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Team F: ADD_IN

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ILR05

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I - Individual progress

My goals this week were to order the slip ring and hollow stepper motor, test the hot end design, eliminate the leakage of filament and jams, and design the new mount in CAD.

1.1 - Ordering the stepper motor and slip ring:

This part proved to be quite time consuming, but choosing the right components for the project is really important so I did a lot of research before ordering. For the slip ring we needed a compact hollow shaft one with at least 6 lines, so the choice was made for the 504-0600 by Orbex, and it is shown in figure 1.1.a.

For the stepper, many parameters were taken into account, such as:

- The weight: for clear reasons we wanted to add as little weight as possible to the extruder.
- The size: Especially the motor length, as it results in a reduction in the build's volume high. So flat, pancake type steppers are preferred. Also larger diameters increase the inertia, so a compact overall stepper is preferred.
- The repeatability: probably the most important aspect for our system.
- Compatibility: must be drivable with the A4988 chip we have on our board. i.e. 2 phase stepper that can take 12V input. Requiring an additional driver dedicated to this stepper will dramatically and unnecessarily complicate our implementation.
- Hollow shaft: or possibility to customize the shaft to have a through hole of minimum 3mm ID to let the filament through.
- Torque: After estimating the inertia of our hot end and our required acceleration, as compared to the acceleration of the other axes, I realized our torque requirements are very low and satisfied by most steppers, so torque had a low priority.

The choice was made for the 3709 stepper by Lin Engineering, with customized hollow shaft of 3mm ID. The stepper is shown in figure 1.1.b. It satisfies the above requirements with a weight of 60 grams (0.12lbs), length of 14mm by 31mm diameter and 400 steps per revolution with an error of less than 2 arc minutes, or 0.03°,which is much better than standard steppers.

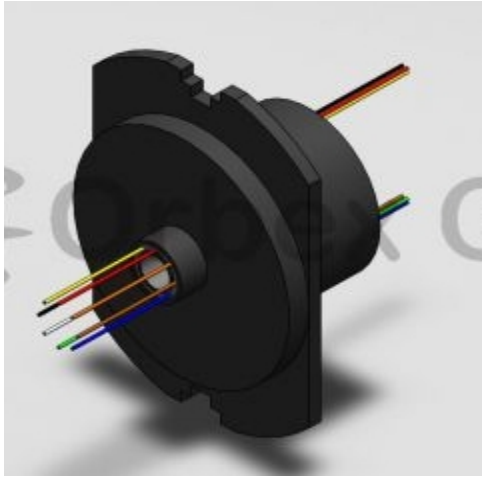

Figure 1.1.a) Slip ring b)Stepper motor

1.2 Designing the CAD mount:

For this part I wanted to have the mount as one piece with the filament drive, which is a 3D printed part so we can have the whole piece 3D printed. I started from the design of the Makergear filament drive shown in figure 1.2.a and designed a mount for the stepper and the slip ring, keeping of course both hollow shafts concentric with the filament path. The result is shown in figure 1.2.b. This configuration has the slip ring below the stepper, that is because the shaft ID is just enough for the filament and cannot accommodate the signal lines. The assembly, with stepper motor and slip ring is shown in figure 1.2.c.

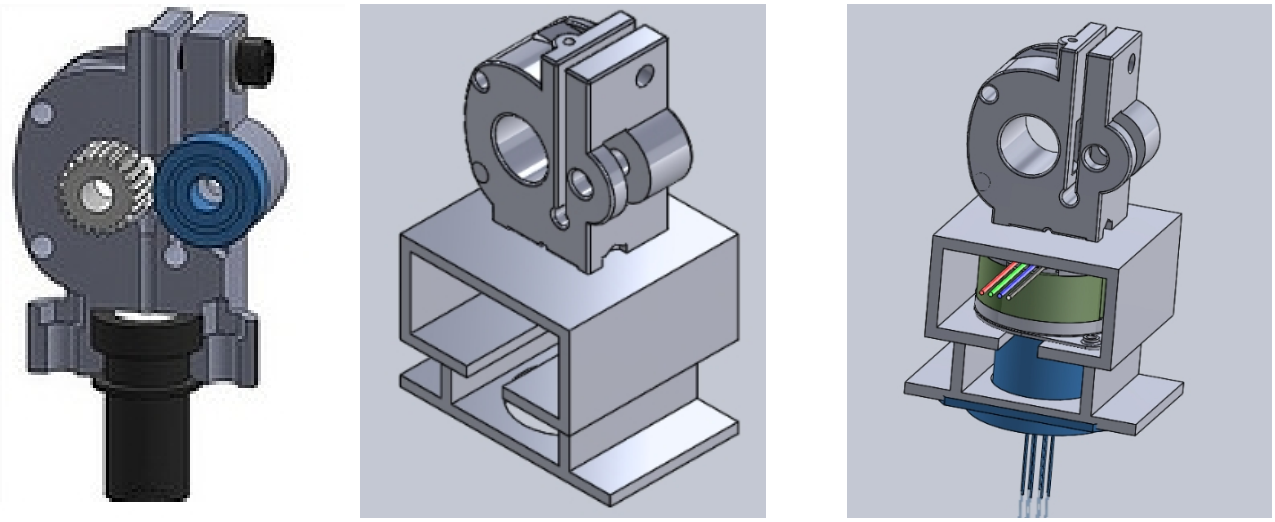

Figure 1.2.a) MG filament drive (in grey) b) ADD_IN mount c) Assembly

1.3 Eliminate the leakage and jams

The filament jamming problem was due to many things, first I had to change the barrel, and use a Makergear one to eliminate the air gap previously mentioned. Then we I was having jams in the heat block, which I theorized was due to the misalignment of the nozzle and the barrel, i.e., the nozzle was screwed in too far and was clogging the barrel. So I used acetone to clean the heat block, mounted a new nozzle and barrel, and added some Teflon tape to stop the leakage. And there were no more jams or leakages afterwards.

1.4 Test the hot end

Once the printer was working consistently without issues, I could finally start printing things and observing the performance of the bent nozzle. After many iterations I learned many things. I was especially interested in the impact that the print direction has on the result, and from experimenting I realized that even though the direction does impact the result, the impact is within the tolerance margin of the part, i.e. resulting part remains usable, but most importantly, the consistency of the filament when going in the direction the nozzle is pointing

at is the same as when the nozzle is going in opposite direction but printed at about 0.1mm higher. This is illustrated in figure 1.4. This makes sense as the amount by which the nozzle tip pushes the filament on the bed is reduced when the tip is higher, ultimately becoming the same as the direction on the left figure when the height difference is of about 0.1 mm. This is important because it means we can have a perfectly consistent print by intruducing a simple software fix that makes the nozzle go slightly higher when printing in a specific direction, and then back.

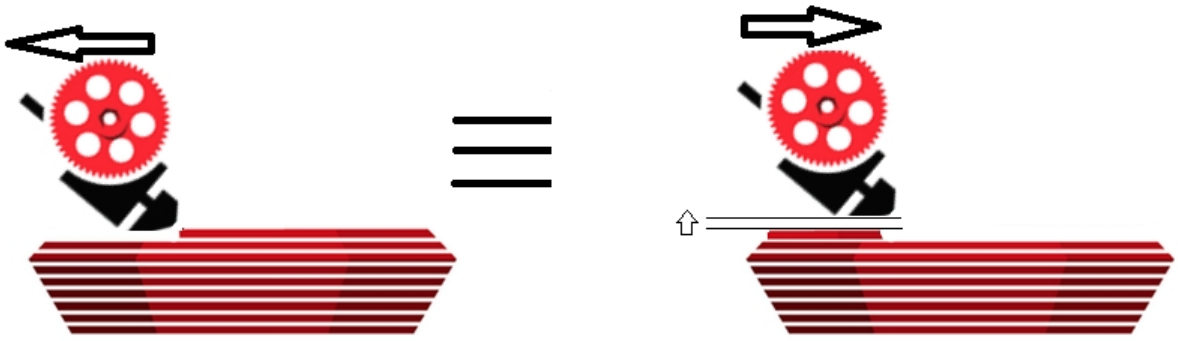

Figure 1.4. Printing in various directions

II - Challenges

The challenges that I faced this week were mostly related to the jams that were happening with our printer. I tried many things before finally getting rid of it as mentioned earlier, such as varying the temperature or drilling a larger path for the filament. It was also difficult to find a stepper motor that comes standard with hollow shaft and satisfies our requirements, which is why I finally decided to request a customized stepper to make it hollow shaft.

III - Teamwork

During last week, Nikhil worked a lot on the firmware, and is now able to control the fourth axes independently with and by a set angle, and also updated our website. Astha and Dan worked on eliminating the filament trail that was happening when pausing, and Dan also gave me some advice on how to improve the design of the mount since he is a mechanical engineer.

IV - Future Plans

The parts we have to show for the FVE are currently ready, so our future plans in the next two weeks are to improve on that and make sure our system is robust and reliable. We will also study the business aspect of the project, which is also our theme for the business class. So we will do the market research and business planning, and that will give us a better idea of what we are designing for, for example is it a product in the form of an add-on extruder(i.e. stress on compatibility) or a printing service (stress on versatility). That will in turn impact our design.