Project Number: ME-CAB-

Releasable Binding Disc Snowboard Binding Accessory

A Major Qualifying Project Report

Submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

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Degree of Bachelor of Science

in Mechanical Engineering

by

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Approved:

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Abstract

The goal of this project was to design and simulate a test of a releasable binding disc that could be placed in between the snowboard binding and the snowboard. The project would allow riders to disengage their rear foot from the snowboard to allow for easier loading and unloading from the chairlift. This would make it easier for beginners to learn as well as reduce the annoyance of flat stretches. The device was designed using the axiomatic design philosophy. Solidworks was used to create a three dimensional model which was put through stress tests. The Releasable Binding Disc is designed to prevent vertical movment by way of a pair of interlocking rings held in place by tabs which are spaced to allow them to be disengaged. Once the rings are engaged they are rotated to the proper position and locked in places with spring loaded pistons.

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1 Introduction

1.1 Objective

The goal of this project is to design and test, through simulation, a mechanical device that will allow a snow boarder to release their rear foot to allow easier chairlift loading. Another function is the ability to easily release the rear foot which will enable movement on the annoying flats spots which can trap a snowboarder if they do not prepare ahead of time and accumulate enough speed before hand.

1.2 Rationale

This device will allow for easier loading and unloading of chairlifts. It will reduce downtime after getting off from the chairlift as snowboarders will no longer have to sit down to strap into their snowboard bindings anymore. The device takes the best points of both the step in binding system and the traditional strap in binding system. It allows quick connections to the board without stopping, after getting off the chairlift, sitting down and strapping in while still keeping the structural stability and support of more traditional snowboard bindings. As there is no device currently patented or in production that releases a foot from a snowboard only when the user wants without a hand operated manual release, this device will be unique. After discussing the concept with several snowboarders and skiers all were interested in the device as it would save snowboarders time directly and skiers' time waiting for snowboarders.

1.3 State of the Art

There is currently no device patented or in production that the functions for which my device was designed. There is one design (figure below) which is close in that it releases the boot from the board; however this is designed similarly to the ski binding in that it is a safety feature not designed for convenience. It is designed to release when a certain threshold is reached and then it releases just like a normal ski binding. It has a "user adjustable tension release allowing the release of the binding system to free the user from the sliding board" (Furr et al. 2007).

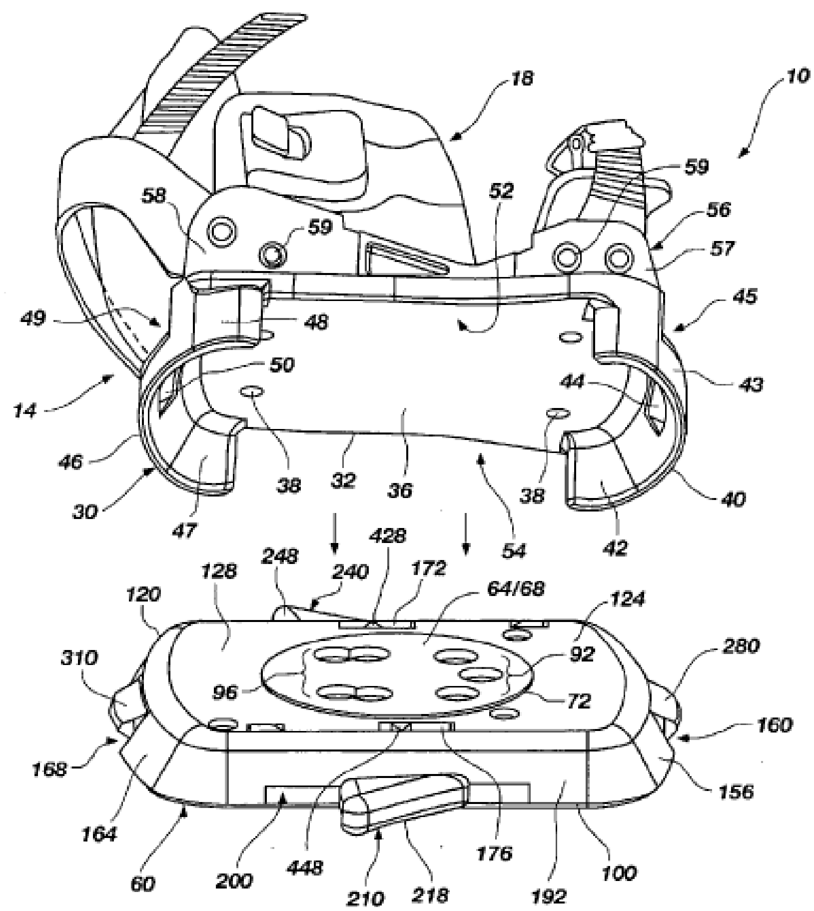

Figure 1 Example 1 Releasable Binding

Another safety release design (figure below) is that of this next design which also features an automatic break if the tension release is triggered.

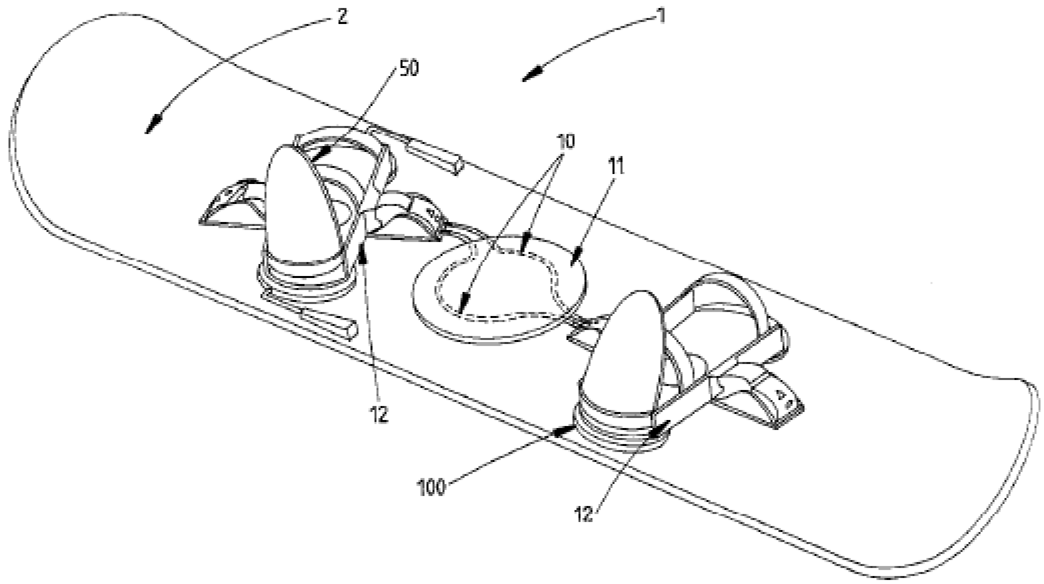

Figure 2 Example 2 Releasable Binding

There are several designs which rotate a foot or are safety release mechanism (for example US patent 7390010, US patent 7384048, US patent number 7270337, US patent 7281717) but there are no devices which have voluntary release mechanisms without a manual release.

The closest I could come to finding anything like my device was clip-less bike pedals designed and produced in the early to mid 1980s. It was designed by Puma and released in Germany and is essentially this device shrunk down to fit onto a hard sole bike shoe. Additionally I used a concept similar to the Cyclebinding pedal system, US patent number 4640151, to secure the device from unwanted rotation. From the Cyclebinding pedal system the ability to prevent rotation until desired was taken which was in the form of spring mounted half spheres matched to corresponding indentions on the actual Releasable Binding Disc to lock it in place.

1.4 Approach

The Releasable Binding Disc and the other releasable snowboarding designs while similar are different in a fundamental way. They are designed to break away at different times for different reasons. The Releasable Binding Disc is designed to release only when the rider wants it to and is released by rotating their foot. The other designs were designed to release when too much force was applied and then they would release as a safety precaution. The methods of release for the binding systems were also quite different. The Releasable Binding Disc rotates then pulls up while both other systems just pull of their base plates thus requiring specific calibration based on the snowboarder's weight and skill level.

1.5 Method

This project was started by coming up with several preliminary designs. Each design was then compared to the critical functional requirements and constraints and examined for incompatibilities. After that each deign was examined for compliance with the constraints and functional requirements each was examined for independence. After determining the designs with maximum independence for their functional requirements the remaining designs were examined for minimum information. Next each design was examined for manufacturability, and it should be noted that if minor corrections to the design would make the design more compatible with the requirements then they were implemented. The remaining design formed the basis of the current design for the Releasable Binding Disc.

After the basic design was chosen the design was compared to the less critical functional requirements for incompatibilities. These incompatibilities, when found, were analyzed and solutions were devised and implemented. After that process was completed it was repeated several more times until no more incompatibilities could be found. Next the individual design parameters were integrated and the design was rendered using Solidworks. It was again checked for incompatibilities with the functional requirements and redesigned to compliance. Next the design was tested with the Cosmos package in Solidworks. The design was tested with several materials but the final material settled on was that of wrought stainless steel. The stainless steel was selected because it was compatible with the designs in that it would not fail under the expected conditions as well as not being able to rust from the wet conditions associated with snowboarding.

2 Design Decomposition

1	FR	Attach boot to board through system	DP	Existing binding
1.1	FR	Attach snowboard binding to system	DP	Middle Connector Plate
1.2	FR	Attach system to board	DP	Base Plate
1.3	FR	Attach Middle Connector Plate to Base Plate	DP	Top Plate

The Releasable Binding Disc is meant to feel and control as if it were not there. The Releasable Binding Disc connects to the board the same way that a regular snowboard binding would in its place and simply bolts down with the same hardware that the snowboard binding would have used. The Releasable Binding Disk is connected to the regular snowboard binding the exact same hardware as would be used to connect the snowboard binding directly to the board.

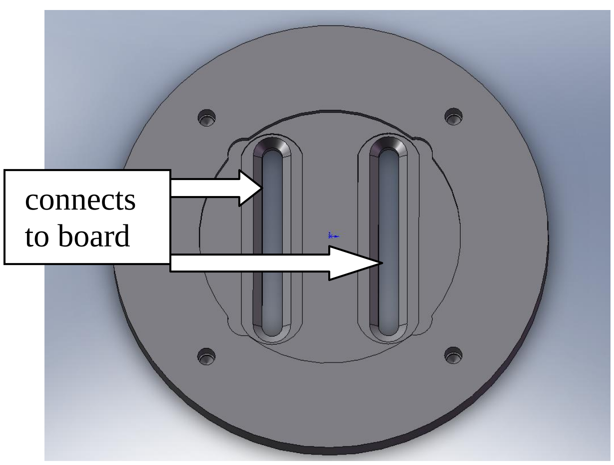

Figure 3 Base Plate connecting to board FR 1.2

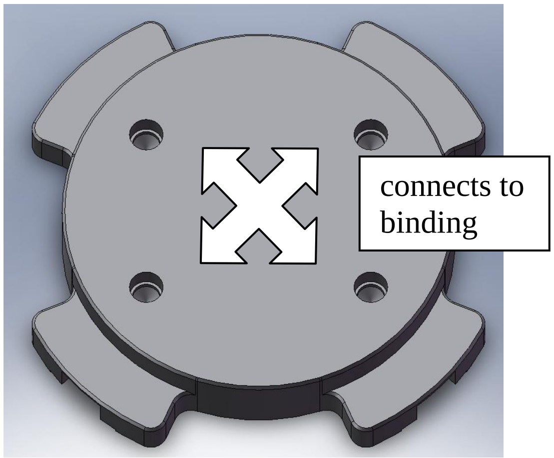

Figure 4 Middle Connector Plate connecting to snowboard binding FR 1.1

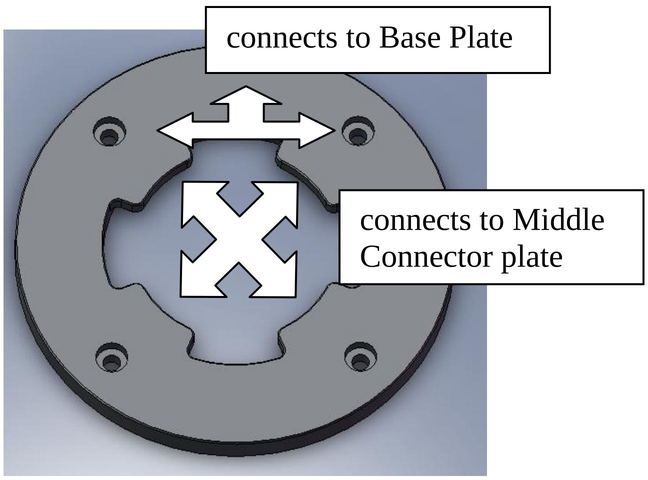

Figure 5 Top Plate connecting to Middle Connector Plate and Base Plate FR 1.3

2	FR	Transfer moments	DP	System that transfers moments
2.1	FR	Transfer My	DP	Metal overhangs in x
2.2	FR	Transfer Mx	DP	Metal overhangs in y

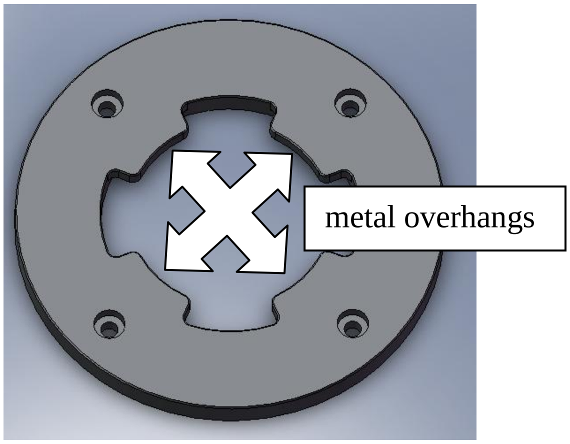

Figure 6 Top Plate overhangs FR 2

The transfer of moments was considered a high priority when designing the Releasable Binding Disc. The mechanism for transferring the moments from the boots to the board can be thought of as starting at the normal snowboard binding then are transferred to the Middle Connector Plate. The moments are transferred from the Middle Connector Plate to the Top Plate which then transfers them to the Base Plate which transfers the moments directly to the board, and thus the board receives the moments from the boots. (The following image is to standardize the coordinate system used throughout the project.)

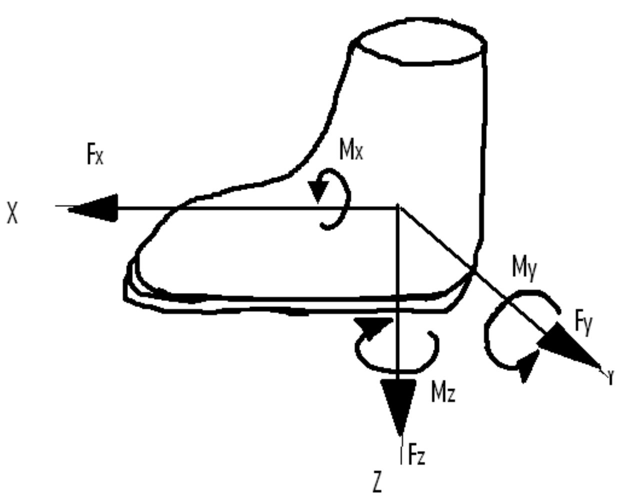

Figure 7 Coordinate System Reference

3	FR	Linkage between board and snowboard binding	DP	Locking device
3.1	FR	Keep the device from rotating	DP	Springs locks device in place
3.2	FR	Releases only when desired	DP	Wafers decrease spring length
3.3	FR	Allow release of Middle Connector Plate	DP	Tolerances allow rotation

The Releasable Binding Disc should be free to rotate when necessary however it should only rotate when it is needed to rotate and should be unable to do so by itself unintentionally. The unintentional rotation is prevented by placing in each wing on the Middle Connector Plate a spring loaded dimple which corresponds to a divot that forms when the Top Plate and the Base Plate are connected. The spring is adjusted through placing fitted wafers in the back of the compartments of the spring loaded dimple to decrease spring length and correspondingly increase the pressure it exerts upon the divot.

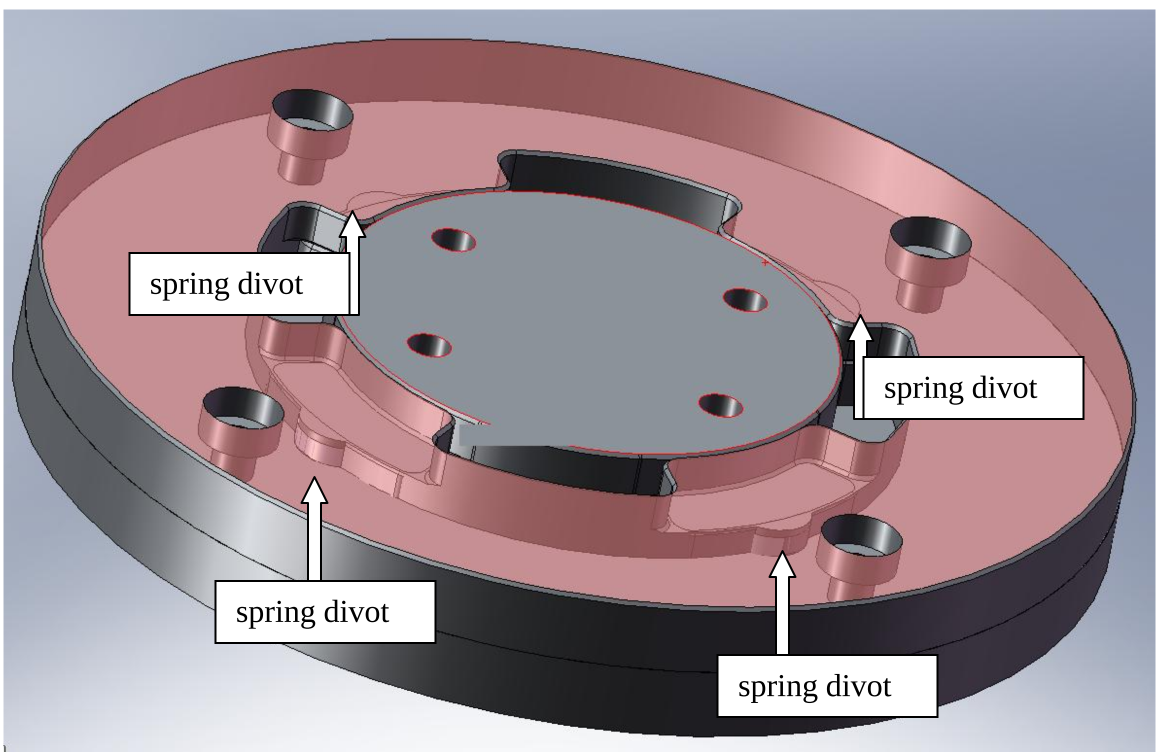

Figure 8 Showing spring divots FR 3.1

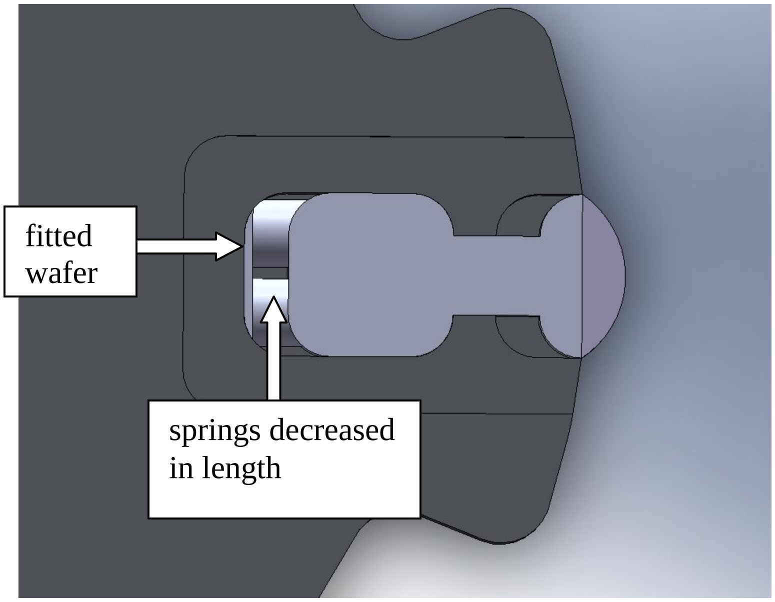

Figure 9 showing fitted wafer FR 3.2

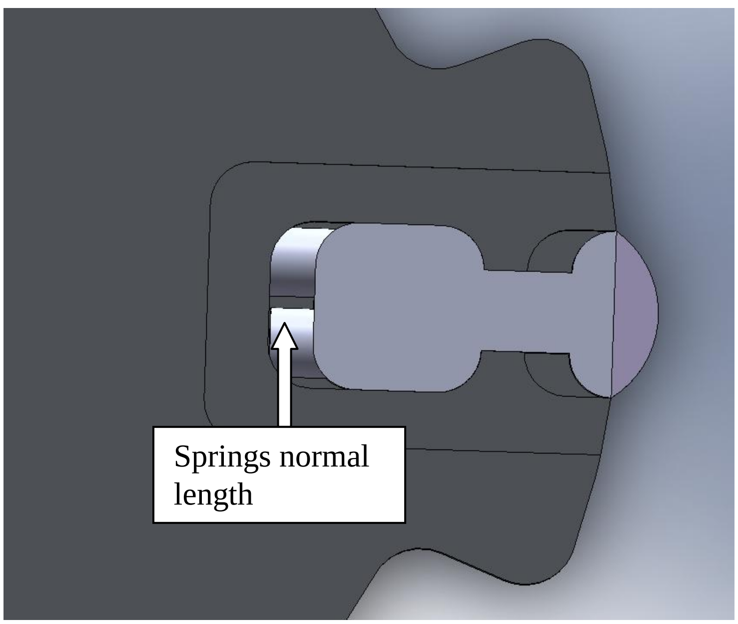

Figure 10 showing normal spring

There must be enough room for the Middle Connector Plate to rotate so that it does not get stuck when it needs to rotate. Therefore the Releasable Binding Disc must have the proper tolerance to ensure that even in cold weather the Middle Connector Plate is able to rotate freely. This is done by setting a fit at an RC 7 Free Running Fit. The Free

Running Fit was selected because it is used where accuracy is not essential and it can accommodate large temperature changes. The diameter of the tip of the wings is 90 mm, which when applied to the Machinery's Handbook Table 4. American National Standard Running and Sliding Fits a clearance ranging from 0.127 to 0.2716 millimeters.

4	FR	Provide for ease of use	DP	Structure ensures ease
4.1	FR	Prevents clogs	DP	Structure prevents snow from entering
4.2	FR	Facilitate movement	DP	Steel edges grip snow well

The goal of the Releasable Binding Disc is to make riding a snowboard a simpler and easier experience. This would be negated if the rider was required to clean out the device every time they release their device to use it. Thus it is necessary that the rider, while using the device, does not have to extensively clean the device as well as be able to use the released foot to propel and stop the rider when necessary.

2.5 Explanation

The Releasable Binding Disc works on a simple principal. The wings on the Top Plate are spaced so that the wings on the Middle Connector Plate will fit through and can then rotate the Middle Connector Plate's wings underneath the Top Plate's wings. This locks the wings of the Middle Connector Plate in place and combined with the eight springs, two springs on each of the Middle Connector Plate's wings which prevent unintentional rotation. With one step and a quick twist of the foot a rider can lock onto the board.

With a simple intentional twist of the foot an entire snowboard binding along with half the Releasable Binding Disc will break away and free up your foot to balance or propel a rider on and off chairlifts.

Table 1 Axiomatic Decomposition

0	FR	Allow rear foot to detach	DP	Releasable binding disc
1	FR	Attach boot to board through system	DP	Existing snowboard binding
1.1	FR	Attach snowboard binding to system	DP	Middle Connector Plate
1.2	FR	Attach system to board	DP	Base Plate
1.3	FR	Attach Middle Connector Plate to Base Plate	DP	Top Plate
2	FR	Transfer moments	DP	System that transfers Moments
2.1	FR	Transfer My	DP	Metal overhangs in x
2.2	FR	Transfer Mx	DP	Metal overhangs in y
3	FR	Link board and snowboard binding	DP	Locking Device
3.1	FR	Keep the device from rotating	DP	Springs locks device in place
3.2	FR	Releases only when desired	DP	Wafers decrease spring length
3.3	FR	Allow release of Middle Connector Plate	DP	Tolerances allow rotation
4	FR	Provide for ease of use	DP	Structures to insure ease of use
4.1	FR	Prevent clogs	DP	Structure prevents snow from entering
4.2	FR	Facilitate movement	DP	Steel edges grip snow well

3 Physical Integration

3.1 Base Pate

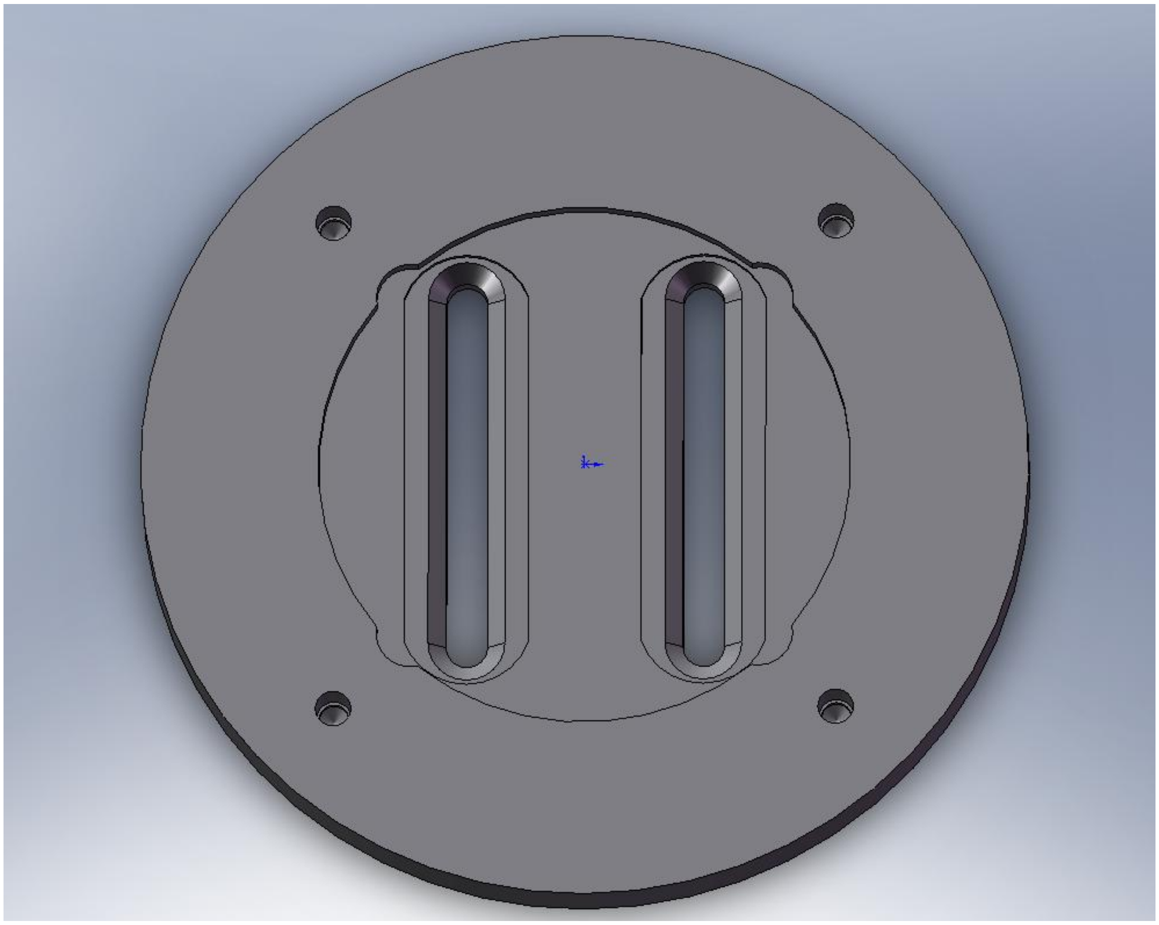

Figure 11 Base Plate

Figure 11 is the Base Plate which connects the Releasable Binding Disc to the board. The Base Plate transfers the moments and forces from the Releasable Binding Disc to the board. The four tapped holes on the outer ring of the Base Plate are to connect the Base Plate and the Top Plate. The center is similar to that of a traditional snowboard binding and functions the same in all respects. The Base Plate can be seen in an exploded assembled view in Figure 14.

3.2 Middle Connector Plate

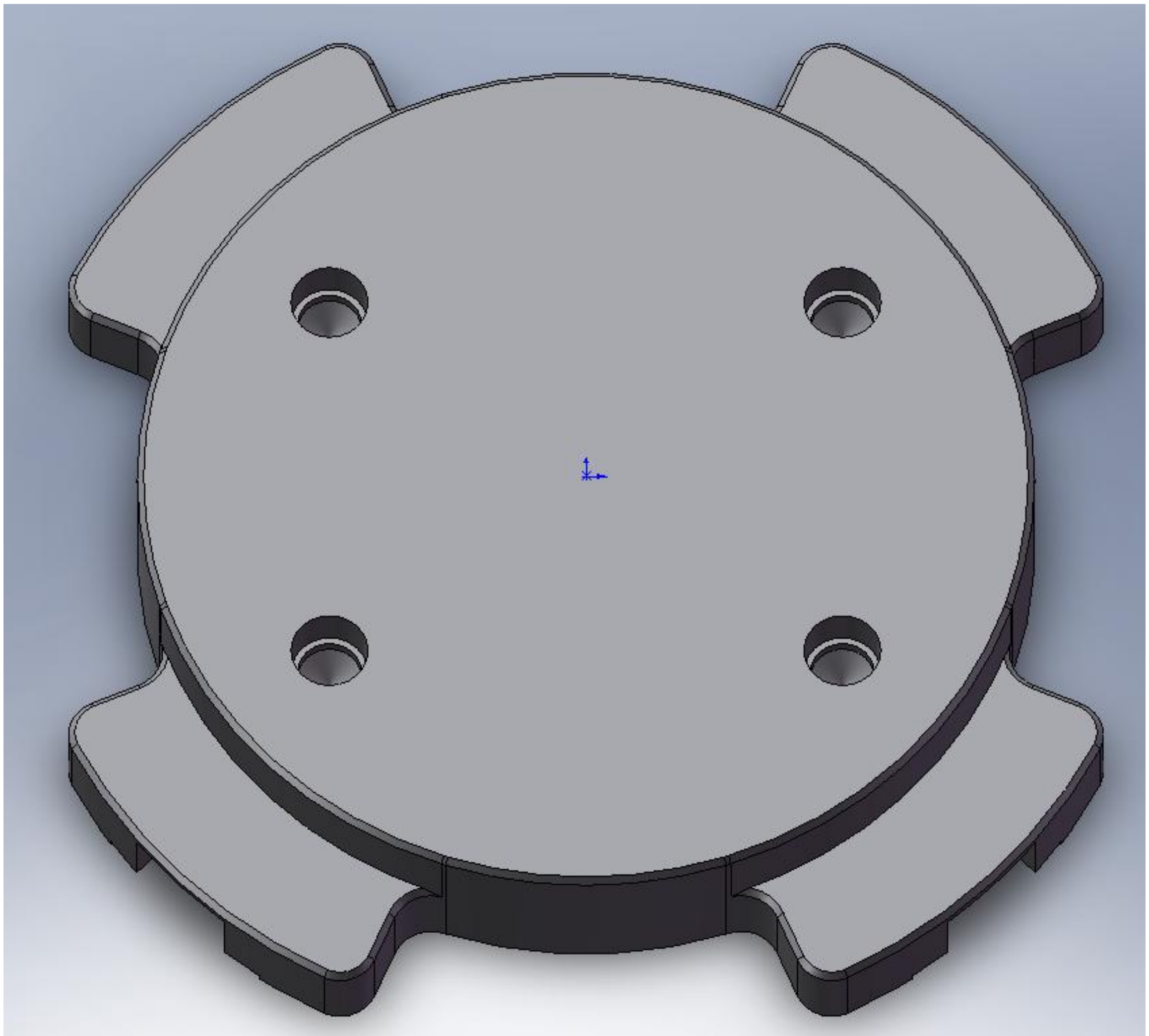

Figure 12 Middle Connector Plate

Figure 12 is the Middle Connector Plate which connects the Releasable Binding Disc to the traditional snowboard binding plate. The Middle Connector Plate transfers the moments and forces from the regular snowboard binding to the Releasable Binding Disc. The four tapped holes are for the screws of the traditional snowboard binding to attach to and function like the tapped holes found on snowboards for the snowboard bindings to attach to. The four wings jutting out from the core of the Middle Connector Plate slide under the Middle Connector Plate can be seen in an exploded assembled view in Figure 14.

3.3 Top Plate

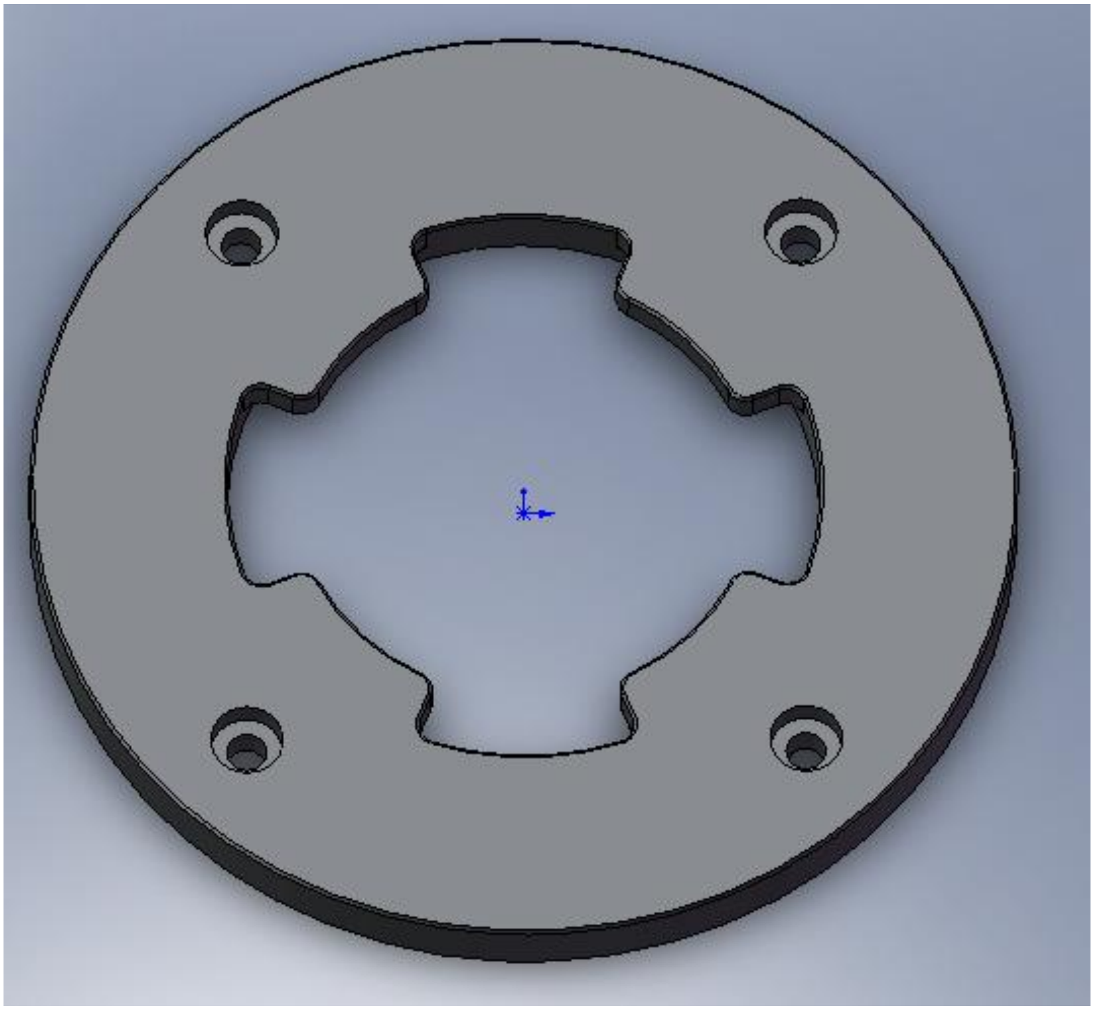

Figure 13 Top Plate

Figure 13 is the Top Plate which transfers forces and moments from the Middle Connector Plate to the Base Plate. The Top Plate also locks the Middle Connector Plate in place and prevents the Middle Connector Plate from prematurely disengaging from the Releasable Binding Disc. The four holes on the outer ring of the Top Plate are to secure the Top Plate to the Base Plate. The four wings jutting into the center of the Top Plate are to secure the Middle Connector Plate to the Top Plate and still allow the Releasable Binding Disc to release. The Top Plate can be seen in an exploded assembled view in Figure 14.

3.3 Assemblies

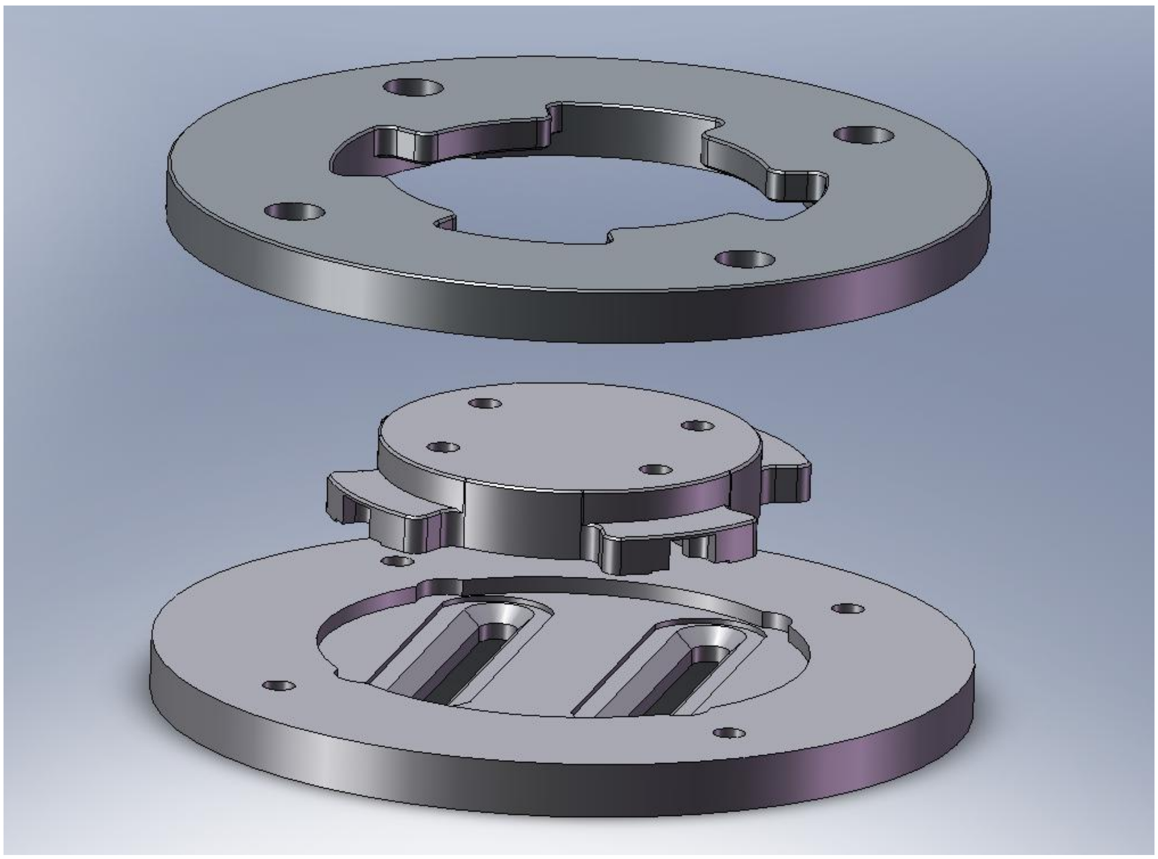

Figure 14 exploded assembly of Releasable Binding Disc

Figure 14 shows an exploded view of the assembled Releasable Binding Disc. It shows the Base Plate on the bottom, with the Middle Connector Plate in the middle, and Top Plate on top to secure everything together. Figure 15 contains a non-exploded assembly view.

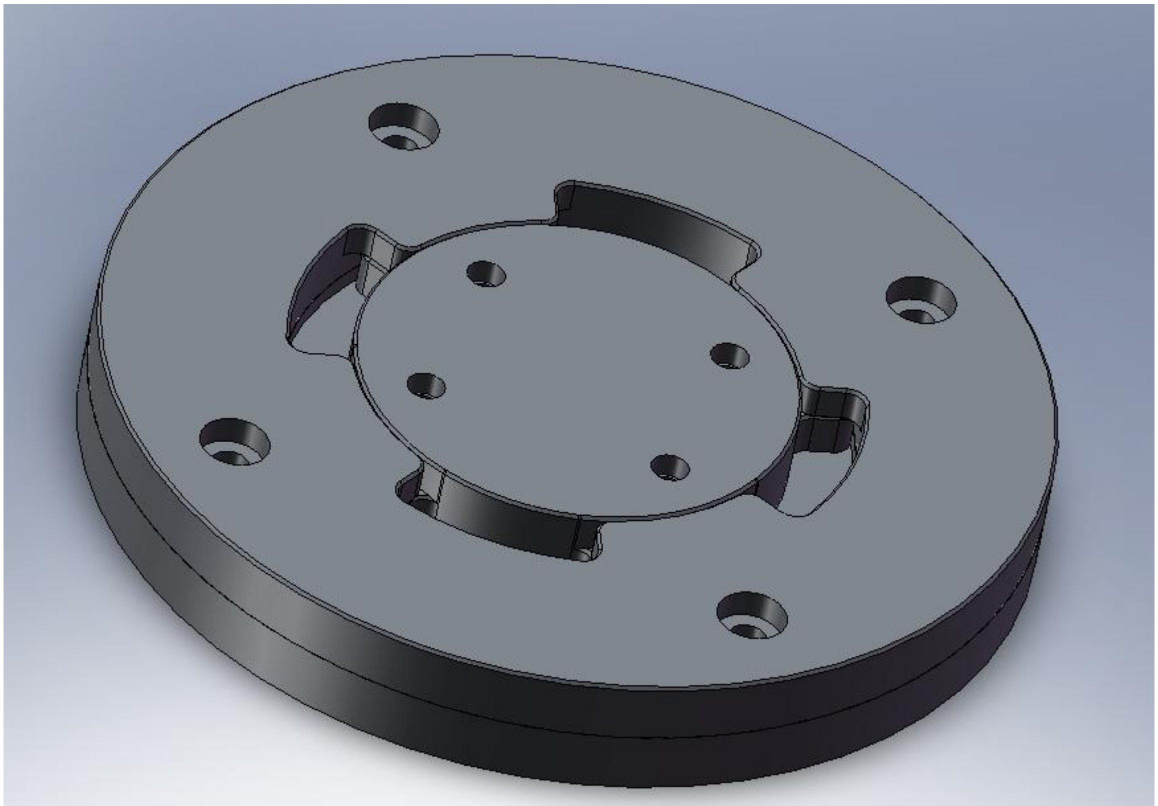

Figure 15 assembly of the Releasable Binding Disc

Figure 15 is an assembly view of the Releasable Binding Disc. The Middle Connector Plate is held in place by the Top Plate and prevented from rotating out inadvertently by the spring assembly found in Figures 16 and 17.

3.4 Spring Assembly

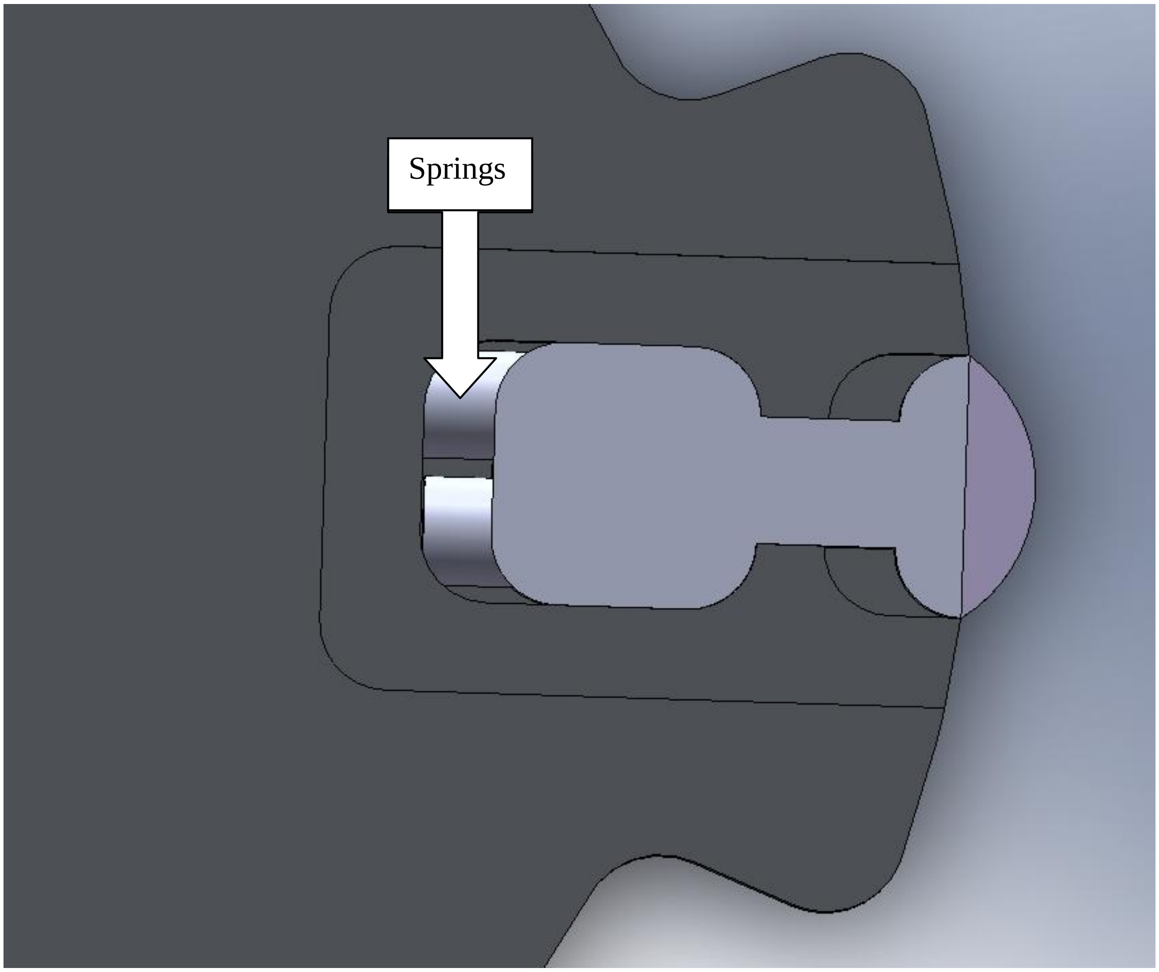

Figure 16 spring assembly

Figure 16 is the spring assembly, which is designed to prevent accidental rotation which could lead to the release of the Releasable Binding Disc, has a hole going through half the back end which the spring to some extent resides in. this prevents the spring from getting out of alignment as well as providing additional space for the spring to reside. The spring assembly achieves its goal of preventing rotation by forcing the rounded head into a divot placed on the insides of the inner rings of the Top Plate and the Base Plate.

The springs are 15mm long with a 5.5 mm diameter circumference. The springs have a k value of 21 N*m and there are two in each wing. The target amount of torque required to twist out is 45 N*m,

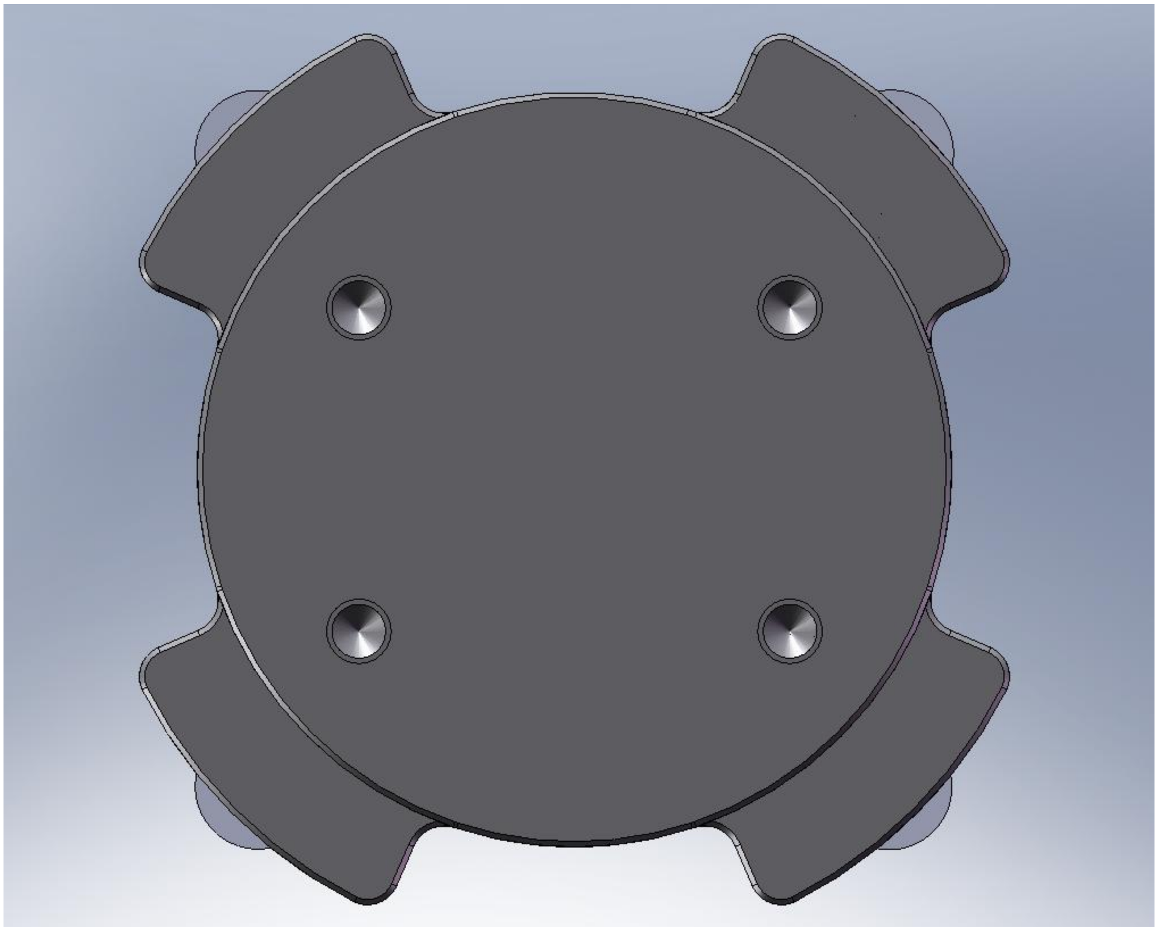

Figure 17 spring top view

Figure 17 is what the Middle Connector Plate will look like from a top view with the spring assembly sticking out. This is the part that will prevent unintentional rotation which would prematurely release the Releasable Binding Disc.

Testing

The Releasable Binding Disc was not manufactured and thus could not be physically tested. However, because it was designed in Solidworks it was capable of being tested by software compatible with the Solidworks program. The designs were tested using simulated loads and restraints in the Cosmos package. The simulated tests were all run using the same loads for each plate. The loads were set at 1260 newtons which is fifty percent larger than the largest force recorded in two studies (Bally et al. 1996, Nachbauer et al. 2001). The increase in expected tolerance is to compensate for larger and/or stronger users then those tested. On top of the fifty percent increase there is a safety factor of at least 1.5 on any of the plates. The restraints were always placed in the bolt sockets.

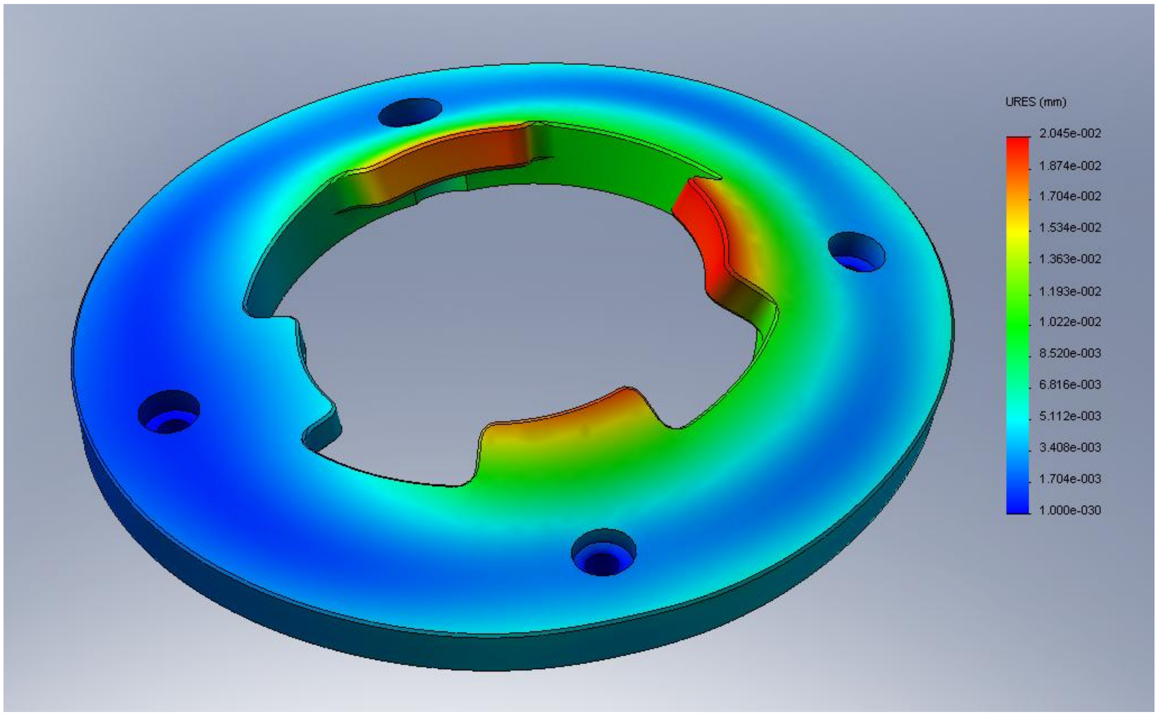

Figure 18 Top Plate displacement

Figure 18 is an analysis of the Top Plate’s theoretical displacement by using 300 lbs of force and wrought stainless steel as the material used to make it. The weight of 300 lbs was chosen so as to reinforce the device in addition to the regular safety factor. As seen below the Top Plate was loaded on the wings where a normal would be encountered in everyday use and was restrained in the bolt sockets.

According to the graph the maximum theoretical displacement is 20.5 micrometers, the displacement when stressed does not exceed the tolerances as it is under the maximum clearance for a Free Running Fit in the size class of 0-3 millimeters of which the maximum clearance is 66 micrometers.

In the tolerance analysis there is enough clearance designed into the design to compensate for worst case scenario tolerance extremes.

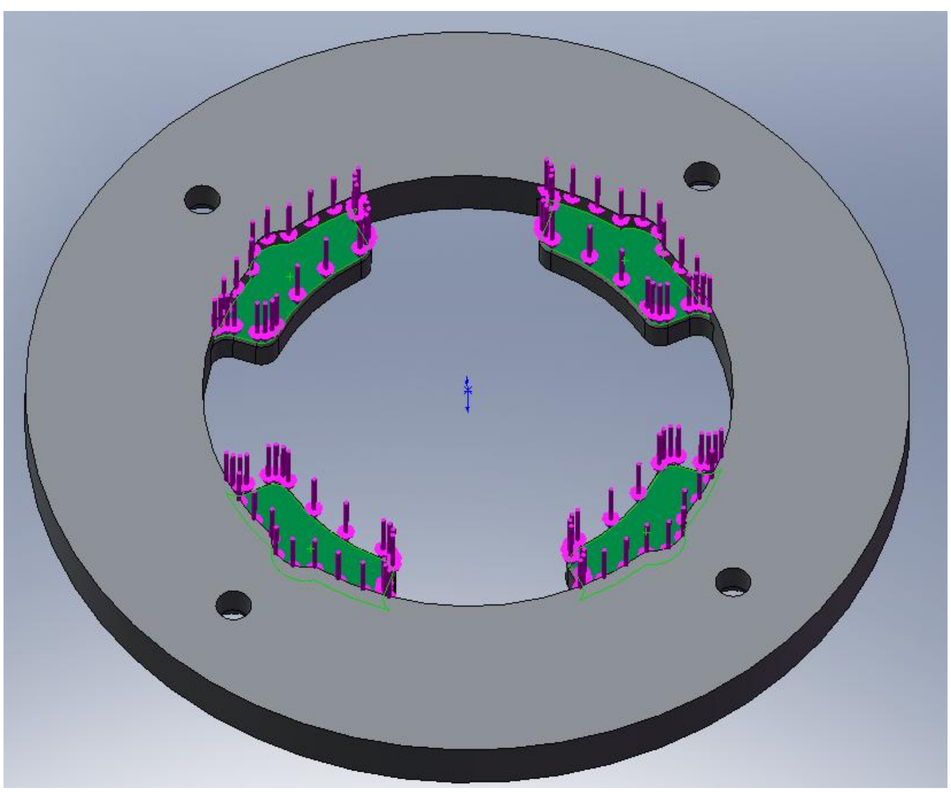

Figure 19 Top Plate simulated load

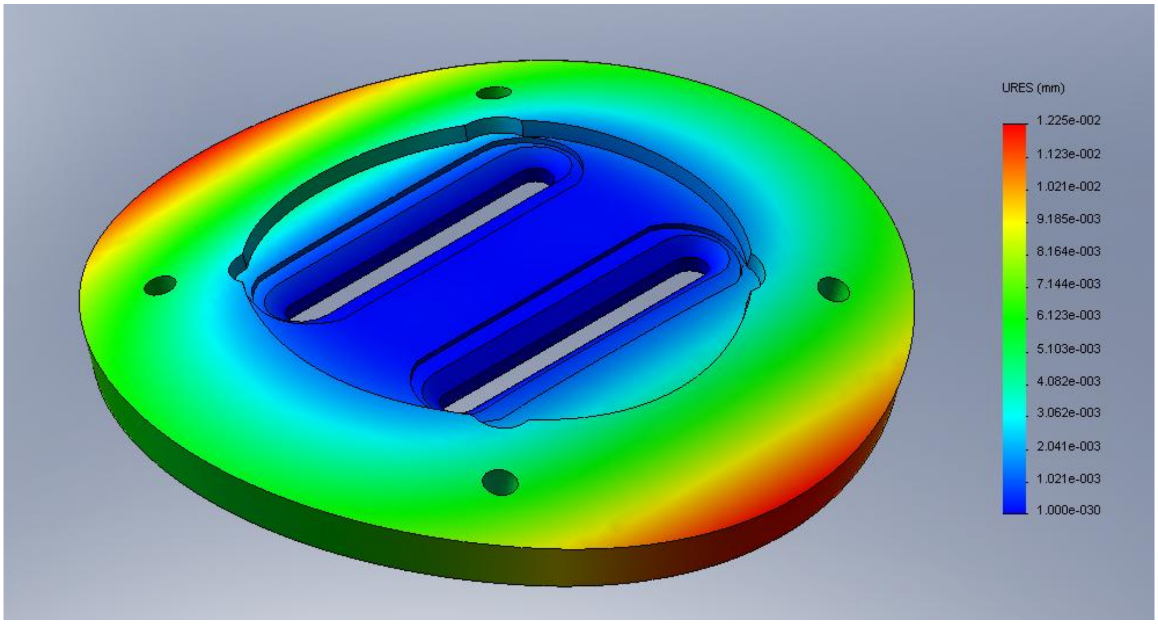

Figure 20 Base Plate displacement

Figure 20 is an analysis of the Base Plate's theoretical displacement by using 300 lbs of force and wrought stainless steel as the material used to make it. As the maximum theoretical displacement is 12.25 micrometers, the displacement when stressed does not exceed the tolerances as it is under the maximum clearance for a Free Running Fit in the size class of 0-3 millimeters of which the maximum clearance is 66 micrometers.

Figure 21, located below is the simulated load on the Base Plate and restraints are the two long grooves down the center.

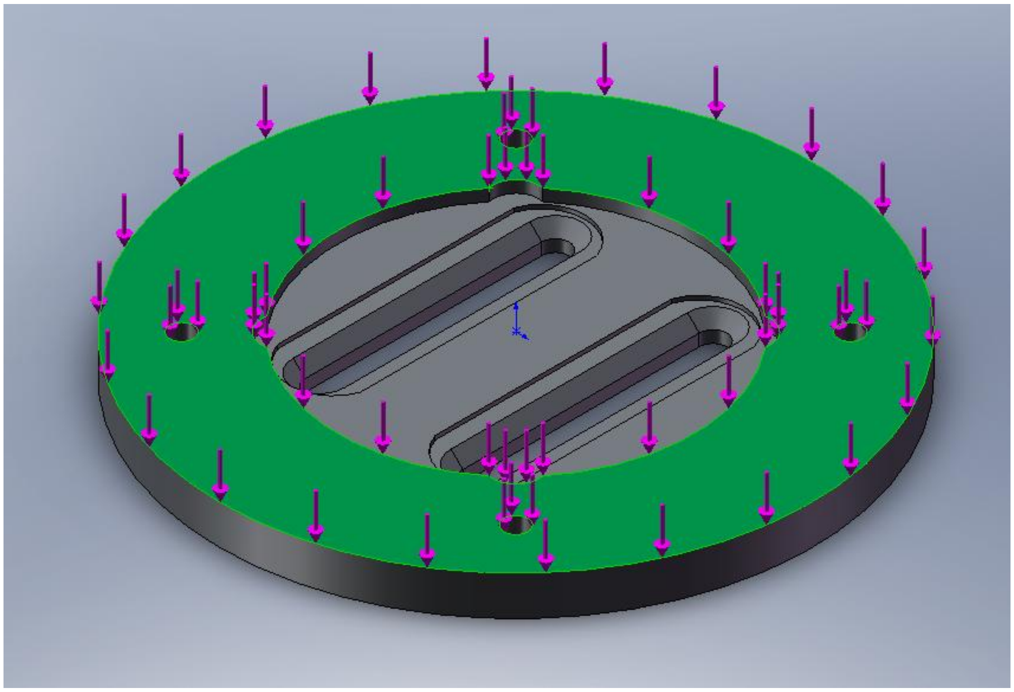

Figure 21 Base Plate simulated load

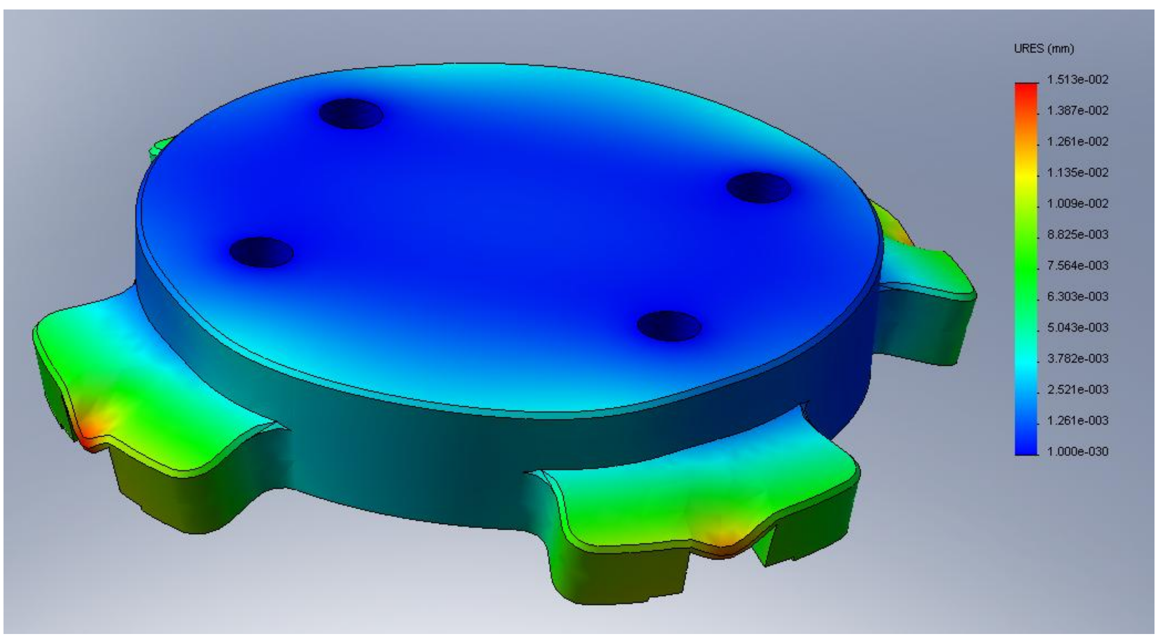

Figure 22 Middle Connector Plate displacement

Figure 22 is an analysis of the Middle Connector Plate's theoretical displacement by using 300 lbs of force and Wrought Stainless Steel as the material used to make it. Since the maximum theoretical displacement is 15.1 micrometers the displacement when stressed does not exceed tolerance as it is under the maximum clearance for a Free Running Fit in the size class of 0-3 millimeters of which the maximum clearance is 66 micrometers.

Figure 23 as shown below is the simulated load of the Middle Connector Plate with the restraints located in the bolt sockets.

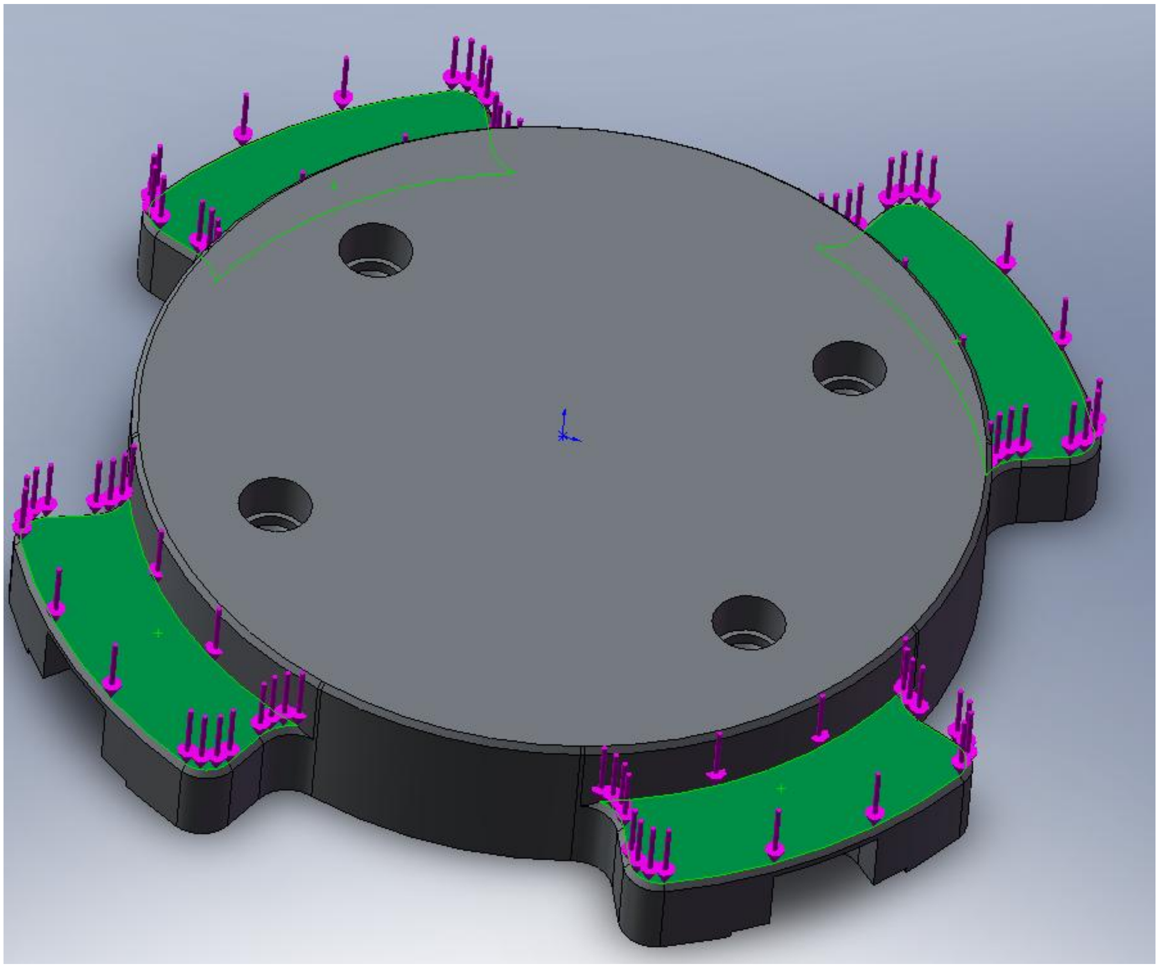

Figure 23 Middle Connector Plate simulated load

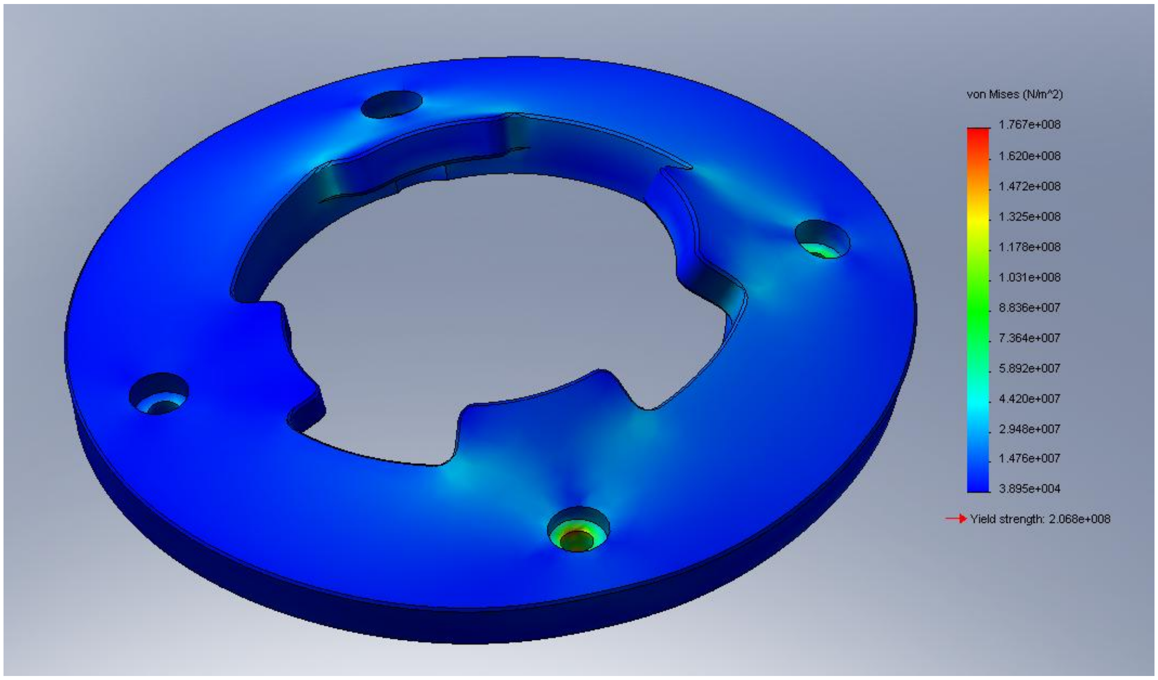

Figure 24 Top Plate Stress

Figure 24 is an analysis of the stresses that the Top Plate would endure while undergoing 300 pounds of force and being constructed of Wrought Stainless Steel. The maximum theoretical stress depicted in the diagram is 176.7 megapascals and with a yield strength of 290 megapascals (Specialty Steel Industry of North America) that gives the Top Plate a safety factor of 1.64.

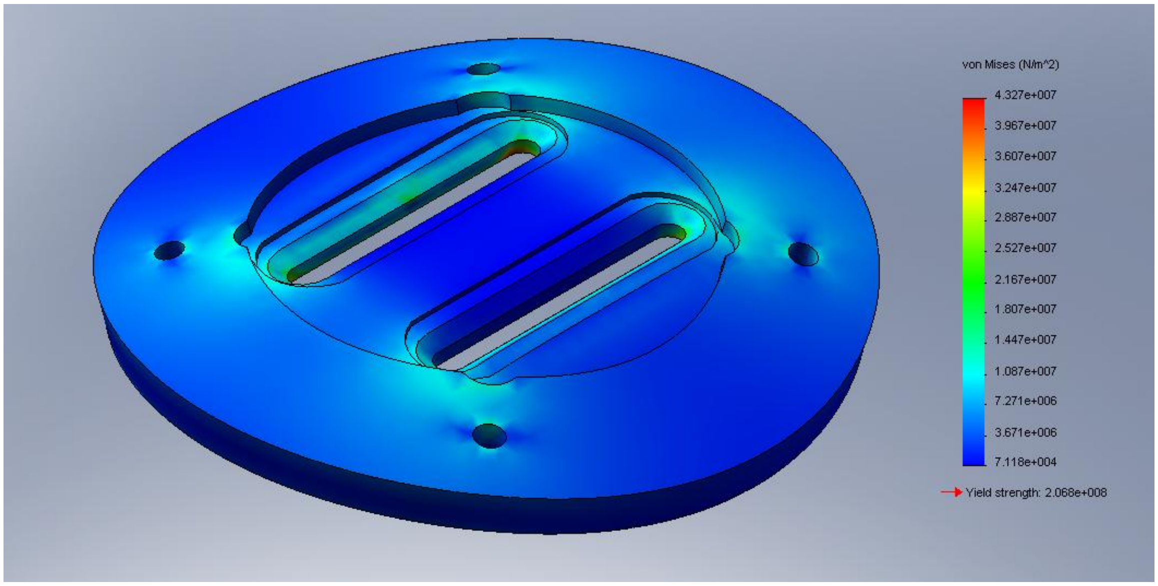

Figure 25 Base Plate stress

Figure 25 is an analysis of the stresses that the Base Plate would endure while undergoing 300 pounds of force and being constructed of Wrought Stainless Steel. The maximum theoretical stress depicted in the diagram is 43.27 megapascals and with a yield strength of 290 megapascals that gives the Base Plate a safety factor of 6.70.

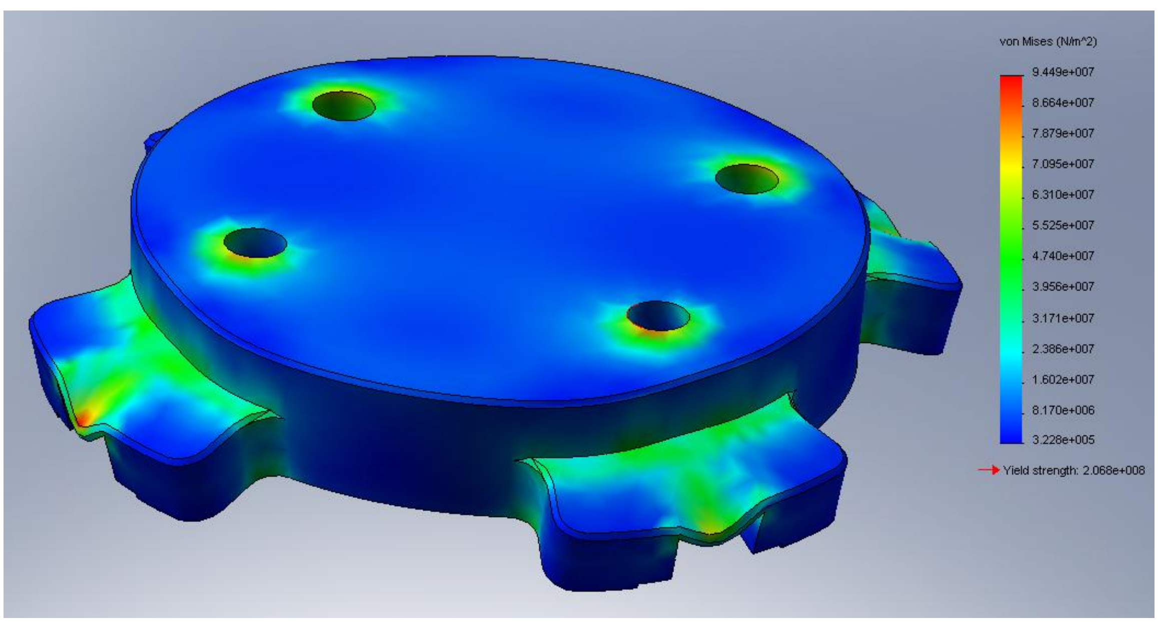

Figure 26 Middle Connector Plate stress

Figure 16 is an analysis of the stresses that the Middle Connector Plate would endure while undergoing 300 pounds of force and being constructed of Wrought Stainless Steel.

The maximum theoretical stress depicted in the diagram is 94.5 megapascals and with a yield strength of 290 megapascals that gives the Middle Connector Plate a safety factor of 3.07.

Discussion

Several potential problems may exist within the design of the Releasable Binding Disk. One problem is that the device may become clogged with snow and ice during the normal use. Snow and ice may become trapped in the Releasable Binding Disk and become frozen in place preventing the device from operating properly. The walls of the device should however keep most, if not all, of the debris from accumulating in the center of the device. Another potential problem is that the eight springs working in concert may not be sufficient to prevent accidental release from more aggressive riders. The desired tension was calculated based on a model however real life sometimes adds variables not taken into account during calculations.

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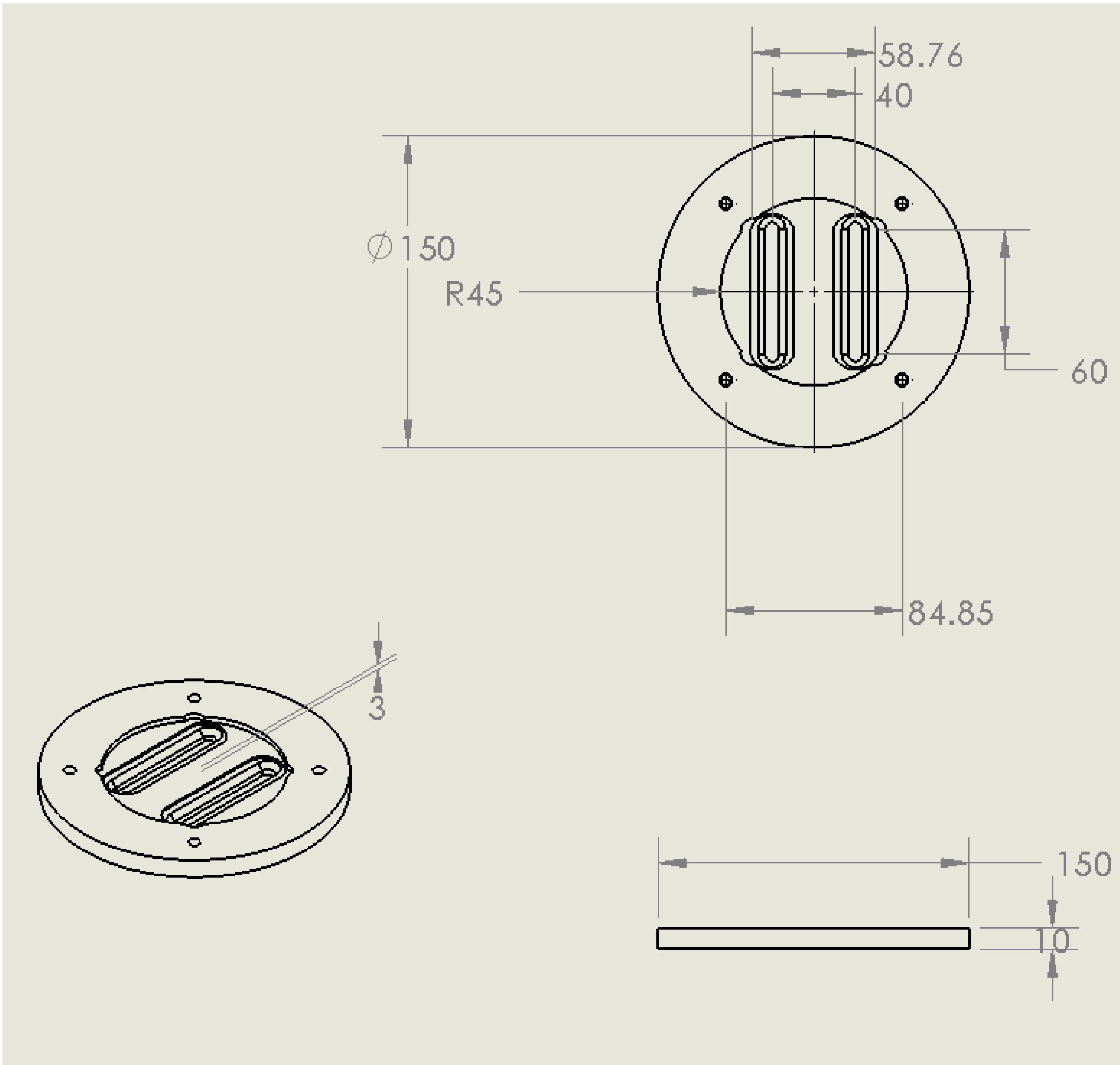
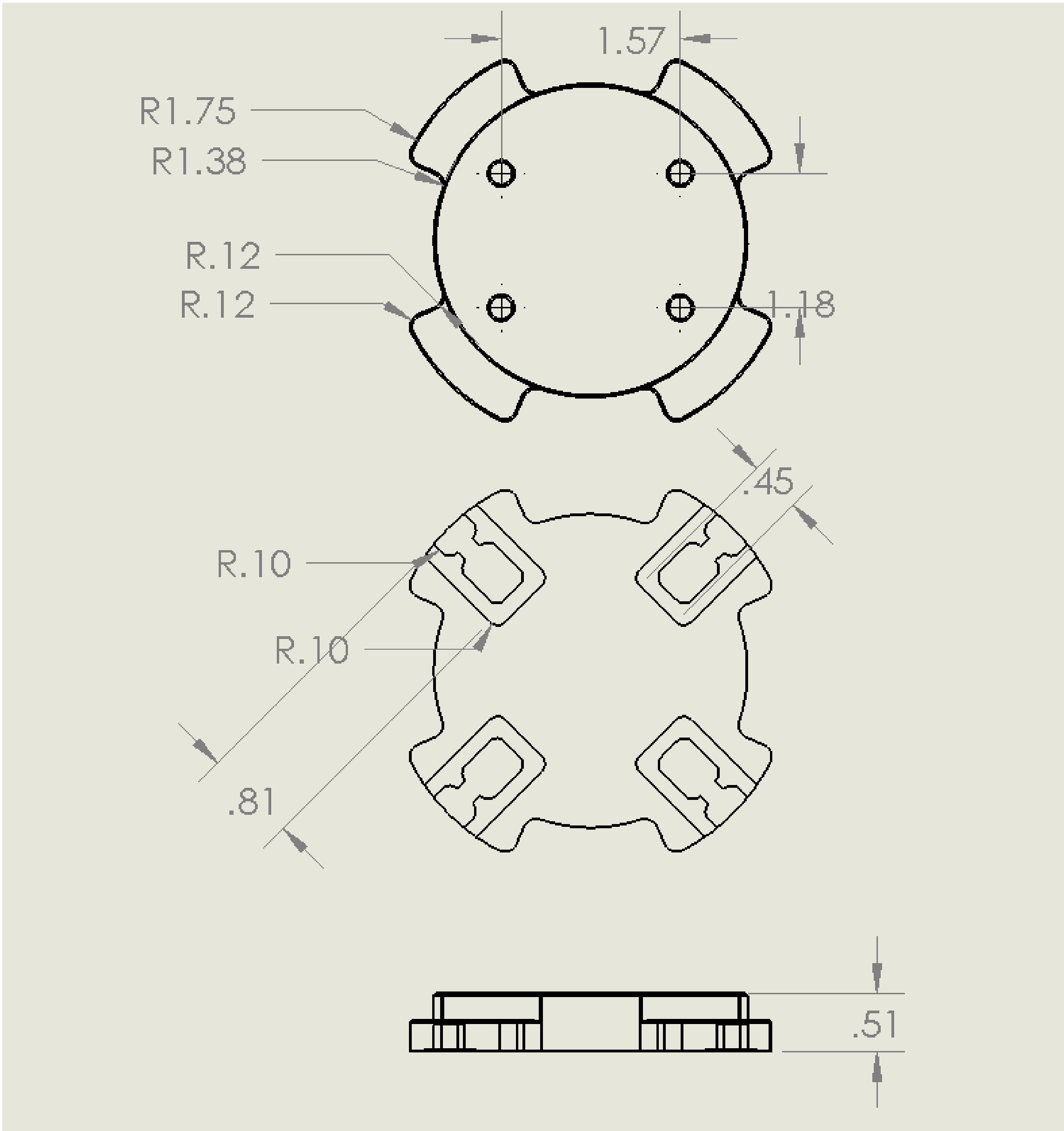
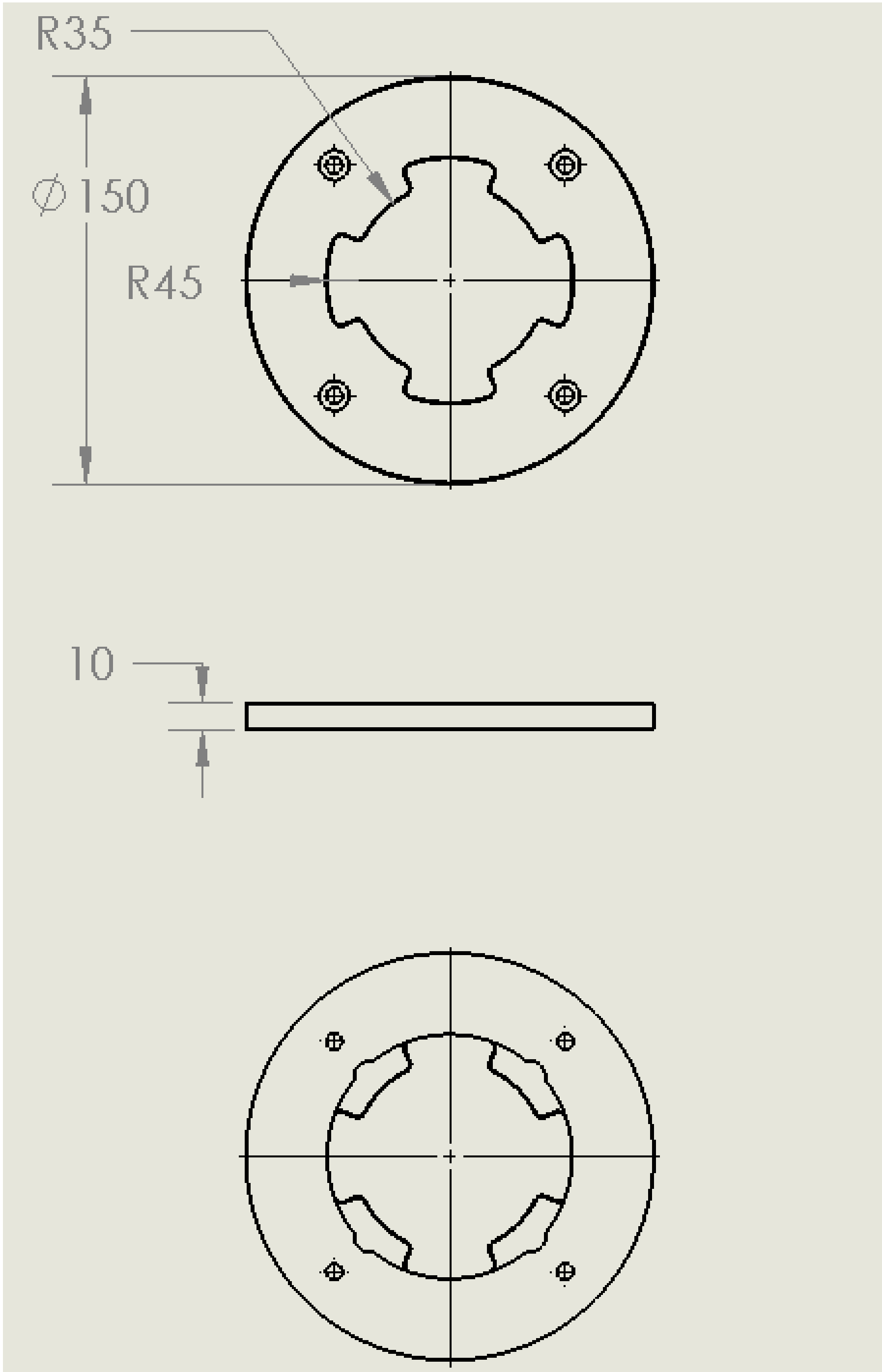
Appendix



Bas Plate (in mm)



Middle Connector Plate (in mm)



Top Plate (in mm)