule, all the tests that were planned for originally were done and documented. Recently, some stronger springs were ordered and put onto the Composite Recycler and testing has been continued to be worked on so that the cutter doesn't grab ahold of the composite material and make it slip through the shafts. The springs orders had forces of 100 pounds, 60 pounds, and 50 pounds. The 100 pound springs were inserted in the beginning (first shafts), the 50 pounds were inserted in the second set of shafts, and the 60 pound springs were inserted for the last shafts. What is predicted to happen is that there is no slippage with the composite material whatsoever.

Appendix F – Expertise & Resources

- Professor Dr. Johnson, Craig. Mechanical Engineering Technology Coordinator.
- Professor Pringle, Charles. Mechanical Engineering Technology Professor.
- Professor Dr. Choi, John. Mechanical Engineering Technology Professor.
- Professor Bramble, Ted. Mechanical Engineering Technology Professor.
- Professor Burvee, Matt. Mechanical Engineering Technology Professor.
- Solid Works 2018
- Machine Shop at CWU Engineering Tech. Building
- Google
- McMasterCarr.com
- JCATI SPONSOR
- Boeing Company
Appendix G – Testing Data

Tests were created and done. These tests helped figure out what the resistance was on the existing springs, what force will be needed to keep material from slipping, and finding the spring rate on the existing springs.

**Spring Gauge Test: Dual Gauge Pulling Down**

In this test, two spring gauges were used to replace the springs located on the spring pins. Composite material was then inserted. Both gauges were then pulled downward while the material was being pulled out until a force was acquired that didn’t let the material slip. Then the values were recorded.

<table>
<thead>
<tr>
<th>Spring Gage Replace Test: Dual Gage Pulling Down</th>
<th>Pounds (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>34.0</td>
</tr>
<tr>
<td>Trial 2</td>
<td>33.0</td>
</tr>
<tr>
<td>Trial 3</td>
<td>35.0</td>
</tr>
<tr>
<td>Average</td>
<td>34.0</td>
</tr>
</tbody>
</table>

**Existing Spring Rate**

In this test a single spring gauge was used. A hole was drilled at the end of the composite material. The spring gauge was then attached. The material was inserted through all 3 rollers. Then the gauge was pulled and the resistance was recorded when slipped.

<table>
<thead>
<tr>
<th>Resistance with Current Springs: Pull Horizontally</th>
<th>Pounds (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>35.0</td>
</tr>
<tr>
<td>Trial 2</td>
<td>31.5</td>
</tr>
<tr>
<td>Trial 3</td>
<td>32.5</td>
</tr>
<tr>
<td>Average</td>
<td>33.0</td>
</tr>
</tbody>
</table>
Spring Rate

In this test the compression tester was used. The springs were stacked on top of each other as they are on the frame. Then the springs were compressed at three different lengths and the pound-forces was recorded. Then the spring rate was calculated.

<table>
<thead>
<tr>
<th>Spring Rate: Existing Springs Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force (lbf)</td>
</tr>
<tr>
<td>K1</td>
</tr>
<tr>
<td>K2</td>
</tr>
<tr>
<td>K3</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>

Which Springs Best Fit

In this test, different springs with different spring rates were ordered. They were attached to the Composite Recycler and a pulling test was done with the composite material and the spring gauge.

<table>
<thead>
<tr>
<th>Springs: Which Springs Best Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slippage (lbs)</td>
</tr>
<tr>
<td>Spring Rate (lbf/in)</td>
</tr>
<tr>
<td>Trial 1</td>
</tr>
<tr>
<td>Trial 2</td>
</tr>
<tr>
<td>Trial 3</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>

Appendix H – Evaluation Sheet

AVAILABLE UNTIL SPRING QUARTER 2019
Appendix I – Testing Report

Spring Force

Testing Method: (Introduction)

In this testing procedure, the spring force will be tested on the Composite Recycler. The springs are located on the spring pins that are attached to the shaft guide, which have the shafts attached to them, allowing the shafts to move up and down on the material when in contact, while putting force on the material. The springs should have enough force to put down on the materials so that the cutter won’t pull the composites through, but will instead be controlled. In order to test for this, gauges will be used to see what force of springs will be needed for no slippage, the gauge will be put at an end of the composite to see at what force the springs slips, and multiple springs with different compression forces will be ordered and put on the spring pins and will be ran with composites to test the pull the cutter will have on the material being fed into the recycler. The sheet metal guards will have been put up to provide safety for users.

Requirements:

- The 1/4” thick material must be able to go through the frame body in between the shafts with the spring rate constant increasing the gripping force on the composite boards.
- It must grip the material to increase the material going through to 1.5-2.5 inches.
- The Springs must give enough force so that the cutter doesn’t rip out the composites being fed into the Recycler.

Parameter of Interest:

The material will roughly be 1/4” thick after delamination process and will take around 5 minutes to complete one trial run of testing.

Predicted Performance:

The spring pressure, feed, and delamination process will work together to have a good outcome.

Data acquisition:

As the feed is running, the spring pressure is holding onto the material, and delamination ramming down on the material it is important to listen to the sound inside the frame body. Bad noise will indicate something went wrong. Making sure the material does not move out of place. Also, it is important to see how the composites get pulled into the machine and if slippage occurs, to note it and apply springs with more spring pressure.

Schedule:

Testing this plan will take an approximate 15 minutes.
Method/Approach:

Approach:
- Acquire different pairs of springs with different compression forces.
- Apply pair onto Recycler.
- Feed composite material.
- Observe how the material gets pulled in comparison to what the handle is being turned.
- Decide which spring forces show best control over feed.
- Acquire spring gauges.
- Use drill to drill hole in composites.
- Create data sheets to insert values gathered

Test Procedures:

Test 1: Required Spring Force for no Slippage.
1. Detach top plate.
2. Remove springs.
3. Use two spring gauges and place them where springs would go.
4. Insert composite material.
5. Push down on spring gauges while person is attempting to pull out the material and figure the force needed and produced on the spring.
6. Repeat steps 3-5 two more times.

Test 2: Existing Spring Resistance
7. Acquire new composite material.
8. Drill hole towards the end of the composite material.
9. Attach spring gage to end where hole is located.
10. Insert material through all 3 rollers.
11. Pull on the material until slipping starts.
12. Record the pounds.
13. Repeat steps 1-6 two more times.

Test 3: Existing Spring Rate (Original)
4. Take springs off Recycler
5. Put springs stacked on compression tester
6. Acquire 3 compression lengths with pound-force
7. Calculate spring rate using spring rate equation.

Test 4: Which Springs Best Fit
8. Get multiple pairs of springs with different compressions.
9. Detach the top plate.
10. Place first pair of springs on spring pins.
11. Bolt down the top plate.
12. Turn on Recycler.
13. Feed material into Recycler.
14. Record observations, time, and distance material moved.
15. Repeat Steps 2-7 with different pair of springs.
16. Decide which springs work the best while having no slippage of the materials.
Deliverables:

Test 1:

<table>
<thead>
<tr>
<th>Spring Gage Replace Test: Dual Gage Pulling Down</th>
<th>Pounds (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>34.0</td>
</tr>
<tr>
<td>Trial 2</td>
<td>33.0</td>
</tr>
<tr>
<td>Trial 3</td>
<td>35.0</td>
</tr>
<tr>
<td>Average</td>
<td>34.0</td>
</tr>
</tbody>
</table>

Test 2:

<table>
<thead>
<tr>
<th>Resistance with Current Springs: Pull Horizontally</th>
<th>Pounds (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>35.0</td>
</tr>
<tr>
<td>Trial 2</td>
<td>31.5</td>
</tr>
<tr>
<td>Trial 3</td>
<td>32.5</td>
</tr>
<tr>
<td>Average</td>
<td>33.0</td>
</tr>
</tbody>
</table>

Test 3:

<table>
<thead>
<tr>
<th>Spring Rate: Existing Springs Calculation</th>
<th>Force (lbf)</th>
<th>Lenth (in)</th>
<th>Spring Rate (lbf/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1</td>
<td>2.26</td>
<td>0.25</td>
<td>9.04</td>
</tr>
<tr>
<td>K2</td>
<td>3.93</td>
<td>0.50</td>
<td>7.86</td>
</tr>
<tr>
<td>K3</td>
<td>5.12</td>
<td>0.65</td>
<td>7.88</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>8.26</td>
</tr>
</tbody>
</table>

Test 4:

<table>
<thead>
<tr>
<th>Springs: Which Springs Best Fit</th>
<th>Slippage (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring Rate (lbf/in)</td>
<td>Original: 8.26</td>
</tr>
<tr>
<td>Trial 1</td>
<td>35</td>
</tr>
<tr>
<td>Trial 2</td>
<td>31.5</td>
</tr>
<tr>
<td>Trial 3</td>
<td>32.5</td>
</tr>
<tr>
<td>Average</td>
<td>33</td>
</tr>
</tbody>
</table>

Gantt Chart:
Spring Analysis:

<table>
<thead>
<tr>
<th></th>
<th>Force (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>Original</td>
</tr>
<tr>
<td>Spring Rate (lbf/in)</td>
<td>8.26</td>
</tr>
<tr>
<td>Single Spring Rate</td>
<td>2.81</td>
</tr>
<tr>
<td>One Section (2 Springs)</td>
<td>5.62</td>
</tr>
<tr>
<td>2 Sections (4 Springs)</td>
<td>11.23</td>
</tr>
<tr>
<td>All Sections (All Springs)</td>
<td>16.85</td>
</tr>
<tr>
<td>Average</td>
<td>9.13</td>
</tr>
</tbody>
</table>

Figure: Composite being fed into Recycler.

Conclusion:

The point of this test procedure was to improve the spring rate. The composite board needs more pressure and force. The feed should not slip or move when as easily when being pulled. It will need to withstand the pull force of the cutter. There was a higher force slippage with the higher compressed springs, so those will be left on the Composite Recycler.
# Appendix J – Job Hazard / Safety

## JOB HAZARD ANALYSIS
### Composite Feeding

<table>
<thead>
<tr>
<th>Location of Task:</th>
<th>Front of the machine, opening where the composites are fed into.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Equipment / Training for Task:</td>
<td>Hand protection due to handling material that can damage hands if not wearing appropriate gear, Eye protection in case of flying fragments, and appropriate clothing to not get caught in the machine. Documentation of Training before actual use of Machine.</td>
</tr>
<tr>
<td>Reference Materials as appropriate:</td>
<td>Machine Manual</td>
</tr>
</tbody>
</table>

### Personal Protective Equipment (PPE) Required

(Check the box for required PPE and list any additional specific PPE to be used in "Controls" section)

<table>
<thead>
<tr>
<th>Gloves</th>
<th>Dust Mask</th>
<th>Eye Protection</th>
<th>Welding Mask</th>
<th>Appropriate Footwear</th>
<th>Hearing Protection</th>
<th>Protective Clothing</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use of any respiratory protective device beyond a filtering facepiece respirator (dust mask) is voluntary by the user.

<table>
<thead>
<tr>
<th>PICTURES (if applicable)</th>
<th>TASK DESCRIPTION</th>
<th>HAZARDS</th>
<th>CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inserting Composites in Machine</td>
<td>Entanglement</td>
<td>Plastic guard to limit the closeness of hands to the machine.</td>
</tr>
<tr>
<td></td>
<td>Inserting Composites in Machine</td>
<td>Flying Fragments</td>
<td>Plastic guard to cover open areas to prevent flying fragments from reaching the operator.</td>
</tr>
<tr>
<td></td>
<td>Chopping/Shredding</td>
<td>Carbon Fiber Dust</td>
<td>Wear PPE</td>
</tr>
</tbody>
</table>
Appendix K – Resume / Vita

Alfonso Olivera
30 Hard Rock Rd. / P.O. Box 314
Covinche, WA 98923
(509) 388-8742, ALFONSI50210@hotmail.com

Education
Central Washington University: Ellensburg, WA
Major – B.S. Mechanical Engineering Technology Graduation 6/2019

Experience

• Engineering Intern/Assistant
  - Performed projects to help test efficiency of machinery.
  - Assume leadership role in projects.
  - Cherrv line production run data analyses to pinpoint and fix the problems.
  - Evaluated cherrv optical sizer and collaborated with Production and Quality Departments
  - Created 3-D Modeling of controlled atmosphere storage rooms to optimize capacity.
  - Presented to ownership and senior management ideas for investment in automation.
  - Harvest analyses to support the planning of harvest and storage plans.
  - Team member to support a Food Safety crisis management event.

• Training Coordinator
  Cowiche Grower’s Inc., P.O. Box 36, Cowiche, WA 98923 (2015-2018).
  - Responsible for training new employees who get delegated to my area.
  - Assume leadership role in the absence of Supervisors.
  - Ensure pace of line is consistent with optimal efficiency of available laborers.

• Boeing / The Joint Center for Aerospace Technology Innovation (JCATI)
  Mechanical Engineer. Designing, developing, and manufacturing a new composite recycler.
  - Served on a team of four to make the creation of the Composite Recycler possible.
  - In charge of the Frame portion of the project.
  - Used SolidWorks and CAD/CAM to create the frame model as well as analyze teammates parts
    put together to avoid error.
  - The Recycler delaminated carbon fiber as well as cut the composite material into pieces that would
    then be melted to separate the resin to recycle.

• Peer Mentor
  - Helped incoming freshmen feel welcomed and introduced them to the University.
  - Guided them through problems they had and lead them to the right places.
  - Helped them get involved with the community by attending events to help them meet new people.

Volunteer Experience

• Assisted in the clean-up of Saint Juan Diego Parish property leading to the landscaping that my volunteer
  group managed.
• Participated in a volunteer service at Highland High School to help with an AAU basketball tournament.
• Volunteered at the Ellensburg Goodwill.

Special Skills

• SolidWorks
• AutoCAD
• Bilingual – Fluent in both English and Spanish.
• Work well under pressure and achieving deadlines.
• Enjoy leading teams as well as working with them to achieve a common goal.

• CAD/CAM Trained
• CNC Trained
• Adapte at working on multiple projects at once.