DIFF UN-LOCKER TECH REPORT - JBJ56

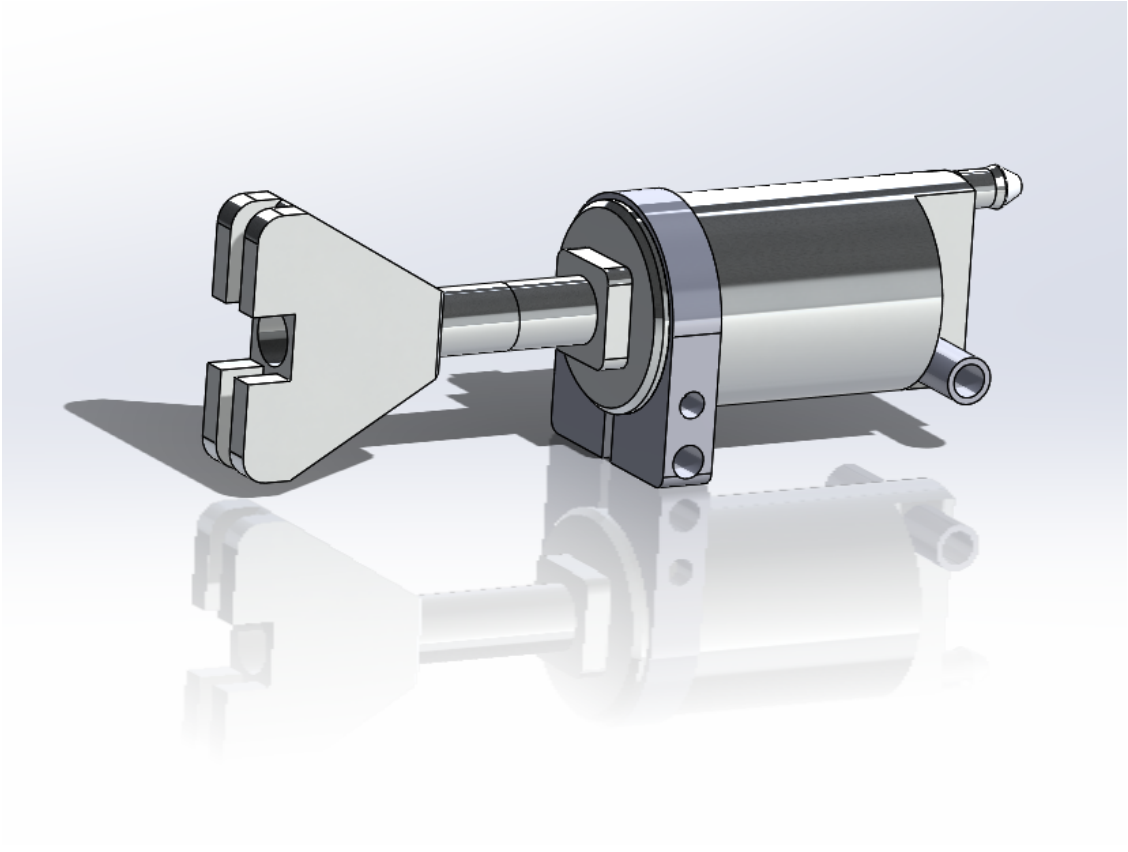
OVERVIEW

This semester I continued working on designing and manufacturing the diff cylinder, along with other brake components on the car. The diff un-locker ensures that the differential is unlocked just as the cutting brakes are applied to ensure that the drivetrain and the wheel are disconnected. What makes this system unique and different from other teams that compete in SAE, is that we can simultaneously actuate the cutting brakes and unlock the diff in one motion. This is the second year that this idea is being used on our car. One of our biggest issues last year was tuning, because it is crucial the diff unlocks at the correct time. I had two main goals in mind this semester that are slightly different than last semester.

1) Improve adjustability so that we can tune the system on site without having to re-machine

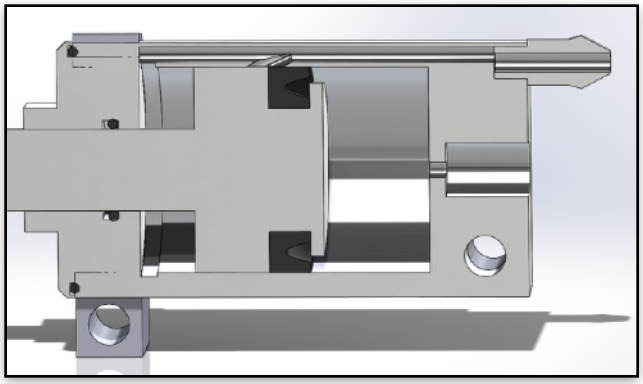
2) Reduce complexity in design, allowing it to be machined using the lathe and mill

DIFF CYLINDER MODIFICATIONS AND MACHINING

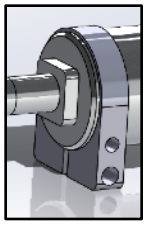


DESIGN REVISIONS SINCE FALL SEMESTER

Coming back in the winter we had a conversation between everyone who was involved in the diff/diff un-locker/cutting brake system along with the team leads and drivers. After this meeting we decided it would be best to increase the overall length of the diff cylinder to allow for more adjustability. Consequently, we increased the pushrod length and increased the threads per inch where the pushrod and the pushrod head connect. In this new system, we could move the pushrod head up and down the pushrod by threading it in either direction. With finer threads, we could do smaller adjustments to guarantee a perfect tune. Another thing the team leads wanted me to do was increases the distance between the internal inlet/outlet holes that allow fluid from the reservoir port to fill the vacuum created when the piston is actuated. To spread out the two holes I needed to greatly increase the width of the support where the reservoir port was connected. This added a lot of weight and made the design look much bulkier.

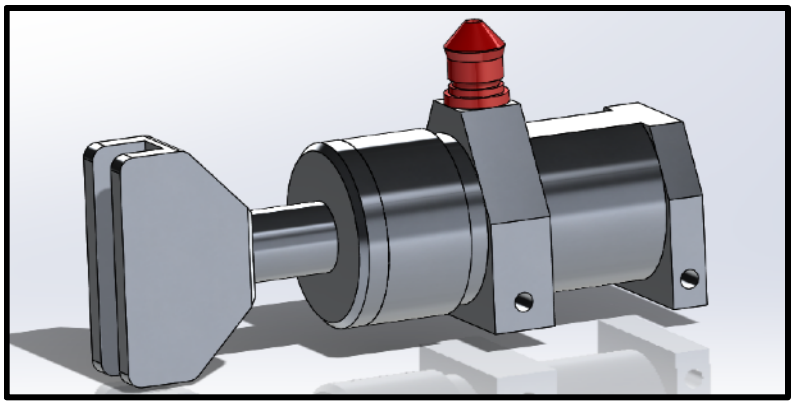


I came up with a design that would solve this problem while simultaneously reducing the fluid resistance when the piston was released. This was important because the piston must release quickly to avoid it losing contact with the lever. The solution is depicted in the figure to the above. The solution was to add a channel all the way through the cylinder above the bore. I moved the reservoir port to the end which conveniently increased the compactness of the cylinder. I added a groove at the top of the bore that intersected with the groove. This new system allowed me to place the inlet and outlet holes as far away from each other as I wanted without adding extra weight. This reduced the resistance because the fluid would return to the reservoir port through the groove rather than through a small channel in the piston, as was done in previous years. The outlet hole is an angled hole that intersects the reservoir channel. This new system allows for much more adjustability, primarily because the distance between the inlet and outlet no longer depends on the length of the piston head. In other hydraulic devices, the distance between the holes is restricted by the size of the piston that has a channel in it. The master cylinders this year is an example of a hydraulic system that used the old system because adjustability isn't as critical. An issue we saw this year with the master cylinders was damage in the u-cup that was in contact with the channel in the piston. In the new diff un-locker which does not require the piston channel, we avoid this issue. I believe that this is the system that we should continue using for following years.

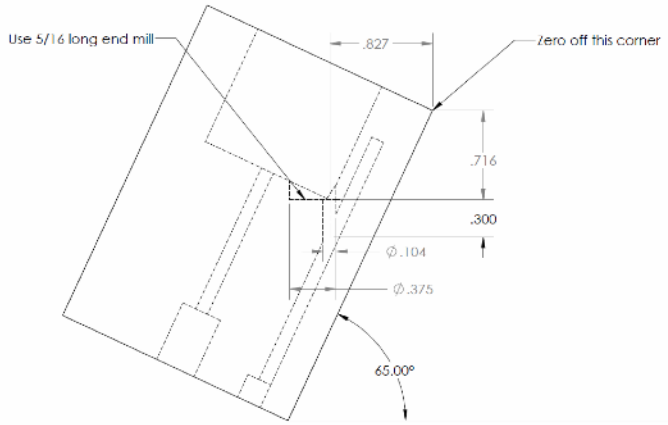


A second minor revision that I did was to mill a square extrude off the top of the cap that would allow you to use a wrench to press down on the crush O-ring. This made putting on and taking off the cap much easier without ruining its' surface. This proved to be very useful considering the minor amount of machining it required.

Initially I had planned to machine the diff-cylinder out of square stock. This would require me to place the stock in the four jaw and cut away at it until it became a cylinder. Part of the diff-unlocker needed to be square because of the placement of the old reservoir port. I've included a picture of the old design I had coming into the semester for demonstration. I would then either use an angled end mill or a belt sander to have those chamfers near the reservoir port and the rear attachment point. With the new reservoir port placement, this was a lot more machining than needed, and a lot more expensive. I decided to use round stock with an OD slightly bigger than the OD of the diff-unlocker.



In order to attach the cylinder, I machined a brace that would clamp down on the cylinder. This was an effective solution because it only needed to withstand vertical forces. Furthermore, since the attachment point was no longer fixed to the housing, I could slide the bracing so that it would match up with the tabs which were not exact. While machining the brace I was unable to find a drill bit / ream that was close enough to the cylinders OD. I decided to use a flying bore head, allowing me to choose the exact diameter needed. This was a very cool experience.



The most complicated part of the new reservoir port design was drilling the angled hole. I will quickly go through the process of doing this. The drawing to the right shows the operation. This was the second Op in the housing machining process. I was conscious of the fact that I was using a small drill bit that was prone to deflection when drilling through a lot of material. Prior to drilling the hole, I bored out a hole using an end mill that was smaller than the final ID to a point that was close to where the hole would be drilled in. I then placed the housing on an angled vice, which I bolted to the mill. I used a smaller end-mill (5\16in) to create a flat surface for the small drill. I had done the first operation the day before, which included drilling the reservoir channel. My mistake was that I had not left the housing in the square collet, so when I went to drill the smaller hole, I had to do some guessing as to where the channel was. If I had left the housing in the square collet, I could have avoided this problem. This is something to consider if the person designing the diff-cylinder next year decides to use this system.

THINGS I DID OUTSIDE OF WORKING ON THE DIFF CYLINDER

CUTTING BRAKE DIFF CYLNDER INTEGRATION

This semester Kyle and I decided to use a bracket that would fix the cutting brake, lever, and diff cylinder relative to each other. The brace would then be attached to the frame using tabs. This ensured that the system was positioned how we originally intended when it was designed, which was not guaranteed when attaching the system to individual tabs. This also required fewer tabs on the floor bar. Unfortunately, prior to competition the bracket was not made as intended, so we ended up using tabs instead. The brackets are also helpful for bleeding the diff cylinder off the car because we can use the lever to bleed rather than having to pump it by hand which was very exhausting. The brackets should be used on next year's car.

BLEEDER POLE

Another very useful addition this year was the bleeding pole, which made bleeding the brakes much simpler and less tedious. This was an idea that I suggested last year and was proven to be very successful. Although it worked great for bleeding the brakes, it was not compatible with the diff un-locker. I believe that including an option to bleed the diff cylinder would be a valuable addition.

SEAL DEGRATION

One of our biggest problems this year was ruining seals when assembling our hydraulic systems. While inserting pistons that had u-cups and O-rings, we had a lot of trouble getting them through the internal threads and grooves in the housing. Once we got the seals in, there was no telling how much damage had been done to them until we saw leaks while driving. Moving forward we should minimize the complexities inside the bore, and if possible have no seals in the housing, and only on the piston. The cutting brakes housing has no internal grooves or threads, and the assembly was significantly easier. In the following years we should have all the hydraulic housing have externally threaded caps.

COMPETITION

This year I went with the team to compete in California. The brakes sub team was scrambling to get everything together before the competition and we were worried there would be some unforeseen issues at competition. Luckily almost everything went smoothly. Our biggest issue was the cap seal in the master cylinder was getting deformed after some use. This did not cause us any issues during competition but we had to replace the seals on the first night when we arrived. We realized the issue when bleeding the brakes. We saw that there was a leak, but it was only apparent while retracting the piston. We hesitated to check the seals at the beginning because that involved disassembling the masters and re-bleeding. Once we realized the issue was probably an issue with the cap seal, we added a second seal which seemed to fix the issue. This was a good short term solution but it was clear that we needed a better solution in the long run. We decided that the cause of the problem was that we were creating a vacuum behind the piston so strong that it was deforming the seals. As a result, we came up with a solution that would eliminate the vacuum all together. This idea can be read in more depth in Kyle's and Thomas's Tech reports. Because it was a new idea and we didn't have time to troubleshoot unforeseen issues before next competition, we decided to put off the idea until next

semester. Although we did not notice this issue in the diff un-locker, there's a possibility that we might see it in the future since it also creates a vacuum when actuated. OD 14's diff un-locker ideally would tackle this issue in the same way as the masters.

IDEAS FOR THE FUTURE

I have already mentioned most of the ideas that I have for the future but one more thing that should be considered is using water instead of dot 3 in the diff un-locker. Currently we use dot 3 simply because that is the fluid we use for the rest of our hydraulic systems. I do not think that the temperatures in the diff un-locker/differential reach temperatures nearly as high as the brakes system. If we switched to water, which is also incompressible, then bleeding would be a lot easier and less messy. We could essentially bleed the system in a tub of water.