The Bracket

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The Bracket

Ryan Skerbeck
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Abstract

- Bracket, casting, aluminum; if any of these for mentioned words interest you in anyway this is a document that you should read.
- There is a need for a compressor to be mounted to the front of a Cummins engine so that compressed air would be available on a work truck. The York compressor and the engine were known quantities, so what this project covered was the bracket that mounted the compressor to the engine and the manufacturing processes. The process chosen to make the bracket was aluminum casting; casting was chosen because of the ease of making many parts very quickly.
- The testing of the finished part consisted of testing the weight and strength of the completed bracket. Another aspect of testing was the analysis of the casting process of the two parts. The program SolidCast was used to predict the flow path of the aluminum. During the process using SolidCast it was found that extreme corners of the part would freeze before the aluminum was done flowing. Through this testing we were able to optimize the flow path of the aluminum to make sure that the casting was successful.
- The part was successfully produced and was reproduced consistently.
Introduction

Description

The product being designed and produced is a bracket to mount a York air compressor to the front of a Cummins engine for a 1991 Dodge W250 pickup.

Motivation

The need has been expressed for a compressed air system to be available for use by mobile technicians completing repair in the field for a system to supply compressed air away from a shop. In the past the only available solutions were either electric or small gasoline engine powered compressors that are either under powered in the case of electric, or overly bulky and complex in the case of the gasoline. This product will provide an alternative method for those looking to add an air compressor system to their vehicles.

Function Statements

The part being cast will provide a sturdy mounting surface on the front of a Cummins 6BT engine for a York air compressor to be

Requirements

These are the requirements that must be met by this bracket.

- Weigh less than 10lbs
- Support up to 15lb
- No more deflection then .250”
- Successful aluminum casting process

Engineering merit

The engineering merit for this project comes from the engineering concepts learned from the CWU MET program. This being project especially focuses on the foundry experience learned in the casting processes class offered in the spring.

Scope

This project focuses on the design and produced of the bracket that will interface between the engine and the compressor, and no other part of the system. The rest of the system varies between different vehicles so it is up to the end user to finish the system.
**Success Criteria**

The success of this product will be determined if the product meets these criteria.

- The compressor is mounted to the engine in a way that the drive belt will interface with the engine correctly.
- The bracket is strong enough to hold the weight of the compressor and the tension of the belt without breaking.

**Success scenario**

The project will be a successful if the above criteria are met. The compressor mounts to the engine successfully aligned the compressor with the belt drive system of the engine, and the bracket can support the weight of the compressor.

**Design and Analysis**

**Design**

The design of this part comes from my experience working as a mechanic and from the skills that have learned taking the foundry Spring of 2018. The design is based on a match plate casting method partly to make production of the part in the foundry here at Central Washington University easier and to make the design more simple.

The most important perimeter that this part is being designed to support the weight of compressor unit itself. The compressor weighs in at 12lbs and it extends past the mounting farthest mounting point by 2.5 inches. To keep the weight down a c-channel design was used to optimize between weight and strength but still be a simple to cast design.

When taking into consideration the sand-casting process the part needs to be designed with a draft. The draft is to allow the pattern to be pulled from the sand without damaging the imprint left in the sand. The minimum draft should be used in green sand casting is a draft of 1 degree from vertical, and this is the draft that was chosen for the design of this part. Although a greater draft would make for an easier time working with the pattern in the foundry it would ultimately make for more time required in the machine shop. When the draft is increased the size of the part is increased to keep the minimum measurements the same. Although there is ample amounts of space in the engine bay of the truck this part will be installed in, that may not be the case in other installations.

**Performance Prediction**

The performance predictions for this project are that part will withstand the weight of the compressor and that it will align the belt drives system on the front of the engine. The part has been designed in such a way that makes it easy manufacture so that many can be produced quickly.
Analyses

For the analysis portion of this project one of the parts that was focused on was the production of the part in the Central Washington University Foundry. The smooth production of this part is important to the success of this project as one of the main facets of the design of this part was to make it easy to produce. Beginning with the calculated weight of the part, which can be found in Appendix A2, it was found that the final weight the part after casting and before machining would be 3.35lb. With the 3.35lb calculation, the number of pours could be calculate with the number of parts that could be made with one pour. The optimum production outcome is to pour all of the parts at one time, the plan is to produce six parts (4 for install and 2 for testing) and with the use of the 30lb crucible it should be possible to do it all in one pour. The gating and runners were predicted to weigh in at about 1.5lb; with that weight added to the 3.35lb and multiplied by six and it comes out to 29.1lb. If there are no mistakes or accidents with the pour should be able to cast all six parts at one time.

Another aspect that is an important analysis in this project is the shrinkage of the part itself after the pour due to the cooling and solidifying of the aluminum. In researching this it was found that the average shrink rate of aluminum is 6% by volume. From this it was possible to take the volume calculated in Solid Works of 33.47 cubic inches, and multiply it by 1.06 to find the needed volume to compensate for the shrinkage, this can be found in appendix A4. With the number calculated (35.47 cubic inches) it was possible to then increase the size of the pattern model to reflect that volume therefore insuring that the final cast part will be the correct size once casting is complete and the part has completely cooled.

During the second quarter of senior project the design was changed from a one piece part to a two piece part. A major goal of the redesign was keeping the volume of the part the same as the so that the original calculations for the volume and production numbers of the part would remain the same as last quarter.

The loading calculation were calculated for the parts to be tested separately for ease of testing. Since both of the parts are well supported by the engine and compressor only the very ends of the parts are subjected to unsupported loads. Two different jigs will be constructed to support the ends of the parts and then the parts will be subjected to loading until failure.

Also analyzed was the flow pattern for the casting using solid cast. The matchplate was drawn up and used to make as a pattern to model the flow. The flow was shown to create a few cold spot and that it could be optimized through further drawing and testing.
Methods and Construction

Construction

The pattern for this part will be made up of two 3D printed sections. This will be dependent on if printing is outsourced to a commercial printer or if the printing is done here at Central Washington University. If the pattern is printed At Central Washington University the bed is too small, as well as the z axis is to shallow, for the part to be fully printed in one piece on the printers. The gating will be built using wood dowels cut down to size and affixed to the match plate with the pattern by glue.

Once the pattern is finished the green sand foundry will be used to cast the part. The production goal for this project is six parts. Two parts will be for testing and the other 4 will be for demonstration and use.

The finished casting will then be brought to the Central Washington University machine shop to have the mounting holes drilled through the bracket. After the mounting holes are drilled the inner draft will need to be milled to achieve a flat matting surface for the mounting points to the engine.

The simplest part of this project will be the machining of the spacer used for the second mounting bolt. McMaster Carr Spacer stock will be drilled and turned down on the lathe to the measurements needed for the appropriate spacing between the alternator mount and the part.

Method

The original design of the part was for it to be a one piece part for ease of manufacture. The issue with that design was that at the CWU foundry doesn’t have any flasks that are deeper than four inches on either side. With the original part depth being greater than seven inches, it was impossible to for the casting to be one piece without modifying one of the facilities flasks. Luckily the original design of this part is lends itself perfectly to being split into two pieces. The two new parts, the upper and the lower, were designed to mimic the original design in basic dimensions and volume so that the shrinkage and volume calculation could remain the same as the previous design.
For the construction of the part the first step was to design and print the enlarged parts for the construction of the match plate. The 3d printer could not print by size of the parts so they needed to be printed in sections and then glued together. Once the pieces were glued together the parts they were attached to the matchplate material that was supplied by to me by Matt Burvee. The parts were attached with two part epoxy with screws as back up to make sure that the parts would not stick to the sand and pull off of the matchplate when being removed. The next step was attaching the gating to the matchplate, it was attached with exclusively with two part epoxy as they did not have enough surface area to have very much pull on the gating as the matchplate is lifted. Once the matchplate was finished the part was cast in the foundry with the help of Nathan Saure and Chris Berry. The part was then machined in the CWU machine shop so that the two pieces could be assembled and attached to the engine and the compressor. There were four holes drilled through the upper portion of the bracket, two for mounting it to the engine and two for connecting the two brackets together. The lower part of the bracket had eight holes drilled into it, four were for the mounting of the compressor, and the other two correspond with the two on the top bracket for connection the two pieces together.

**Testing**

The testing for this part will take place during Spring quarter 2019. For this project the testing will consist of applying loading to the part in similar ways that it will experience under the hood of a vehicle. The goal will be to simulate the loading that the part will experience with the compressor mounted to it, as well as testing to failure to see how much load the bracket can support if it used to support a heavier object in the future. This will be done in the Central Washington University materials lab using the Instron machine with the help of Dr. Johnson and Matt Burvee.

The testing of aluminum flow took place in the office of Hogue 127 using the computer that has the SolidCast program. The total time this testing took was 8 hours. The reason for the testing taking so long is that it is a trial and error process of designing gating and then improving the gating until the flow reaches all corners of the part; as well as if the program works or not. The program has proven to be difficult to work with, although it may simply be the older computer it is on. The information given by the program when it works is very informational, and has helped greatly in the design of the gating system. Once the gating has been modeled on the computer, those files are transferred unto SolidCast. Once in SolidCast the program will show areas of concern on in the casting. From there the gating can be made and added to the matchplate. The use of solid cast has save a lard amount of time that would have been spent in the foundry with trial and error the runner and gating system. The other test that the part will be subjected to is the weighing of the part. The goal for the parts was for the weight to come in under ten pounds. The weighing of the part will be completed in the materials lab.
Testing of the weight was completed in the foundry using the scale on the western wall counter top. The requirement for this testing was for the part to weigh in at less than 10lbs. Both of the part revisions only weight 5.2lbs there for passing the test and fulfilling the requirement.

The testing of the strength of the part was conducted at home in the garage. The bracket was mounted to the front of the truck with the compressor removed and then weight was added to the bracket. The weight was added in 50lb increments until at 250lb the bracket failed. The failure was due to the bolts pulling out where the two pieces of the bracket are affixed together. Both of these things were a surprise, the predicted failure value was slightly over 50lbs for the updated design, and it was predicted that the part would fail just behind the front mounting bolt.

The last testing of the parts will be the fitment of the parts on the vehicle itself. It would be ideal to test the fitment of the part on the truck in the fluke lab. The reasoning behind testing fitment in the fluke lab is that it would be a great place to get film of the insulation of the part and of the part incorporation. Unfortunately the fluke lab was not available for the part to be installed in the building so like the strength testing this was completed at home in the garage. The first design failed the install test as it required modification of the alternator, but the revised design passed and fit perfectly.

**Budget**

The original budget for this project started out at around one thousand dollars. This was an over estimate but from what has been learned on past projects it is always a good idea to air on the side of the project overrunning the budget and have money set aside in case that occurred. As the quarters progressed it came to be that the project was coming in under budget. The most expensive part of this project was the compressor the bracket is designed to mount to the front of the engine. Originally five six hundred dollars was budgeted for this part, but through the help of the people at Off Road Only the compressor was acquired for five hundred dollars with the pulley needed to drive the unit. This saved over one hundred dollars as the pulley was originally not budgeted for. The pulley oversite is a good example of why it is a good idea when taking on a project like this one to budget more than you initially plan to spend.

Another place where money was saved was in the 3D printing. It was originally budgeted to cost around one hundered dollars, but through the help of one of the MET students the printing was completed for twenty dollars.

Throughout the year the budget for this has remained within the constraints. In fact it has remained far below the projected cost. This quarter has only accrues one more cost and that was twenty dollars spent on more filament to re print the redesigned parts for a second casting.
Originally it was thought that the aluminum would have to be bought but in the end it was supplied by Bob Gilmore from Romac industries. This saved a large sum of money and improved the quality of the end product. Also James Mcpherson donated his time in printing all of the parts for the matchplate saving the money.

**Schedule**

The deadline for this project is the end of spring quarter 2019, as this will be the end of MET489 and the end of the class’s time at Central Washington University. As the project is spread out over a long period of time, it is easy to lose track of what needs to be done and when it needs to be done by. For this reason, students were asked to employ a Gantt chart to schedule the allotted time and help with task completion. Most of the work that was supposed to be completed thus far has been done in the last few weeks of the quarter, but next quarter scheduling will improve and the project will get back on track.

Winter quarter was the manufacturing quarter, so the quarter was spent acquiring parts and assembling the project. Much of the scheduled manufacturing time was allotted for parts acquisitions, acquiring the compressor proved to be very difficult. No used compressors could be sourced locally, so multiple compressor manufacturers were contacted to supply a new compressor. All together the acquisition of parts took around 10 hours on the phone with different manufactures and searching the internet. The match plate was constructed over three days in here at the CWU wood shop, with the help of Dr. Johnson and Matt Burvee. As projected the casting and machining of the part went quickly as planned. The part of the project that took the most time compared to what was allotted was the construction of the website. As much of the class has never done any website construction it was difficult to predict the amount of time that would be consumed by this exercise. In total five hours was recorded improving the website from last quarter but more time was spent working on it in the last week before it was due.

Thus far in the testing quarter the schedule has been upheld without deviation. Testing has gone to plan except for a hiccup with the video footage being unusable. With the testing completed the focus has now shifted to preparing for the Source presentation. The part is being recast this week which is necessary to have a part to show at Source. The casting taking place this week is slightly later than anticipated but the printing of the revised design took longer than originally scheduled for. After Source more brackets will be produced to insure that there are extra parts in case the bracket fails in the future.
Discussion

The project over the course of the last three months had a few twists and turns, but in the end the design came together well. At the start of the project the part being designed was for a different vehicle. The difference in the design was that instead of the bracket having a horizontal mounting style at the engine, the bracket mounted to both the engine and the compressor vertically. This provided many design challenges around how the part would be cast. Before that part was abandoned a horizontal parting line match plate had been designed, but it was going to be a very heavy and large piece. In the end what ended up happening was the engine that the part was being designed for was sold along with the truck that it was in. This left the project up in the air as to whether or not it would be finished and shelved for later use if another engine was to come available to mock the part up on.

After working on finding another engine for a week, the search was called off and the design was scrapped. It was decided the make a new design around a more popular engine that would have more sales potential in the future. The best choice was the Cummins 6bt engine, not only because of its wide use in over the road vehicles but also because one is on hand for mock up purposes and measurement taking. Once this engine was selected the redesign commenced. This engine offered an easier mounting solution that allowed the compressor to be mounted on the upper side of the engine where installation would be much easier.

One of the issues that has been encountered in the manufacture of these parts is that the parts themselves. The print bed of the printer is only six by six inches but in reality the printer can only print precisely within a five by five inch window. Because the largest part is six by seven inches so the part had to be split into four parts. Since the part was printed as four parts it needed to be glued together and so it was a little more work was required to assemble the match plate. Although it created more work splitting the parts up, it was worth it as printing on the six by six printer to save money.

Once the part was fully cast it was possible to assess the surface finish and see how much finishing was required on the finished product. Luckily the casting came out very well and minimal machining was required to finish the part for assembly. The last face of the lower piece was faced so that it would have a smoother mating surface with the upper piece. Once the facing was finished the holes for the coprocessor mounting could be drilled as well as the holes for the mounting to the upper bracket. When the holes were drilled and the bracket was to be mounted it was found that the holes on the upper and lower bracket were miss aligned and one or the other would need to be slotted. So the lower plate was slotted to make the holes align and the slots were enlarged so that the bracket could have a little more adjustment to make it easier to align the pulleys when installed on the engine. In the end the product was very easy to machine because the part the casting process went so well. If the surface finish had come out worse it would have required more machining.
One of the problems encountered when testing was the amount of time that was spent using the program SolidCast. The program is slow and fails to produce images more than half of the time. Along with the program being slow, every time the program shows problems with the design, the gating system must be redrawn and the process restarted. Testing was later streamlined by making the gating system modular, meaning that the parts could be copied and added on to each other to increase or decrease the area of gating depending on what was needed in a certain section. Once that change was made the testing time was cut in half.

At the end of spring quarter the CWU foundry was closed due to chemical exposure. This was due to the melting of brass pluming that was coated in zinc during the annual pattern swap. When the aluminum was heated the zinc melted at a lower point and flashed off causing zinc oxide smoke to be dispersed into the air. Zinc oxide when inhaled is very dangerous and can lead to death in severe cases. It was very unfortunate that this happened because this ended up closing the foundry, making it impossible to produce more parts for later sale.

**Conclusion**

This project hen completed should do exactly as the title states, mount a York style air compressor to the Cummins 6bt engine. The skills learned throughout the time spent here in the Central Washington University Engineering program have been and will continue to be applied to this project over the coming months.

The design was optimized for production efficiency by the way of its match plate design and for minimal material usage with the thin wall C-channel form. The part production in the coming months should go smoothly with the help of Dr. Johnson and Nathan Sauer helping, with the metal pouring.

If a strong mounting bracket and smooth production is achieved this project in be deemed a success.

Looking again from the end of winter quarter this project has been progressing smoothly, and with a working part turned in and ready for testing next quarter is looking good. The production of this project proved to be the best learning experience so far. The casting if the part went off flawlessly as well did the machining. Testing should continue smoothly and the lessons learned from them will help improve the design of this part for later revisions. The source presentations will be and excellent place to showcase the design of this project and the effort that went into creating it.

From the end of spring quarter looking back over the this difficult year, the project was successful and even though the foundry was closed at the end of spring quarter due to a chemical exposure everything was completed and finished before then. If it had stayed open a few more bracket would have been completed which would have been great because they could have been sold to recoup the cost of the project. But having compressed air available on the truck was worth the cost and effort put into this project.
Acknowledgments

Acknowledgment is due to Dr. Craig Johnson, without his help and influence the interest in the foundry industry that has now developed would not exist. Also more thanks is deserved for Dr. Johnson for encouraging me to sign up for the AFS and FEF foundations. These foundations let to a scholarship for this project. Credit is also due to FEF for their extension of the Newman Ward scholarship, it would not have been possible to comfortably afford some of the parts needed for this project without it. Lastly Thanks is due to Matt Burvee for his help with the assembly of the matchplate and his help during the machining of the project.
Appendix A

A1: Forces

\[ \text{G: Comp. weight = 12 lb} \]
- diagram with sketch

\[ F: \text{loading} \quad 12 \text{ lb} \quad 2 \text{ in} \]

\[ S: \quad F \quad 1 \]

\[ M_A = F \cdot 2.98^\circ \]
\[ M_A = 12 \text{ lb} \cdot 2.98^\circ \]
\[ M_A = 33.76 \text{ lb in} \]

\[ 12 \text{ lb} \quad V \]

\[ 0.35 \text{ lb} \]
A2: Weight

\[ W = \text{Volume of part from Solid Works Drawing (Appendix B1)} \times \text{密度} \]
\[ W = 2.397 \text{ in}^3 \times 0.1 \text{ lb/in}^3 \]
\[ W = 0.2397 \text{ lb} \]

This 0.2397 lb is less than the 10 lb minimum weight requirement.
A3: Parts Per Pour

Parts per 30 lb crucible

1. With a goal of 6 parts in total, 4 for use and 2 for testing, how many can be poured at a time with the 30 lb capacity crucible.

6i: crucible capacity = 30 lb
    part weight ≤ 3.35 lb
    gating/riser weight ≤ 1.5 lb

2. 3.35 lb + 1.5 lb = 4.85 lb

30 lb
4.85 lb = 6.18 parts per 30 lb crucible

So if all goes to plan then we should be able to get all 6 parts in one pour.
Shrinkage

G: During the casting process, the part that is being cast shrinks as it cools. For aluminum, the shrinkage is about 6% of its total volume. Our target is 33.47 in³ for the actual volume of the part (Appendix B.1).

F: volume of one shrinkage, up to predict needed volume for pattern.

\[ 33.47 \text{ in}^3 \times 1.06 = F_v \]

\[ \text{final volume} = 35.97 \text{ in}^3 \]

For the part to be the required size after casting, we will need to increase the pattern volume to 35.97 in³.
Casting process time analysis

Gi: From the last two castings that were done in the foundry, we found these numbers to be the average times:

- Prep: 10 min
- Melting alum: 1.5 min
- Pouring: 5 min
- Clean up: 10 min

Ei: Projected casting time

\[ \text{Projected casting time} = 40 \text{ min} \]

This is simply for operation of the furnace. Making the sand molds will be a separate process.
A6: SolidCast Modeling 1

Critical Fraction Solid Time – Minutes
A7: SolidCast Modeling 2

Material Density
A8: SolidCast Modeling 3

FCC Criterion
A9: SolidCast Modeling 4

*Niyama Criterion* -- \(^{\circ}\text{C/cm})/\sqrt{^{\circ}\text{C/min}}\)
Temperature -- °F
A11: SolidCast Modeling 6

Solidification Time -- Minutes
Temperature Gradient -- °C/cm
A14: SolidCast Modeling 9

Liquidus Time -- Minutes
A15: SolidCast Modeling 10

Hot Spot – Solidification Time
A16: SolidCast Modeling 11

Hot Spot – CFS Time
Modulus – in

A17: SolidCast Modeling 12
Appendix B

Drawing Tree

York OBA Compressor Bracket

Top Bracket

Bottom Bracket

Bracket Assembly

Spacer

Top Bracket 3D Print

Lower Bracket 3D Print

Match Plate
B1: Upper Cast Part

- Mount part in parallel like in Fig. 1.
- Drill holes with appropriate drill bit.
- Flip part in use and repeat holes on opposite side.
- Mount in use vertically.
- Drill two 7/16 holes.

Finished Part
Upper Bracket

Ryan Skebeck
B2: Lower Cast Part

PROCESS
1. Mount fixture parallel to vice on bridgeport
2. Use DRO to layout and drill holes

RYAN SKERBECK
Compressor Bracket Lower
B3: Spacer
B4: Upper Cast Part Enlarged for Shrinkage

RYAN SKERBECK

UPPER BRACKET MATCHPLATE

3
B5: Lower Cast Part Enlarged for Shrinkage
**B8: Assembly**

**Table:**

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<th>Part Number</th>
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<td>XXI-1</td>
<td>UPPER BRACKET</td>
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<td>2</td>
<td>XXI-2</td>
<td>LOWER BRACKET</td>
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<td>5</td>
<td>XXI-2</td>
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**Diagram:**

- Engine
- Compressor

**Signature:**

Ryan Sikerbeck
Compressor
Bracket Assembly
B9: 3D Print Upper and Lower
B10: MatchPlate
B11: Parts After Casting
B12: After Machining and Assembled
B13: Installed on Engine
### Appendix C/D

C1: Parts List

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<thead>
<tr>
<th>Item ID</th>
<th>Item source</th>
<th>Brand</th>
<th>Model #</th>
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### Appendix E

#### E1: Gant Chart Screenshot

---

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<th>Actual Duration</th>
<th>% Complete</th>
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Labor:
- 0.1
- 10.7
Appendix F

Appendix F: Expertise and Resources

1. Expertise
   a. Dr. Johnson
   b. Mr. Burvee
   c. James Mcpherson

2. Resources
   a. Machining Lab
   b. Foundry
   c. Computer Lab
## Appendix G

**Testing DATA**

### Weight

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<th>Pass/Fail</th>
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<td>&lt;10lb</td>
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<tr>
<td>B</td>
<td>5.2lb</td>
<td>&lt;10lb</td>
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### Strength

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<td>200lb</td>
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<td>250lb</td>
<td>Fail</td>
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### SolidCast
## Appendix H

### Testing Data Forms

#### Weight

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<th>Pass/Fail</th>
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#### Strength

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<th>Weight</th>
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Appendix I

Testing Report

Introduction

For this project the testing consisted of testing the weight of the competed bracket, testing the weight the bracket can support, the brackets deflection under load, and the flow of the aluminum during the casting process to insure successful casting. The bracket is intended to support a bracket so that is where the strength and deflection requirement comes from. The aluminum flow requirement is based on the necessity of the part to have a successful casting every time the casting instructions are followed correctly.

Method/Test Procedures

The testing procedure that was focused on most heavily for this project was the aluminum flow during the casting process. The testing of this aspect of the project took place in the office of Hogue 127 using the computer that has the SolidCast program. The total time this testing took is 4 hours up to this point but more testing is required. The reason for the testing taking so long is that it is a trial and error process of designing gating and then improving the gating until the flow reaches all corners of the part; as well as if the program works or not. The program has proven to be difficult to work with, although it may simply be the older computer it is on. The information given by the program when it works is very informational, and has helped greatly in the design of the gating system. Once the gating has been modeled on the computer, those files are transferred unto SolidCast. Once in SolidCast the program will show areas of concern on in the casting. From there the gating can be made and added to the matchplate. The use of solid cast has save a lard amount of time that would have been spent in the foundry with trial and error the runner and gating system.

The second test that the bracket was subjected to was destructive strength testing. This was done by mounting the bracket in the truck and then adding weight to the bracket until the part failed. The bracket was designed around supporting a 10lb compressor. When doing the calculations for the strength of the part it was found that the bracket should be able to support a little over 50lbs, but after these numbers were calculated the design was modified resulting in the bracket being strengthened. This resulted in the bracket being able to withstand much more than was previously calculated. The bracket withstood 230lb of weight before failing.

The third test will be the test of the weight of the bracket but the testing cannot be completed until the final design revisions have been completed and constructed.

Deliverables

The finished bracket will need to be able to mount to the truck and support the compressor unit without failing or major deflection.
Appendix J

G1: Furnace Hazzard Analysis Form

JOB HAZARD ANALYSIS
Furnace Operation

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<th>Prepared by:</th>
<th>Reviewed by:</th>
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<tbody>
<tr>
<td>Ryan Skerbeck</td>
<td>Approved by:</td>
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| Location of Task: | CWU Foundry |

| Required Equipment / Training for Task: | Foundry Silvers, Face Shields, Boots |

| Reference Materials as appropriate: | Machine Manual |

---

### Personal Protective Equipment (PPE) Required

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

- Gloves
- Dust Mask
- Eye Protection
- Welding Mask
- Appropriate Footwear
- Hearing Protection
- Protective Clothing

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

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<th>PICTURES (if applicable)</th>
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<th>HAZARDS</th>
<th>CONTROLS</th>
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<td>Burns</td>
<td>Safety glasses, Gloves, Silvers</td>
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<tr>
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<td>Spills</td>
<td>Safety Person</td>
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---
Appendix K

RYAN SKERBECK

207 North Sampson Street, Ellensburg, WA 98926 • Cell: 360/750/511 • skerbeck@cwu.edu

Professional Summary

Mechanical Engineering Technology student at Central Washington University, with an anticipated graduation of Spring 2019. My previous work experience at HF Hauff Co Inc. who specializes in agricultural machinery, taught me skills in all processes of manufacturing: from design to assembly, troubleshooting, and installation of agricultural machinery. In addition, I have two years of professional painting on both residential and commercial properties while working at B.E. Schultheis Painting. Some recent skills I have learned while attending CWU include using manual and CNC milling machines and lathes. In my free time I enjoy restoring automobiles and motorcycles. With my experience and skills, I am seeking a full-time employment in mechanical engineering or mechanical contracting after graduating this coming spring 2019.

Skills

- Strong mechanical and electrical skills
- Forklift operation
- AutoCAD proficient
- Machining
- Geometric dimensioning and tolerancing
- Advanced critical thinking
- Technical problem-solving
- CAM and CAE
- Mechanical component design
- Motivated self-starter
- Organized
- CNC machine operation
- Efficient troubleshooter
- Mechanical drawing interpretation
- Quality control analysis
- Keen manual dexterity
- Engine components, pumps, and fuel systems knowledge

Education

High School Diploma: 2009
Sequim High School - 601 N Sequim Ave, Sequim, WA 98382

Associate of Arts: 2011
Peninsula College - 1502 E Lauridsen Blvd, Port Angeles, WA 98362

Bachelor of Arts: Mechanical Engineering, Current
Central Washington University - 400 E University Way, Ellensburg, WA 98926
Work History

Dental Lab Technician, 06/2008 to 09/2013
Peninsula Dental – 218 S Laurel st, Port Angeles, WA 98362
Performed all forms of dental lab work including, impression preparation, model making, creating wax models of teeth, and gold investment casting.

Painter, 06/2014 to 09/2015
B. E. Schultheis Painting – 11303 S. Stevens Creek Road, Spokane, WA 99223
- Painted surfaces using brushes, spray guns and paint rollers.
- Applied putty, wood filler, spackling and caulks to prep uneven surfaces.
- Applied primer, paints, varnishes and lacquers to walls and surfaces.
- Applied exterior caulking to building joints and seams.
- Minimized disruption of client space and thoroughly cleaned up after the completion of each job.
- Painted indoor areas such as hallways, bathrooms and lobbies.

Production Assembler, 01/2016 to 01/2016
H F Hauff – 2921 Sutherland Road, Yakima, WA 98903
- Planned and pared work efficiently in order to meet daily, weekly, project or production goals.
- Dealt with production hang ups and created work around
- Operated forklift and tractor
- Operated Large metal press
- Spot welded petal hoods
- Worked in the installation of wind machines
- Boom truck experience

Mechanical Engineering Intern, 07/2018 to 09/2018
Angeles Composites Technologies – 2138 W 18th St, Port Angeles, WA 98363, WA
- Read and interpreted blueprints, drawings and sketches.
- Wrote supporting documentation in a professional, clear and error-free manner.
- Created engineering documentation, including manufacturing processes, equipment specifications and change notices.
- Studied the manufacturing processes used by ACTI.
- Performed calculations according to standard procedures.
- Served as liaison between Production and QA.