3D Design Competition (MAMSS)

Submission: GEAR GOGGLES

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Introduction

3D printing is a versatile manufacturing method that is not only making its mark on the commercial manufacturing industry, but has found its way into our homes as well. For this challenge I will propose a 3D printed design that will represent the Mechanical Engineering department of McGill University. To incorporate the idea of mechanical design into this project, it was decided that it would involve moving parts. There are two methods to do this, print parts separately and then assemble, or print the entire assembly. When coming up with various concepts the one which presented a great challenge, showed originality in design and would be fun to print was chosen.

Conceptual Design

The final concept chosen was the design of a pair of glasses with 2 movable gears attached by a rotational sliding slot to the main frame. This is a challenging print as it not only involves many parts, yet is a wearable product. This means that it will have to be comfortable and most importantly safe to wear and operate. The glasses were named “Gear Goggles”. The name originates from the phrase “Beer Goggles”, which refers to hazy vision due to intoxication. This is appropriate as the product is fun, flashy, and would make the perfect party tool!

The design of the product involved many joining operations and trial gear sizing. Thus, there are many referenced documents. Please note that the name of the final assembly is: “REDOAssembly2.SLDASM”.

From an aesthetic point of view, hashtags and phrases were extruded/cut into the gears and the temple pieces. Dimensions for the glasses would have to be general such that it would fit any face as best as possible. For the first iteration, I modeled the frame dimensions on my glasses frame dimensions. As previously mentioned, printing assemblies is very challenging and often required multiple iterations through trial and error to reach a perfect tolerances, fill, and support. The concept is now ready to undergo design and print iterations to reach the perfect final product.

Prototyping

The prototyping phase is the longest part of the design process as it involves indefinitely reprinting and redesigning the product. Note that the printing tests were conducted on a Prusa MK3 printer. It was thus ensured that the glasses can be printed and fit within a volume of 200mmx200mmx200mm such that it is printable on a FDM printer. The Prusa Slic3r for the MK3 was used as the slicing software.

The prototyping stage consists of 3 design and print iterations before a successful product was created. For simplicity the step be step method for all iterations is outlined in bullet points.

Iteration 1

This is the first print so a successful printed sliding assembly was not expected. The first print will also allow us to see any changes to the fit of the frame that would need to change.

- Fill of: 20%
- Layer Height: 0.2 mm
- Nozzle diameter : 0.4mm
- Print speed: 25mm/s
- Sliding assembly tolerance of 0.3mm
- No supports generated (accidentally)

The problem with the first iterations is that it did not fit well on the face. Supports for nose pads were too long while nose pads themselves were too small and formed a high stress concentration on the nose. This made the glasses difficult to wear for a long time. In this design iteration the temple/earpiece was printed attached to the frame. This did not allow the temple/earpiece to fold as it does in conventional glasses. The temple piece also broke very easily, its thickness was thus increased in the following iteration. As supports were not generated, the gear and the frame piece were bonded together and no sliding mechanism was achieved (as can be seen in figure 3).

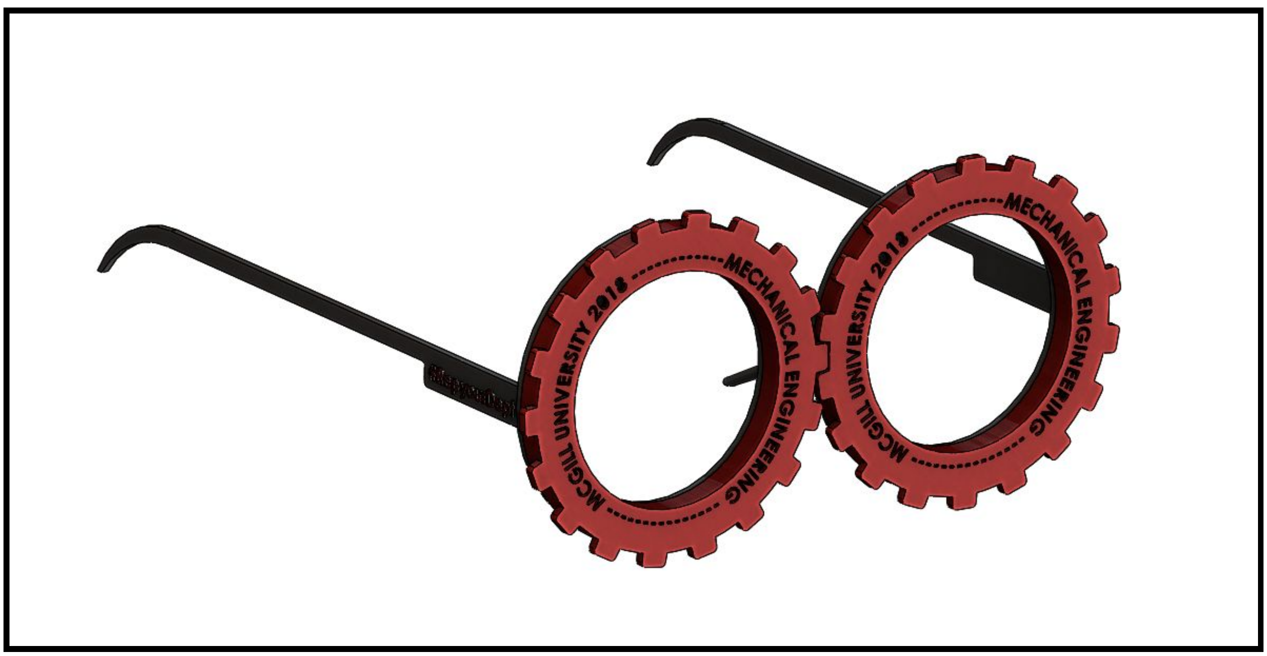

Figure 1: Isometric Front View of Iteration 1

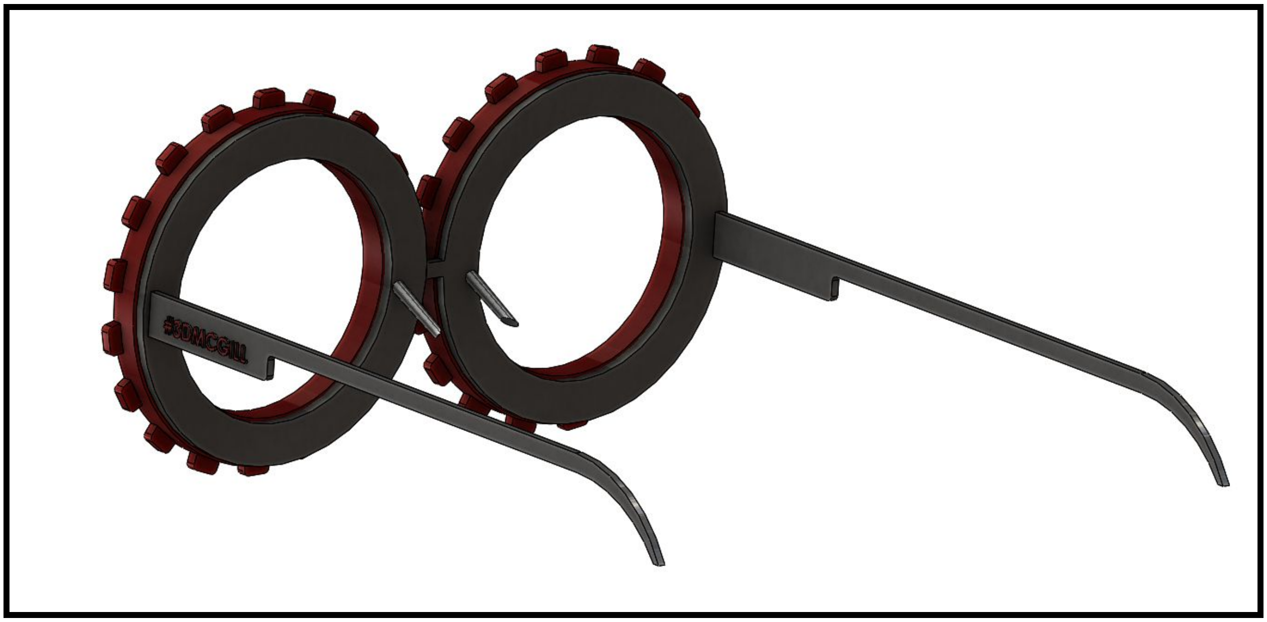

Figure 2: Isometric Back View of Iteration 1

Figure 3: Prototype Gear and Frame Piece of Iteration 1

Iteration 2

Iteration 1 proved to be unsuccessful thus many changes were made to the design of iteration 2. The dimensions of the nose pads had to be changed. In this design iteration the temple pieces are hinged, allowing them to fold. To decrease overall print time the temple and hinge pieces were printed on the flatbed separately and then later assembled into the hinges. The

temple piece itself was also made thicker for increased rigidity. The distance left between the sliding parts was increased to 1 mm as no supports were generated in the sliding region previously.
Shape of the gear teeth were refined to include a pressure angle (as opposed to the rectangular teeth)

- Fill of: 15%
- Layer Height: 0.15 mm
- Nozzle diameter : 0.4mm
- Print speed: 25mm/s
- Sliding assembly distance of 1mm
- Supports generated

The fit of the glasses ended up much better, the distance between the nose pads were increased as well as the size of the nose pads. However, The nose pad supports were also very weak and broke easily. Also, Frame bridge was too weak to allow breaking of the inner gear supports and failed instead of the internal supports when a torque was applied on the gear to free it. The internal support was too rigid to free the gears by applying a torque.

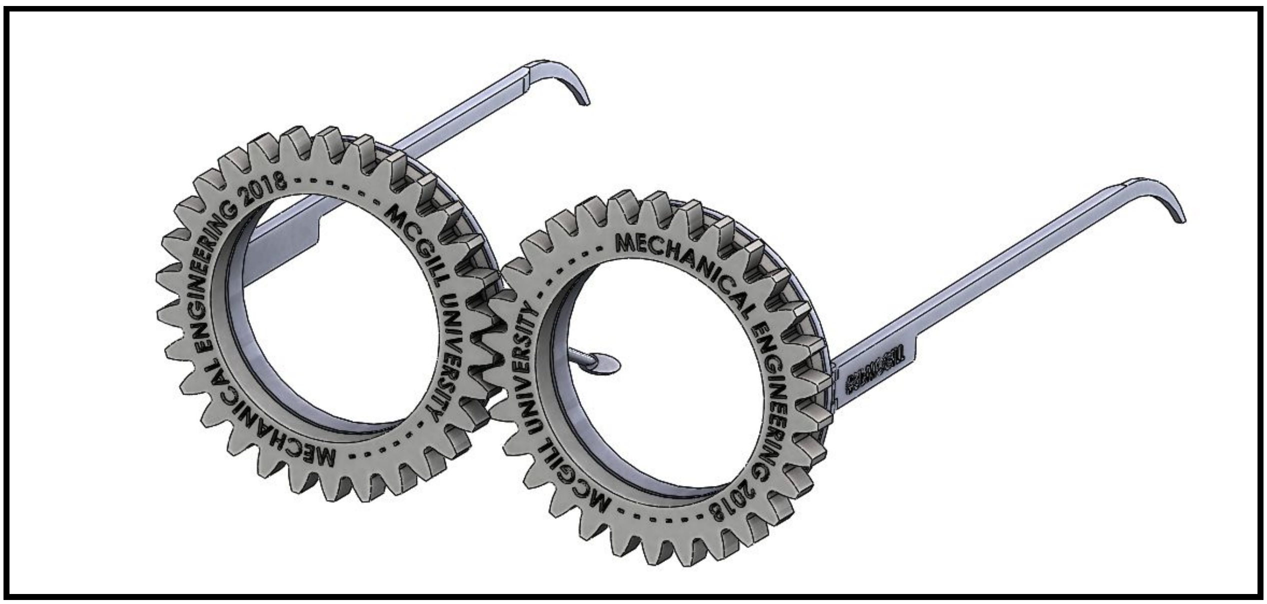

Figure 4: Isometric Front View of Iteration 2

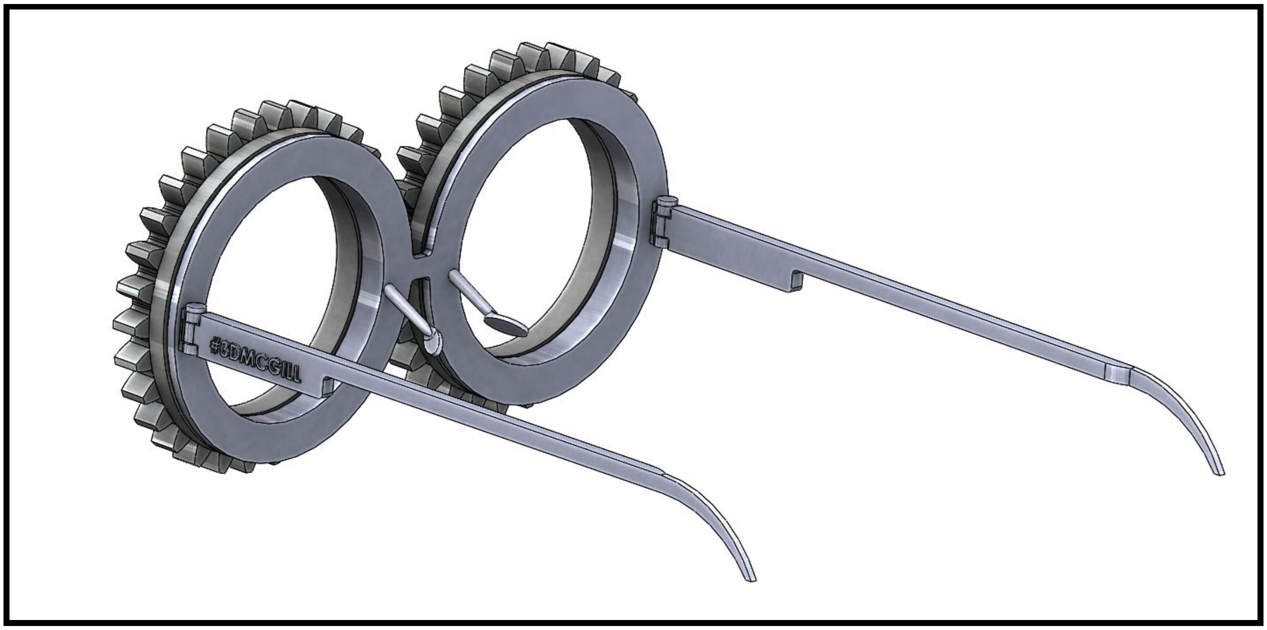

Figure 5: Isometric Back View of Iteration 2

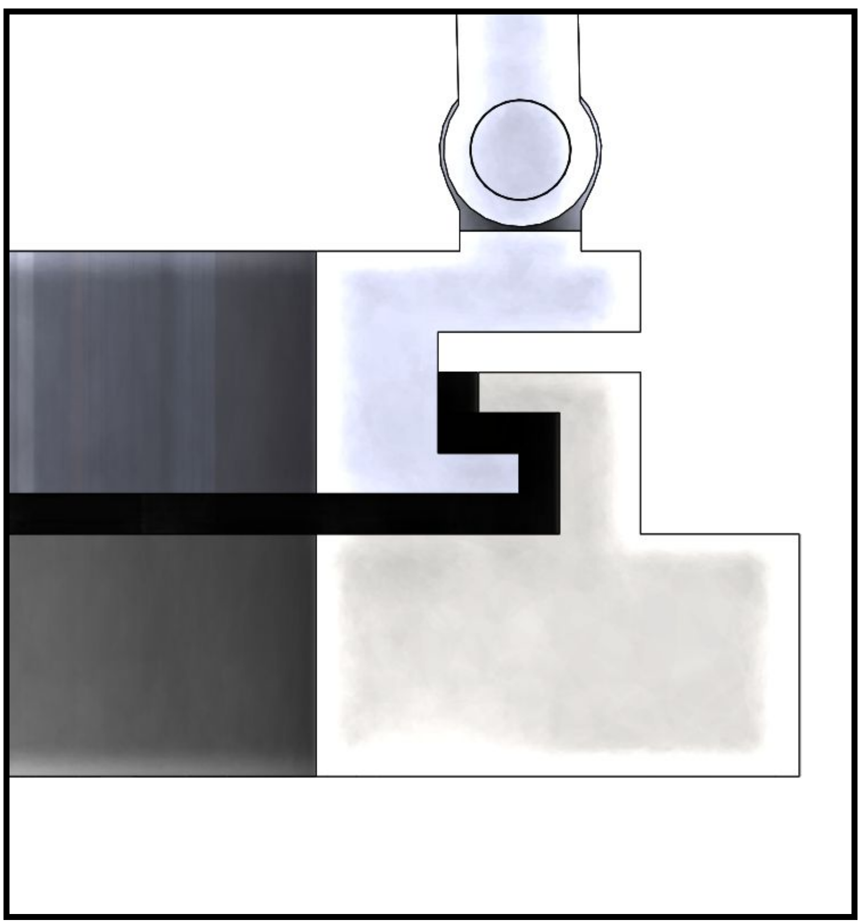

Figure 6: Top Section View of Iteration 2

Figure 5 (above) shows the L-slot sliding mechanism used. Clearances between the gear piece and the frame piece are 1 mm.

Figure 7: Prototype Gear and Frame Piece of Iteration 2

Iteration 3

For the final iteration it was decided to print parts separately then assemble. The sliding mechanism matches the previous iterations (L-slot type), however, 2 slots were made to allow for assembly after printing. The 2 slots on the frame fit into 2 slot holes on the gear, once they fit the gear can rotate freely. One of the slots on the frame is made longer than the other, such that after 180 deg rotation the gear cannot be freed due to the large frame slot lining up with the small gear slot hole. However, there still exists the issue concerning a 360 deg rotation where the right sized slots and slot holes line up perfectly, possibly allowing the gear to detach from the frame. For the slot fit tolerance, a distance of 0.3 mm was used. We wish to keep this distance to a minimum to prevent separation of the gear pieces from the frame while rotating.

The bridge between and frames and the nose pieces were merged in the center of the frame. This makes the central point between the frame much stronger. The supports for the nose pads were connected to the central frame bridge and made thicker to avoid breaking (as in the previous iteration).

- Fill of: 15%
- Layer Height: 0.15 mm
- Nozzle diameter : 0.4mm
- Print speed: 25mm/s

- Sliding assembly distance of 1mm (curved) and 0.5mm (flat)
- Slot fit tolerance of 0.3mm
- Supports generated

The resulting prototype proved the designs functionality. The sliding assembly tolerances were ideal and the frame fit sufficiently.

Figure 8: Isometric Front View of Iteration 3

Figure 9:Isometric Back View of Iteration 3

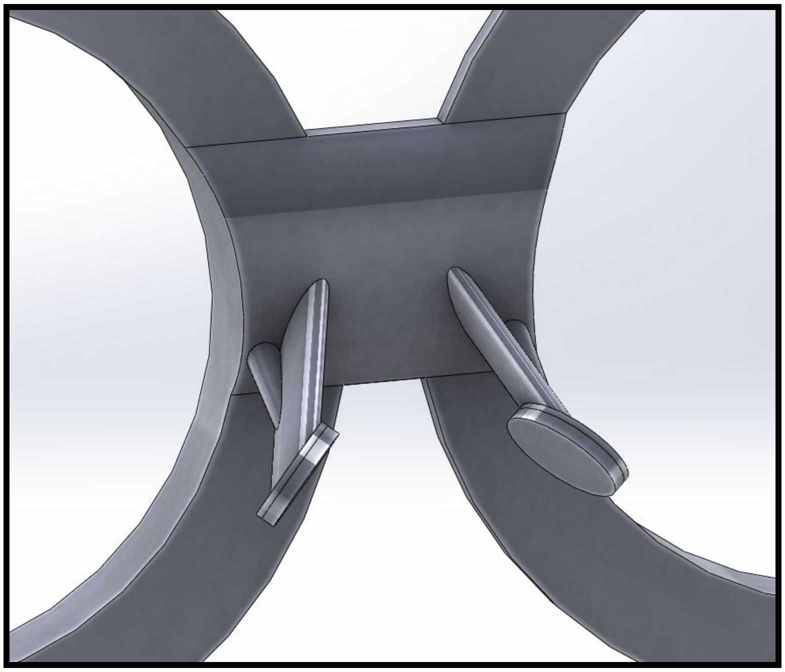

Figure 10: Prototype Modified Support Iteration 3

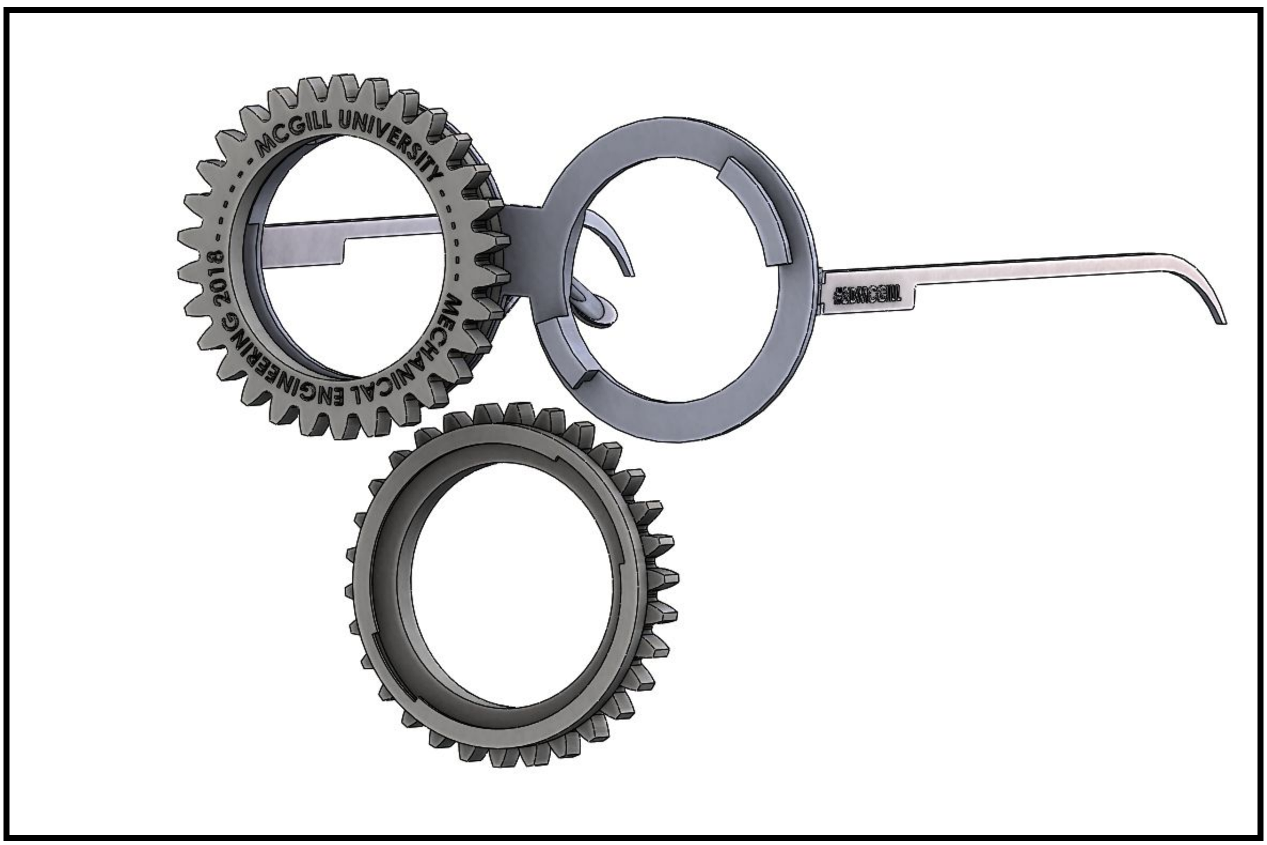

Figure 11: Prototype Slot View of Iteration 3

Conclusion

Apart from difficulties faced in the prototyping process the final product is a success. The glasses fit very well and have a strong construction. To print the models, access them in Solidworks through the “REDOAssembly2.SLDASM” assembly file. All parts can be printed disassembled in the same print command. The printing of the full assembly assembled with a single nozzle is not advised. Instead it is advised to use soluble supports when printing all the parts assembled. The support structure is very much trapped within the L-slot and proves too tough to break by applying a torque to the gears. A further extension to the design could be to use wireframed bodies when printing with a single nozzle printer such that supports can be removed from the internal slot. Overall, the design was a success and resulted in a very entertaining product. All moving components function ideally and the design supports a very amusing aesthetic.

Check out the Final Product on Instagram!
@senmtl