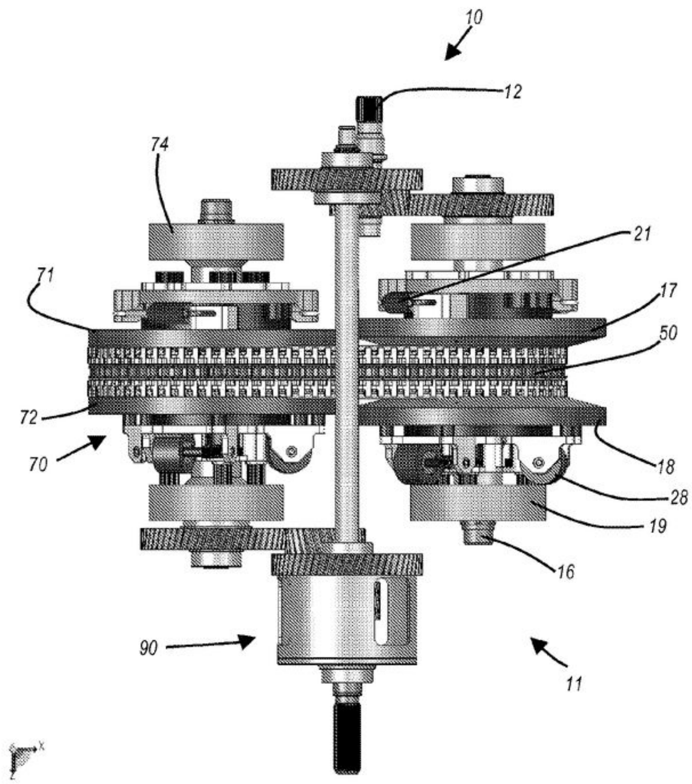
# Manufacturing a Model CVT Transmission




By: Mahnoor Azim

The City College of New York
ME 46200

***Abstract***

One of the most fundamental skills of a successful engineer is to effectively utilize his or her judgment and prior experience when coming up with an innovative design. The design process is used by most if not all types of engineers, and requires extensive knowledge that a good engineer should already possess. For this project, we were given the task of designing any mechanism of our choosing, and to carry out all the necessary steps that were needed in order to successfully manufacture it. Coming up with a design, selecting the materials, using SolidWorks for modeling, manufacturing the parts, and finally assembling them all, were processes carried out as a team in order to make our design a reality. In the following report, we will talk about how we used this procedure to produce a model CVT transmission, and what we learned collectively as a team while we worked together on this project.

*Table of Contents*

***Introduction & Background***

In recent times you may have heard the term CVT transmission when car shopping or in car tv ads and wondered what it was. For years, general knowledge has told us that there are only two types of transmissions: automatic and manual. Technically, this is still true given that CVTs are a type of automatic transmission; however, CVT or Continuously Variable Transmission differs as it changes flawlessly through an infinite range of gear ratios whereas standard automatic transmissions traditionally have a fixed number of gear ratios. The main difference is that automatic transmissions contain a complex series of gears, brakes, clutches, and principal devices. Ordinary or your typical automatics possess a finite amount of gears that are referred to as speeds. For example, you may have heard the term 6-speed automatic. This refers to six gears within the transmission. Each gear is set to only reach a certain vehicle speed; when the driver keeps accelerating, the transmission must shift up through the gears starting with first, second, and so on. In comparison, a CVT produces the most efficient engine speed for each driving situation and is constant even if the vehicle is rapidly accelerating. While there is no comparison in how a CVT operates from the driver's perspective, as in changing gears from Park to Drive, everything else is a bit more complicated. A continuously variable transmission does not have individual gears and instead, has one gear that is variable for all driving conditions. Unlike ordinary automatic transmissions, drivers will not feel the shift from one gear to the next. Instead, drivers will notice a change in engine speed or RPMs, often higher for acceleration and lower for cruising. CVTs are an example of how vehicle manufacturers are improving vehicles from day to day. And while this is a new way of creating power, CVTs have been gaining popularity in recent years.

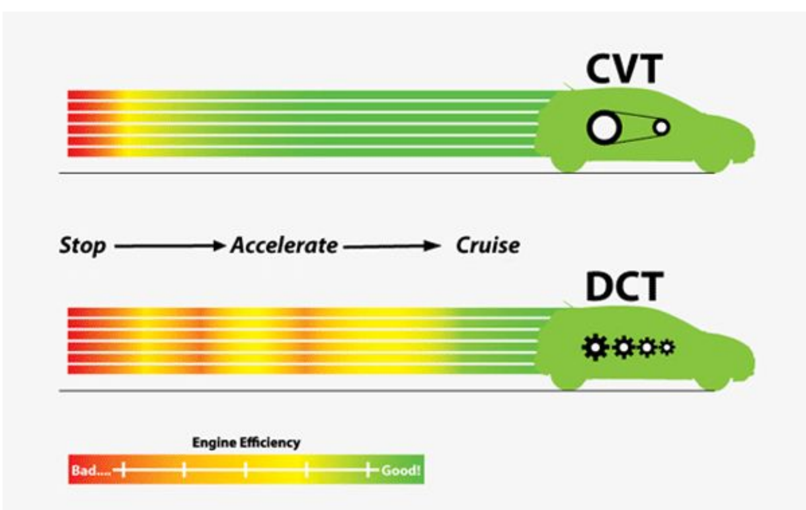



***Fig. 1*** *- A CVT engine uses one set of gears for all speed types as opposed to other engines.*

CVTs possess many microprocessors and sensors, but the hydraulic pressure, spring tension, or centrifugal force used to create the force necessary to adjust two pulleys are the key to enabling this technology. The two pulleys are known as the driving "input" pulley and the driven "output" pulley. The driving pulley is connected to the crankshaft of the engine. The driving pulley may also be referred to as the input pulley because it is where the energy from the engine enters the transmission. The driven pulley is so named because the driving pulley is turning it. Also referred to as the output pulley, it transfers energy to the driveshaft.

A belt rides in a groove between two cones on each pulley. When the two cones of a pulley are far apart, the diameter increases, the belt rides lower in the groove, and the radius of the belt loop moving around the pulley shrinks. The distance between the center of the pulleys and where the belt comes into contact with the groove is called the Pitch Radius. The gear is determined by the ratio of the pitch radius on the driving pulley to the pitch radius on the driven pulley. When one pulley increases its range the other decreases to keep the belt tight. As the pulleys change their radius, together, they create an infinite number of gear ratios ranging from low to high. The diagram for a typical CVT is shown below in Figure 2.

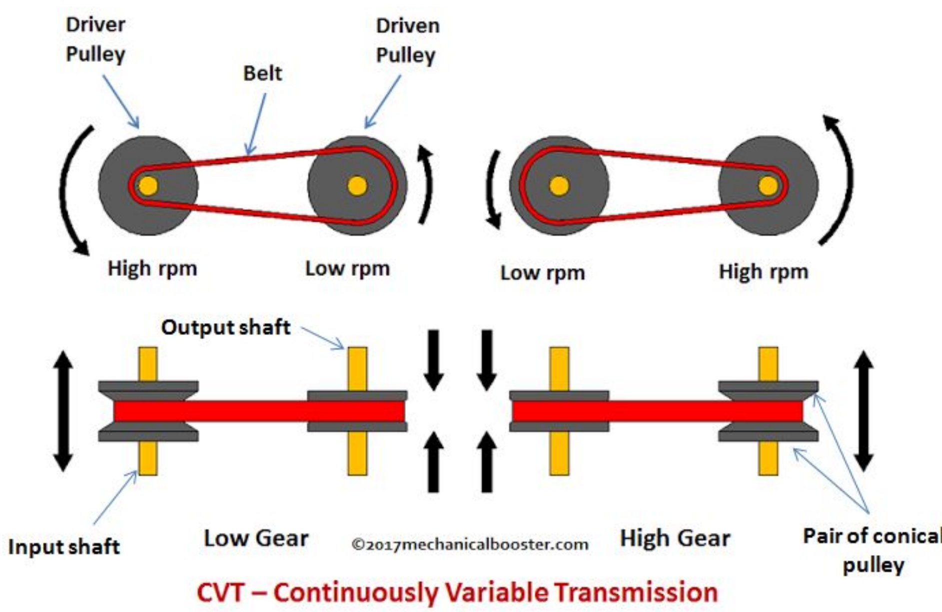



***Fig. 2*** *- Diagram showing how a CVT transmission works.*

## ***Design***

Our project criteria was governed by simplicity of design, which meant making no electronic parts and having a manually operated mechanical system. Other governing factors were practically of manufacturing with the time, cost, material and method we had at our disposal. In approaching the design for our CVT Transmission, it was noted that the main advantage of the CVT was its ability to provide countless varying gear ratios. This is done according to the driving conditions, with a transmission control unit adjusting the width between the cones, allowing the belt to move. The complexity of this pulley cone system was translated into our duel cone system, which can be seen in Figure 3. This system allows the varying diameter of the input and output, while keeping the effective diameter of the belt. We created a guide rail with a housing unit. The housing unit comprised of three bearings, one allowing it to slide along the rails, the other two bearings being connected to rods in order to move the belt without interruption. This housing unit was implemented to act in the place of the transmission control unit that would be present in vehicles. This sliding rail allowed us to manually move the belt simulating the same changes that would occur in a vehicle. In a Vehicular system the CVT transmission would be connected to a motor, while the transmission is used to keep the car in an optimum torque range. This motor would act as the input system that would turn the input cone, turning the belt which turns the opposing cone shown in Figure 2 above. To keep cost within range and keep a simple design, this meant our input power would have to be done manually. Thus we created the Crankshaft and gear system.

***Fig. 3*** *- A model showing the pulley cone system that is used in the CVT.*

This project is meant to simulate a real life application and being engineering students, we must factor in efficiency. An example of this would mean thinking about energy loss which is why the ball bearings were selected to aid in preventing this loss in energy. The bearings were implemented in areas with moving parts such as the housing. If the bearings were not present in the housing unit, we would have a lot of energy lost to friction, being the belt friction against the steel rods, and added friction due to the additional force it would need to slide in the rail. Since the purpose of a ball bearing is to reduce rotational friction and support radial and axial loads, them being present in the steel rods and on the guide rail significantly lowered friction.

The Guide rail was selected under the same pretext of the bearing. The D profile Rotary Shaft was selected over a normal circular shaft as the D profile allowed it to fit better within the gears and maximize the rotational force being transferred to the gears. Acetal Rod was selected for the Cones due to ease of manufacturability via the Lathe, as Acetal does not chip or shred easily as some other plastics do. The size restrictions on Mac Master also led to this being chosen. Our other parts were chosen primarily due to the budgetary restriction of $200 given to this project, with a large amount of the budget being allocated to the bearings and Acetal. This is because they were part of our main components of the project being apart of the cone system. The materials selected can be seen below in Table 1.

***Table 1*** *- A tabulation of the materials that were ordered from Mac Master for the project.*

| Item | Number of Units | Cost |
|---|---|---|
| Plastic Ball Bearing, Trade No. R4A, for 1/4" Shaft Diameter | 4 | $33.84 |
| Acetal Rod, White, 3" Diameter, 1ft | 1 | $35.97 |
| 1.630" Wide Guide Rail for Track Roller 1ft | 1 | $16.83 |
| Track Roller for 1.630" Wide Rail | 1 | - |
| 1/2" Wide Flat Belt 24” | 1 | $16.32 |
| Stainless Steel Ball Bearing, Flanged, Open, Trade Number R188 | 4 | $25.16 |
| Low-Carbon Steel Rod, 1/4” Diameter, 3 ft | 1 | $1.19 |
| Zinc-Plated Steel Corner Bracket, 7/8" x 7/8" x 5/8” | 4 | $1.72 |
| Steel Binding Barrels and Screws, 10-24 Thread Size, for 1/4"-3/8" Material Thickness | 1 | $4.24 |
| D-Profile Rotary Shaft, 1045 Carbon Steel, 1/4" Diameter, 12" Long | 1 | $9.40 |

*Total Cost:* ***$144.67***

***SolidWorks Processes***

*Solid Modeling*

Each significant part of our design was carefully modeled using SolidWorks.

Gears**:**

For both of the two gears, we used the same method to complete the SolidWorks model. The steps carried out to make the gear models are as follows:

1. First we open a new part file.
2. Create a new sketch, choose the top plane.
3. Use Circle to draw three circles that have the same center point.
    a. For big gear: the diameter of outside circle was 3 inches,
    the diameter of the inside circle was 2.5 inches.
    b. For small gear: the diameter of outside circle was 2 inches,
    the diameter of inside circle was 1.5 inches.
    c. Keep the smallest circle for both gear parts with a diameter of 0.25 inches.
4. Using two lines to get a trapezoid, the top base should be on the outside, and the bottom base should be on the inside. One of this means a tool of the gear.

Note: there is a angle of about 25 or 26 degrees between the right side and left side, in which two sides have the same length with 0.26 inches. Also the top base of trapezoid has the same length of 0.1 inches.

5. Use Trim Entities to cut off the outside circle, but keep the top base of trapezoid.
6. Use Circular Sketch Pattern to copy the trapezoid, the center is the center of circle. Choose how many tools are needed for the number of copies.
   For big gear: choose 24 tools.
   For small gear: choose 16 tools.
7. Use Trim Entities to cut off the bottom base for all trapezoids.
8. Use Boss-Extrude to get a solid model. The depth of what we enter will be the thickness of the gears, the selected contours being the face of the gears.

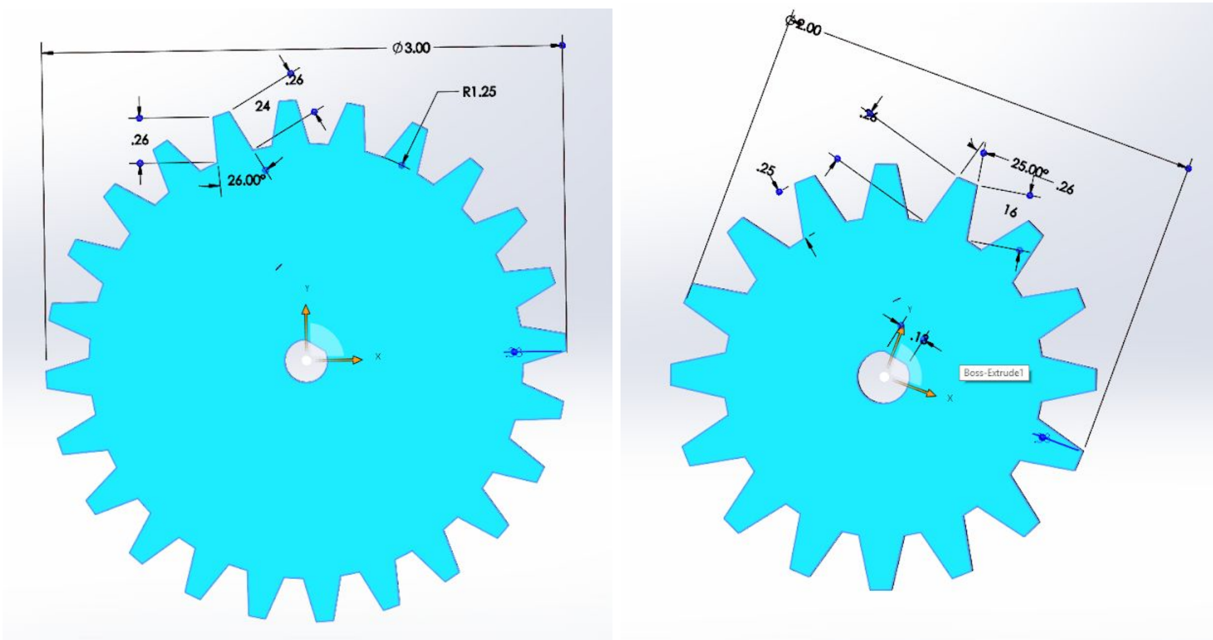



***Fig. 4-5*** *- SolidWorks of the two gears with corresponding dimensions.*

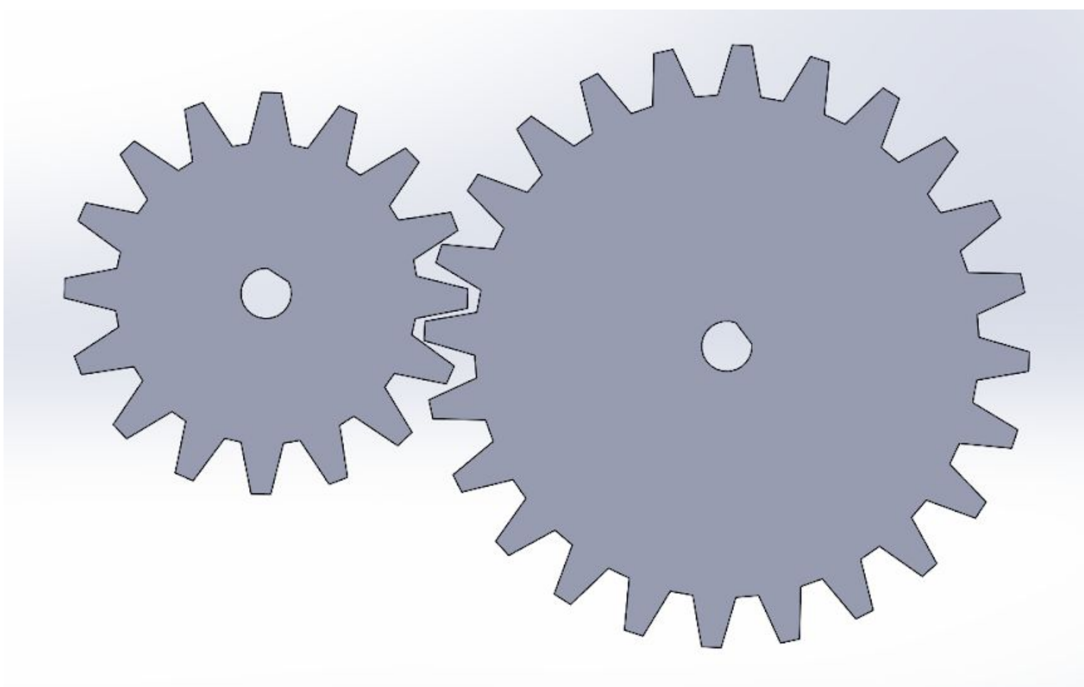


***Fig. 6*** *- The resulting connection of the two finished gear SolidWorks parts.*

*Housing*:

In this case, we needed two of the same housing, so we just needed to create one model. The steps carried out to make the housing model are as follows:

1. Open a new Part file.
2. Create a new Sketch, choose the top plane.
3. Use Center Rectangle to draw a rectangle with 1 inch for width and 2 inches for length.
4. Use Boss-Extrude to get a solid model with 0.38 inches thickness.
5. Create a new Sketch, choose the top plane of the solid model.
6. Use Circle to draw three circles, one being 0.25 inches in diameter, the other two being 0.50 inches in diameter. The small circle is at the center of the top plane of the rectangle. The two big circles stay on either end of the smaller circle. The dimension of the two big circles is 0.50 inches to the lines of the rectangle.
7. Use Cut-Extrude to cut the space of the three circles. Choose the option Through All.
8. Create a new Sketch, choose the top plane of the solid model.
9. Use Center Rectangle to draw a small rectangle.
10. Use Smart Dimension to get the right dimensions for the smaller rectangle. The dimension of width line between the two rectangles should be zero. The dimension of length line between the two rectangles should be 0.1 inches.
11. Use Cut-Extrude to cut the small rectangle space, the depth is 0.5 inches through the solid model.
12. Create a new Sketch, choose the top plane of the solid model again.
13. Use Center Rectangle to draw the same width of the rectangle for the top space of the solid model, the length of this rectangle should be 0.1 inches more for both sides.

Note: This is for using the model in HSM.

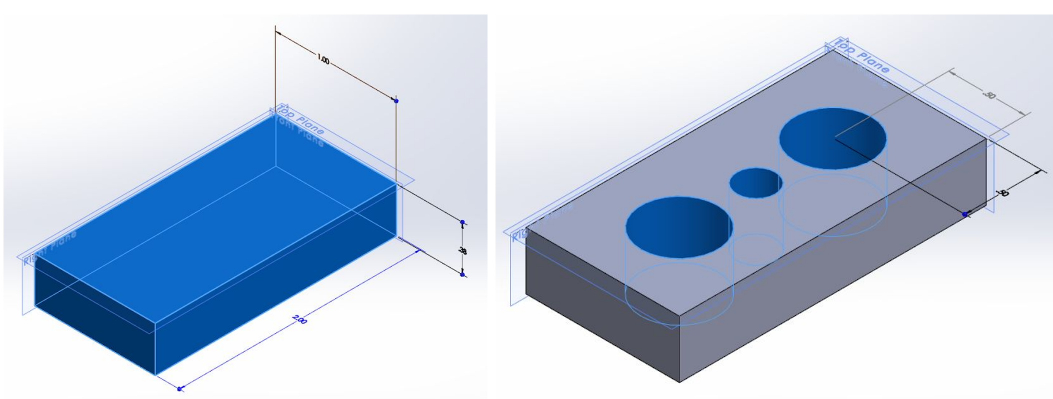


***Fig. 7-8*** *- The general shape of the housing and the resulting piece after the use of the cut-extrude feature.*

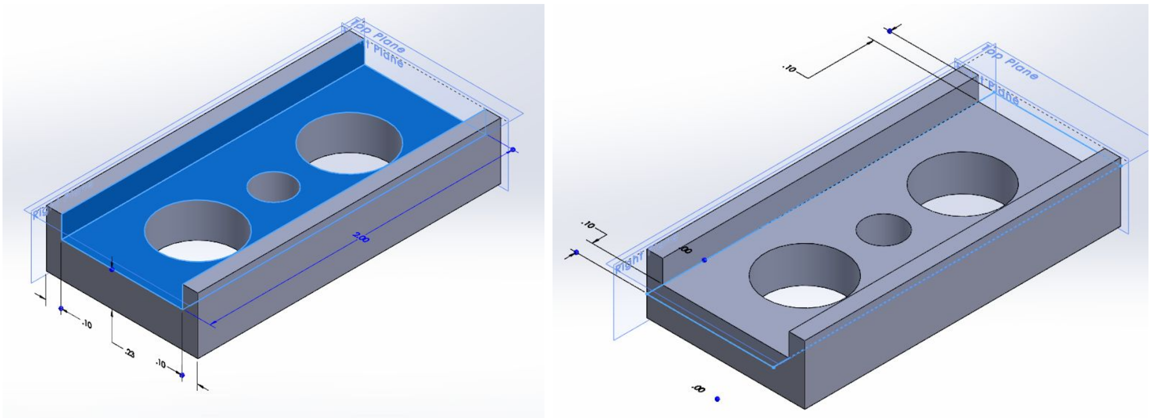


***Fig. 9-10*** *- Extruded bottom of the housing and the final SolidWorks model.*

<u>*Crankshaft Connection*</u>

The steps carried out to make the model of the crankshaft connection are as follows:

1. Open a new Part file.
2. Create a new Sketch, choose the right plane.
3. Use the Straight Slot feature, with the length of the two points being 1.5 inches and the diameter being 0.5 inches.
4. Use Circle to draw two of the same circles, the center is same as the point of above. The diameter is 0.25 inches.
5. Use Boss-Extrude to get the solid model, the thickness being 0.25 inches.

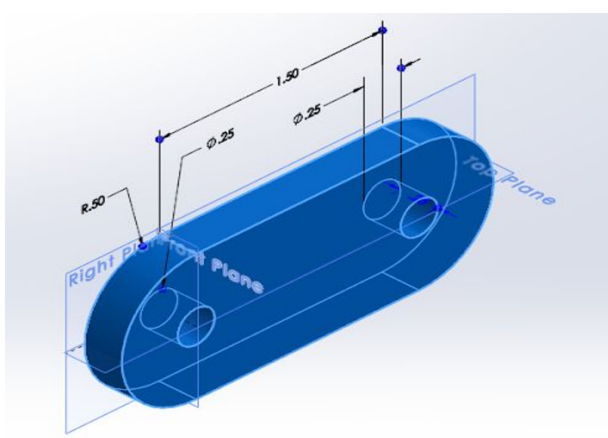



***Fig. 11*** *- The crankshaft connection model in SolidWorks.*

*HSM: High Speed Machining*

## Gears

After the two gears were finally designed in SolidWorks, we started doing the computer-aided manufacturing processes. The big gear, which is about 3.0 inches in diameter, was setup where a new job was created. The Boss-Extrude 1 model was selected where the stock is a “Relative Size Box”. The Work Coordinate System (WCS) was the Top Plane at the left bottom corner.

Next the toolpaths were added from the 2D Milling tab. A 2D Pocket toolpath was selected with a ½” flat tool. This will cut the hollow circle of the gear. The spindle speed was 250 rpm and the cutting feed rate was 40 in/min. The face of the hollowed inner circle was selected. From the heights tab, the top had the setting of “From Stock Top” and the bottom had the setting of “From Contour”. Multiple Depth was set as 0.04 inches and the ramping to plunge. Next another 2D Pocket toolpath was selected with a 3/16” flat tool. This will cut the hole where a shaft will be inserted. The spindle speed was 250 rpm and the cutting feed rate was 40 in/min. The bottom edge of the inner circle was selected. From the heights tab, the top had the setting of a “From Stock Top” and the bottom had the setting of “From Stock Bottom”, where a bottom offset of -0.02” was set. Multiple Depth was set at 0.04 inches and the ramping to plunge.

After that, a 2D Contour toolpath was selected with a 3/16” flat tool. This will manufacture the outer contour of the gear. The spindle speed was 3000 rpm and the cutting feed rate was 40 in/min. The bottom edge of the teeth of the gear was selected. From the heights tab, the top had the setting of a “From Stock Top” and the bottom had the setting of “From Stock Bottom”, where a bottom offset of -0.02” was set. Multiple Depth was set as 0.08 inches. After all the toolpaths had been added, a simulation was run, in which the resulting gear was machined. The result is shown in Figure 12 below.

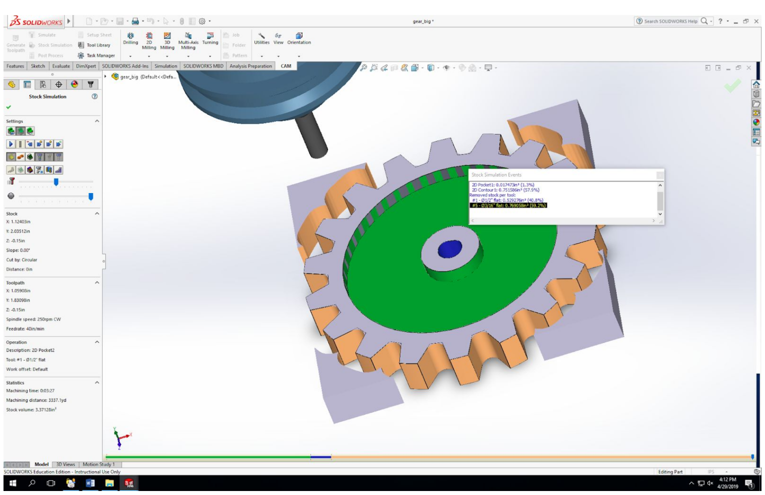


***Fig. 12*** *- Machined 3.0” gear.*

After the 3.0” gear had been machined using CAM, we started doing the computer-aided manufacturing processes of the 2.0” gear. The small gear, which is about 2.0” in diameter was setup where a new job was created. The Boss-Extrude 1 model was selected with the stock having a “Relative Size Box”. The Work Coordinate System (WCS) was the Top Plane at the bottom left corner.

Next the toolpaths were added from the 2D Milling tab. A 2D Contour toolpath was selected with a 1/8” flat tool. This will cut the inner hole of the gear. The spindle speed was 3000 rpm and the cutting feed rate was 40 in/min. The top edge of the hole was selected. From the heights tab, the top had the setting of a “From Stock Top” and the bottom had the setting of “From Stock Bottom”, where a bottom offset of -0.02” was set. Multiple Depth was set to 0.08 inches.

Next another 2D Contour toolpath was selected with a 1/8” flat tool. This will cut the outer profile of the gear. The spindle speed was 3000 rpm and the cutting feed rate was 40 in/min. The bottom edge of the gear was selected. From the heights tab, the top had the setting of a “From Stock Top” and the bottom had the setting of “From Stock Bottom”, where a bottom offset of -0.02” was set. Multiple Depth was set at 0.08 inches. After the toolpaths had been added, a simulation was run, in which the resulting gear was machined. The result is shown in Figure 13.

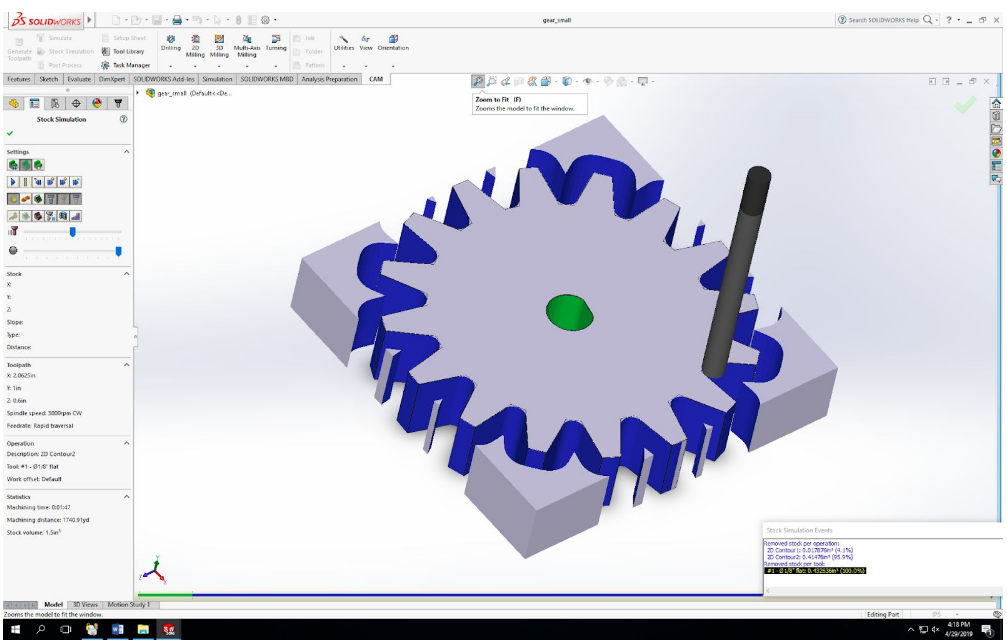


***Fig. 13*** *- Machined 2.0” gear.*

*Housing*

After the 2.0” gear had been machined using the HSM simulation, we started doing the computer-aided manufacturing process of the housing part. The housing, which is about 2.5” in length, 1.0” in width, and 0.38” in height, was setup where a new job was created. The Cut-Extrude 2 model was selected with the stock having a “Relative Size Box”. The Work Coordinate System (WCS) was set using “Use Stock and Orientation” option. The plane that was chosen was 0.38” from the Top Plane. This was done so the tool could be oriented to cut from the top of the part as shown in Figures 14-15.

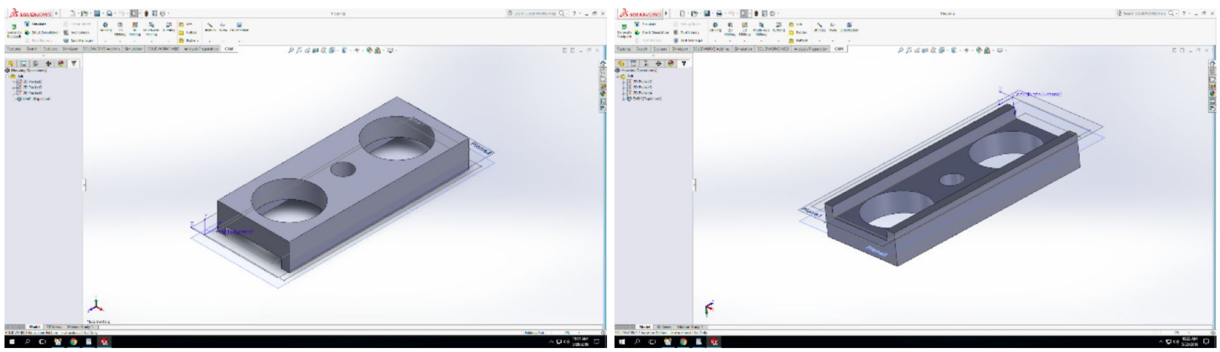


***Fig. 14-15*** *- Housing with original orientation and housing part with new plane and new tool orientation.*

Next the toolpaths were added from the 2D Milling tab. A 2D Pocket toolpath was selected with a 5mm flat tool. This will cut the pocket of the housing. The spindle speed was 3000 rpm and the cutting feed rate was set at 40 in/min. A rectangular sketch was selected as shown in Figure 3. The length of the rectangle was slightly larger than the model so that the tool can completely machine the pocket. The “Tool Orientation” option was selected, because the original isometric view of the housing model was the bottom as shown on the left in Figure 14. Thus, the tool had to be oriented from a new position where the origin selected is the top far-right as shown in Figure 15.  From the heights tab, the top had the setting of “From Stock Top” and the bottom had the setting of “From Contour”. Multiple Depth was set at 0.08 inches.

Next another 2D Pocket toolpath was selected with a 5mm flat tool. This will cut the two large 0.50” diameter holes. The spindle speed was 3000 rpm and the cutting feed rate was 40 in/min. The bottom edges of the two holes were selected. The tool orientation has the same setting as the previous toolpath. From the heights tab, the top had the setting of “From Stock Top” and the bottom had the setting of “From Stock Bottom”, where a bottom offset of -0.02” was set. Multiple Depth was set at 0.08 inches.

Next a Drill toolpath was selected with a ¼” flat tool. This will cut the 0.25” diameter holes. The spindle speed was 3000 rpm and the cutting feed rate was 40 in/min. The face of the hole was selected. The tool orientation has the same setting as the previous toolpath. From the heights tab, the top had the setting of “From Hole Top” and the bottom had the setting of “From Hole Bottom”. The “Drill tip through bottom” was selected to cut the hole on the bottom. Multiple Depth was set at 0.08 inches. After the toolpaths had been added, a simulation was run, in which the resulting housing was machined. The result is shown in Figure 16.

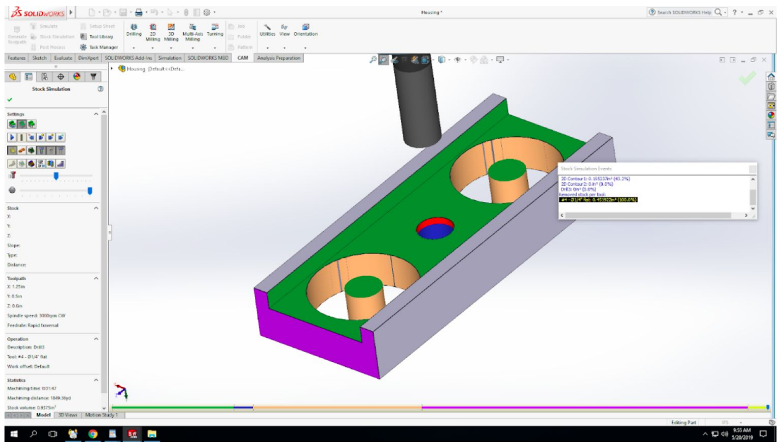


***Fig. 16*** *- Machined housing piece.*

<u>*Crankshaft Connection*</u>

After the housing part had been machined using the HSM simulation, we did the computer-aided manufacturing process for the crankshaft connection. The connection, which is about 2.5” in length, 1.0” in width, and 0.38” in height, was setup where a new job was created. The Boss-Extrude 2 model was selected with the stock having a “Relative Size Box”. The Work Coordinate System (WCS) was set using “Use Stock and Orientation” option. The plane that was chosen was the Top Plane. This was done so the tool could be oriented to cut from the top of the part.

Next the toolpaths were added from the 2D Milling tab. A 2D Contour toolpath was selected with a ¼” flat tool. This will cut the outer profile of the crankshaft. The spindle speed was 3000 rpm and the cutting feed rate was 40 in/min. The bottom edge of the part was chosen. From the heights tab, the top had the setting of “From Stock Top” and the bottom had the setting of “From Stock Bottom”. Bottom offset was set at -0.02 inches.

Next a Drill toolpath was selected with a ¼” flat tool. This will cut the two 0.25” diameter holes. The spindle speed was 3000 rpm and the cutting feed rate was 40 in/min. The bottom edges of the two holes were selected. From the heights tab, the top had the setting of “From Hole Top” and the bottom had the setting of “From Hole Bottom”, where a bottom offset of -0.02” was set. The simulation of the crankshaft is shown in Figure 17.

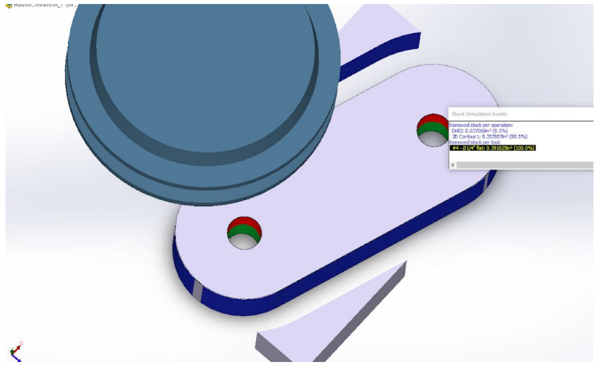


***Fig. 17*** *- Machined crankshaft connection part.*

After all the SolidWorks models had been simulated using the CAM feature, the machine lab technician came over and saw all the parts that were being manufactured. He made the necessary adjustments by inputting the parameters he felt were correct. After he finished this process, he post-processed all the CAM SolidWorks files into G-code. The group then was ready to manufacture the parts using the CNC machine. The lab technician used the G-Code files to CNC machine the parts we needed. Scrap plastic material was used to cut both gears, two housing parts, and a crankshaft connection.

*Assembly*

The assembly of our CVT transmission contains many parts that depend on one another in order for the transmission to run smoothly. Before creating an actual model of our CVT transmission, we decided to create a solid modeling for all the parts we needed and then creating an assembly of all the parts in *SolidWorks*. The purpose of creating an assembly was to get an idea of what the final physical model will look like, as shown below in Figure 18 below.

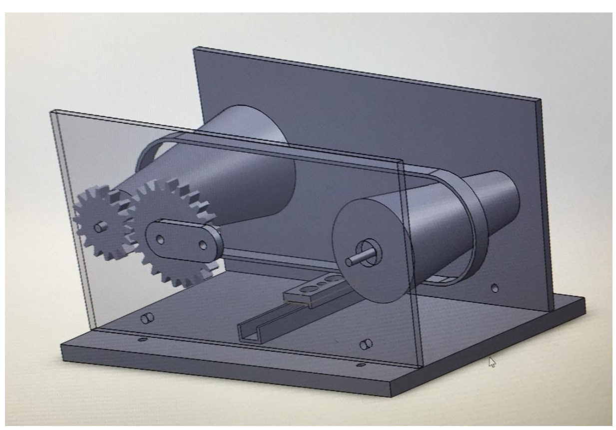


***Fig. 18*** *- The projected assembly of the individual solid models of our parts in SolidWorks.*

***Manufacturing***

The next step in building our model was to properly manufacture all the pieces that were needed. Using the machine shop located in the basement of the Steinman building, we utilized different tools and machinery to carry out the necessary tasks. One important tool that was used was the band saw which allowed us to cut through different material of the pieces that needed cutting. For this project the band saw was used for cutting the steel rods and shafts into smaller pieces, and for cutting the acetal rod in half which can be seen in Figure 19.

***Fig. 19*** *- Band saw being used to cut the acetal rod in half for the cones.*

Another important piece of machinery was the drill press, which was used to make holes into the wall pieces for the screws and bearings. Since the lab technician had previously taught us how to use it, it was one of the easier tasks to accomplish by ourselves in the manufacturing process. The CNC machine was to be used for the actual manufacturing of the parts that could not be produced any other way. The machine technician operated the CNC machine with the HSM files for the part files and made sure that the parts were correctly manufactured. We used this CNC machine to manufacture the crankshaft connection, housing, and gears. The lathe machine was used to machine the halved acetal rods down into a cone shape.

***Fig. 20*** *- The CNC machine that was used to manufacture the HSM parts.*

***Fig. 21-22*** *- The final manufactured gears and housing pieces.*

## ***Final Assembly***

The first step of the assembly was to cut out the base and the walls. For the base and walls we used half an inch of acrylic glass. The dimensions for the base were 12 inches by 12 inches and the dimensions for walls were 12 inches by 6 inches. The base and walls were connected by using four Zinc-Plated Steel Corner Brackets along with a 1/8 inch deep slot on the base, meant for the walls to slide into. These two redundancies were in place since the walls had to withhold the cones and the gear crank system. Then, the 6 inch guide rail was fastened using screws unto the base. The bearings were then glued into their respective ½ inch holes in the housing and placed on the guiding rail. The Steel rods were attached to the two bearings. The acetal resin tube was put in the lathe machine to machine the cones having dimensions of 3 inches in diameter for the larger end and 1.5 inch diameter on the smaller end, at a length of 6 inches each. A drill press was used to place ¼ inch holes, 3 inches deep on both sides of both cones. The steel shaft was glued into each of these holes. We then proceeded to drill holes into the walls for correlating shafts. Then the cones were placed between the two walls with a shaft inserted into the holes. Next, we attached the gears by glueing the shaft into its pre cut hole. After that, we connected a crankshaft to one of the gears to manually move the gear and make the CVT device run.

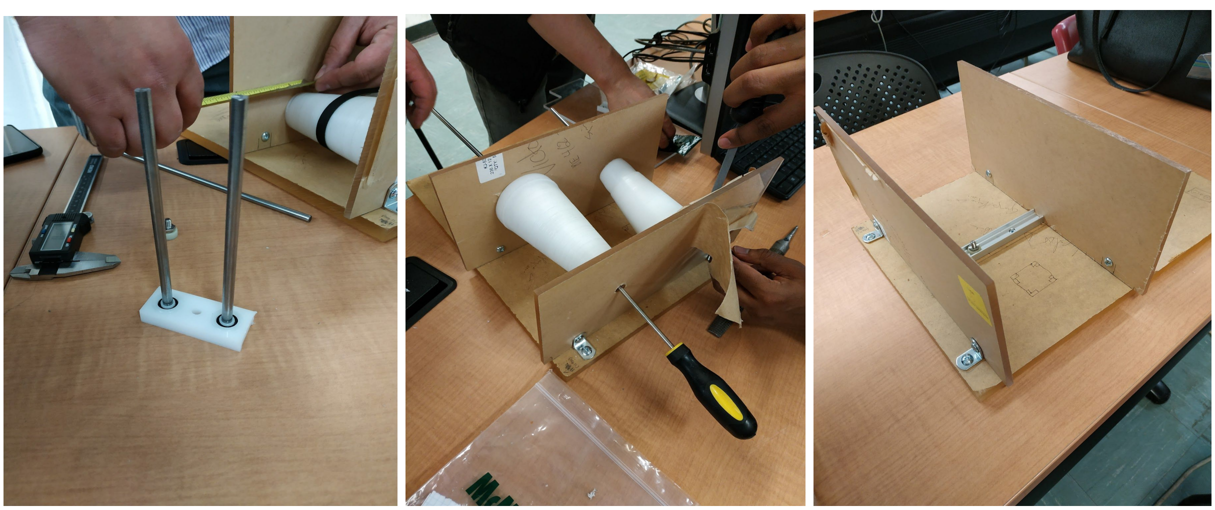
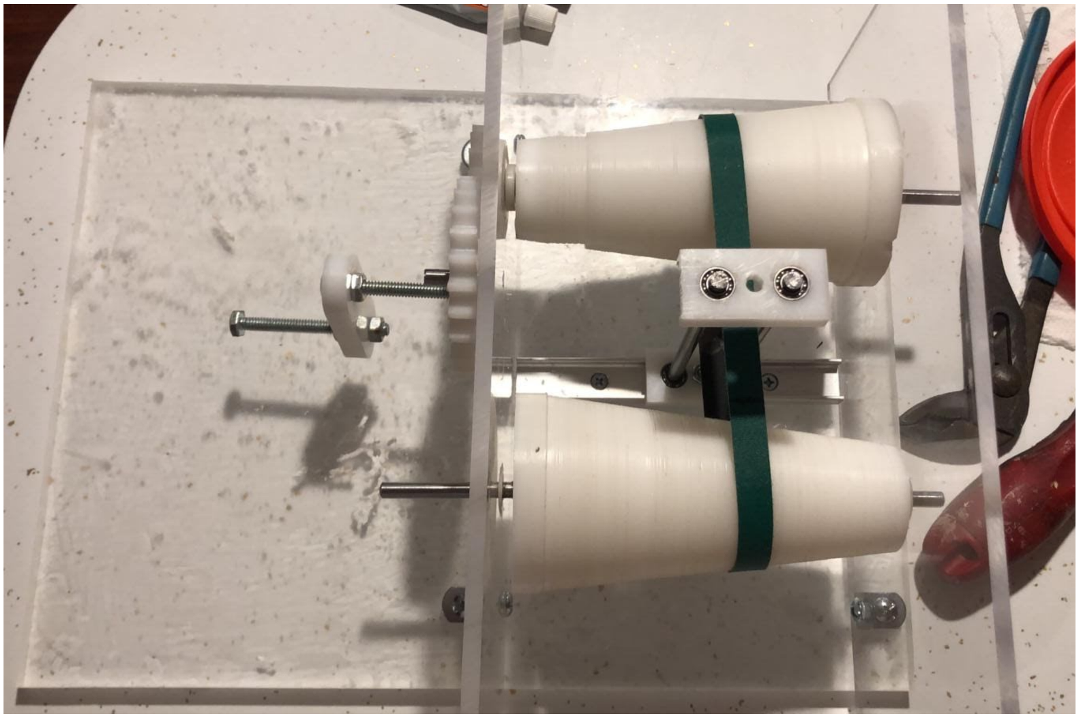


***Fig. 23-25*** *- Rods inserted into the bearings connected to the housing.*



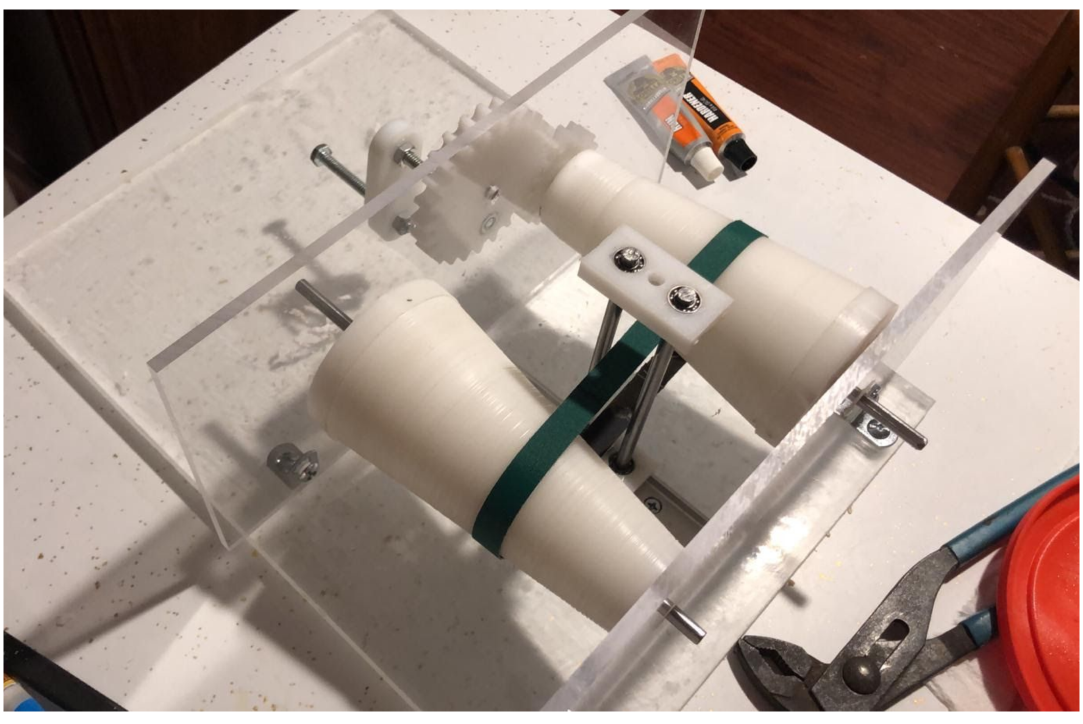


***Fig. 26-27*** *- The manufactured CVT transmission fully assembled.*

***Performance & Results***

Using the Spring 2019 semester to research, design, and manufacture the parts, we were able to successfully to make a model CVT device. When the crankshaft is rotated, the bearings go back and forth in a continuous motion without any interruption. The device works well enough as is manually, however an addition of an electric motor would most probably make the CVT device work at faster rate. The device worked reasonably well given that all the mechanisms worked and it performed as it was designed. Some problems that we had to deal with were that the belt had to be shortened and it slipped a little, and the gears had to be glued to the shaft in order for them to rotate the shaft. The cones were not exactly inverse of each other, and the bearings had to be glued to the walls.

The initial belt we used was slipping because it was too wide and only a part of the belt was in full contact with the cones at any given time. Another reason why it slipped was because the material the cones are made of is very smooth hence not a lot of friction was present in order to create traction. The cones suffered a machining accident where more material was taken from one end of one of the cones. This makes the belt lose tension and slip as well. A round rubber belt also called a “machine belt” would have been a better option since its round design would allow for more surface area contact and friction due to the material, and would therefore result in more traction and less or no belt slipping. The gears had to be glued to the shaft because the material the gears were made out of was too soft and the D pattern hole (for a D-shape shaft) made by the CNC just became a circle and the gear would just slip on the shaft. The bearing had to be glued in part because there are miniscule variations in size from one to the other, and while some would fit by applying pressure, others wouldn’t. The second problem was that the small axial forces weren’t taken into account and in the design the bearing would slip out of place if they weren’t held in place by something stronger than a pressure fit. When designing the sliding/gearing changing mechanism, these forces were accounted for but they didn’t make it after the part was CNC.

***Conclusions***

Before taking this ME 462 course, we all had little to no experience in knowing how to manufacture. Most of us were not familiar with either using the HSM software found in SolidWorks, nor the CNC process. Some members in our group had never even used a band saw or a drill press before. However, once we started to design our CVT transmission and thought about the manufacturing techniques, we were able to become accustomed on how to use each piece of equipment that was available to us. Some of the most important parts of our CVT transmission were the cones and gear manufacturing. We all believe that the simulation of the gear in motion was a vital part in our CVT transmission since it is the part allows the belt rotation in the mechanism to move the cones.

At first when we manufactured the gears, the teeth were not matching. In this case we had to redo them since they were the part that would make the other components in the CVT transmission move. The CVT device that the group manufactured and constructed, successfully works. It runs smoothly and efficiently without any loss. Overall, our project was successful since we were able to manufacture all the parts and put them together in an appropriate manner which resulted in the kind of performance that we were hoping for. This class allowed us to use what we learned in all of our previous classes and to implement that knowledge in our design and fabrication of the model. As a group, we collectively learned that communication was extremely important in projects like this in order to get the work done efficiently, and to be able to finish it by the given deadline. We were able to work well together as a group because of this. Since we all had different strengths, we divided the work based on what we were most comfortable with doing which helped us save time and work cooperatively as a team.

This course gave us an insight on our job expectations in the future. Creating a proposal for our project and getting an approval on it was an example of what will be expected in the work field. We were also given the chance to choose what we wanted to manufacture, as well as selecting materials and originating a design in order to build the model. One of the most important aspects of this project was working in a large group and being able to work well together since engineering heavily promotes the concept of teamwork, and the ability to rely on one another to get a job done. This class gave us a real world engineering experience that not many other courses are able to provide. We want to thank Salih Yildiz for finding the time to help us order the parts so that we could build our project. Also, we to thank Professor Gursel for teaching us on how to use HSM in SolidWorks. Lastly, we want to thank the machine technician for assisting us in manufacturing the CVT device.

***References***


Liberman. (2018, May 02). How does the cvt transmission model work - DIY with cardboard. Retrieved from https://www.youtube.com/watch?v=FsU7pWehw5g.

CVT Explained Retrieved from https://www.youtube.com/watch?v=MhFK5gfAGpM.

Transmision CVT Retrieved from https://www.youtube.com/watch?v=pyYNvwKPAKA.

Srivastava, N., & Haque, I. (2009). A review on belt and chain continuously variable transmissions (CVT): Dynamics and control. Mechanism & Machine Theory, 44(1), 19–41. https://doi-org.ccny-proxy1.libr.ccny.cuny.edu/10.1016/j.mechmachtheory.2008.06.007.

"cvt efficiency" (PDF). zeroshift.com. Archived from the original (PDF) on 14 July 2014. Retrieved 22 April 2014.

Friedrich Pfeiffer. "Mechanical System Dynamics". 2008. Section "CVT - Push Belt Configuration". p. 320.