Brake Pedal Tech Report

Spring 2018

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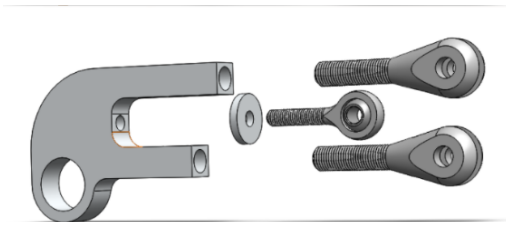
Overview

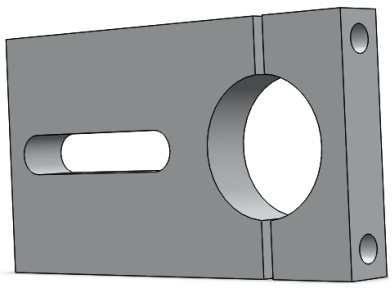
This semester I continued my work on the brake pedal. I was in charge of fabricating the adjustable pedal and the final brake pedals along with some spares. The pedal was designed to be machined in the CNC, so I learned how to CAM and CNC on the TORMACH in auto lab.

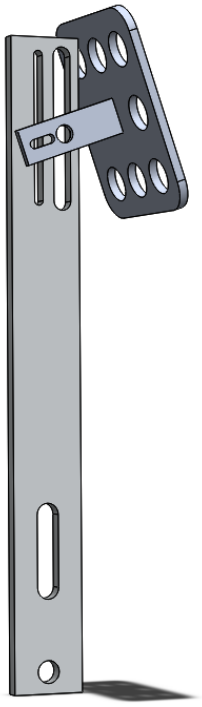
Brake Pedal Design Considerations

Adjustable pedal

Last semester I designed an adjustable pedal for the driver to test on. Here is a quick excerpt from my last tech report to show my intentions: *"I came up with a second idea which was to create a temporary fully adjustable pedal that will be used until we find the most comfortable position for the driver. Once we find that 'sweet spot' we can manufacture a proper pedal with the same dimensions. The final pedal will not be adjustable, but it will be tailored to the endurance drivers comfort. Since the seat has some adjustability, the seat can be brought forward for our smaller acceleration drivers."* I decided to make the adjustable pedal completely out of 3d printed parts so that we could allocate our machining time to parts that were going to go permanently on the car. After all, the adjustable pedal only had to last a day while we took our measurements for the driver. My one concern was that the threads on the 3d printed bottom bracket would experience an axial load by the clevis rods as shown on the diagram to the right. I debated between having the threads 3d printed or tapping them after they were printed. I ultimately decided to tap the threads manually because I did not trust the tolerances of the printer as much as a regular tap. In retrospect, when considering the internal structure of the printed part, threading it on the printer might have been a better idea. The mark forge 3d printer creates a grid-like internal structure, and when threaded into, the tap cuts into the gaps between the grid nodes, which created a choppy thread. This wasn't too much of an issue for the bottom bracket, but was a big issue for the tab (the 3rd image). As a result, I had to drill through the threads and have a nut on the back end of the bolt. This solved the issue, but it's worth considering 3d printed threads for next year. Lastly the







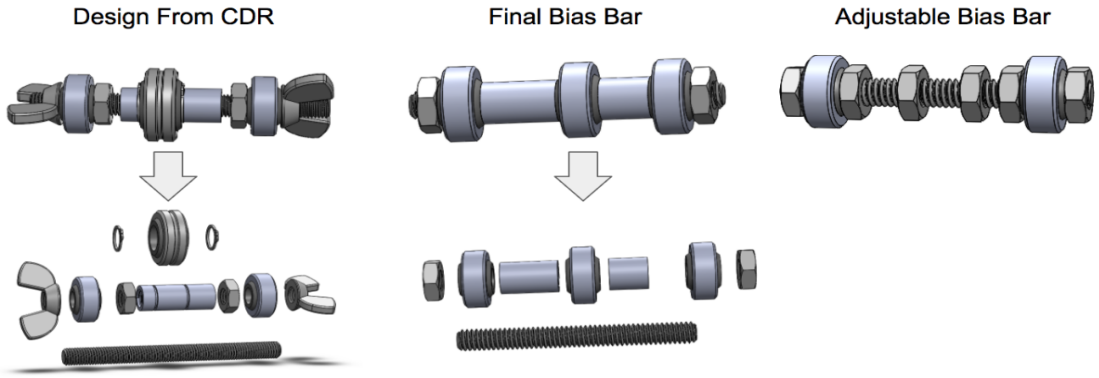
pedal stem shown on the right of the same image was also 3d printed. Although it should only experience a load in the direction of travel, there were some lateral loads. The 3d printed structure was incredibly flexible laterally, which made it difficult to use the adjustable pedal on an actual brake system. This part should DEFINITELY be made out of aluminum. It is also a quick part to make that can be done in one operation. Nevertheless, the pedal helped in determining position without it being connected to the brake system.

Final Pedal

The final pedal geometry changed a bit from last semester based off what we learned from the adjustable pedal. The pedal got longer making it heavier but also giving it more mechanical advantage.

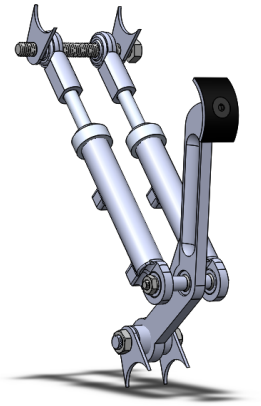
Bias Bar

For CDR I designed an adjustable bias bar that could easily by modified at any point, even during competition. By FDR we decided to scrap it and use a simple adjustable bias bar assembled using only nuts and a threaded rod, and then using machined spacers on the final bias bar. The original thought process behind the adjustable bias bar is that the bias will always change depending on the quality of the bleed, and you cannot always guarantee a 100% perfect bleed. During competition, we had to file down the machined spacers to adjust the bias right before the race. I think next year we should revisit the idea of an adjustable bias bar and perhaps refine it so it is easier to adjust without needing tools (my design requires a wrench to adjust the lock-nuts).



Design Modifications from Last Semester

I made a couple changes in the design this semester after seeing some issues arise during testing. The biggest failure was when the swivel bearing that links the bias bar and the pedal came out of its' press fit. This would be catastrophic if it happened during competition, but it has never been an issue in the past. To accommodate for this, I increased the press fit from a 2 thou press to a 4 thou press. The consequence was that the swivel bearing had a much harder time rotating. This was not a huge issue because the load on the bearing when braking was about 300 lbs, and under this load there was no issue rotating the bearing. Another adjustment I made to guarantee the bearing was secured in place, was to include a set screw through the pedal stem. Its location is shown by the orange arrow shown on the right. In retrospect, considering we want to prevent axial movement, I should have used snap rings. Given the time constraints and the difficulty associated with finding a grooving tool in the machine shop, I stuck with the set screw.



Experiences gained

Ergonomics

This project has been more of an ergonomic project than a mechanical project compared to my projects in the past years. This is something I've always been interested in and it's an integral part to product design (which is what I am most interested in). I had to design a pedal that was comfortable all the way throughout the stroke, while also providing enough mechanical advantage given the constraints of our small frame.

CNC Machining

Another thing I learned how to do was CAM and CNC on our new TORMACH. I also learned how to use the HAAS CNC in the Emerson Machine shop. I simultaneously took MAE 1130 (the CAM/CNC class offered at Cornell) to improve these skills for the end of this year and next year. I am now CNC certified with a Blue Apron.

Considerations for next year

The main things to consider next year are improvement of the adjustable pedal and adjustable bias bar. The adjustable pedal can be quickly made by 3D printing it, but the pedal stem needs to be made from aluminum or at least reinforced to withstand some lateral forces. The adjustable bias bar should be improved, though my version from CDR is a good first iteration and has not been tested yet. I would recommend replacing the lock nuts with wing nuts, but be sure to ensure that they won't interfere with the pedal stroke.