Tecnológico de Monterrey Campus Chihuahua

Mechanical Analysis of SPARC

Training Partner: Resideo

Involved teams:

Wisdom

Justice

Creativity

Temperance

Introduction

The purpose of this project is to make a robot capable of testing various of Resideo's capacitive screens which are embedded in their thermostats, for there are more than 4 different models which require different test cases, which are currently carried out by testing engineers, and each test could take several hours to be completed. SPARC will improve testing significantly.

Resideo's testing modules could weight up to 4 kg, therefore, SPARC must be able to lift this load without forcing the DC Motors or risking the mechanism to break. In the following pages, we will have an in-depth look to this SPARC's Z axis mechanism, because there is where the main load will be acting, and also because it's made up by 2 worm gears, which were seen in the modules of Machine Design.

Analysis

Nowadays, many 3D printers use a worm gear mechanism to be able to move along the Z axis with enough force to support the actuator attached to it. This SPARC's Z axis was design around the same concept, which consists of two worm gear, each one on the 2 parallel face of the robot. Each worm gear has a spindle attached to a 3D printed part which supports the base where the load will be laid.

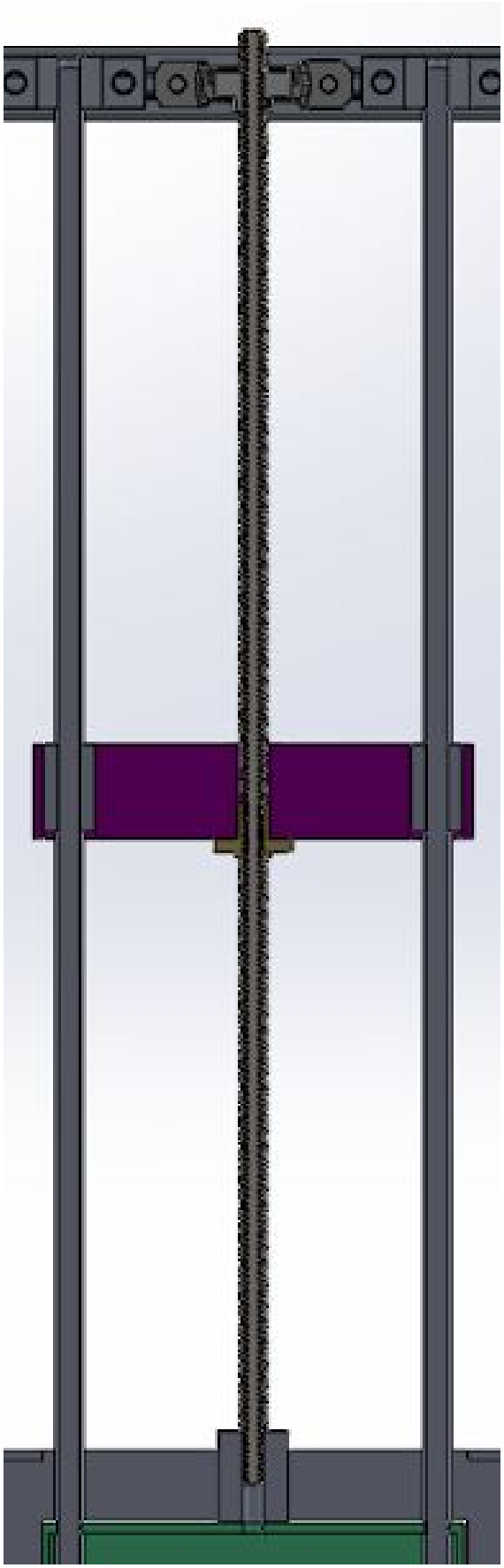
Whenever the worm gear spins, the spindle will move up or down along the gear's axis, depending whether it rotates in a clockwise or counterclockwise manner. To prevent the load from resting totally on the gears, 2 smooth rods were placed at the sides of each gear to distribute the weight and prevent the gear from bending.

In order to keep the analysis simple, many physical factors were not considered because they made the mechanical analysis much complex. Those factors are:

1. The spindle's friction against the gear.
2. The 6 mm acrilic base's bending.
3. The smooth rods and the worm's bending.

At one end, the worm gears rotates freely thanks to a fixed rowlock on the upper frame of the robot, and at the lower end, the gear is attached to a DC motor by a 5x8 coupler. The force diagram of the worm gear can be seen as the following:

2 kg load



$$Nw = 1 \text{ (number of teeth)}$$

$$nw = 62\ rpm \text{ (motor's angular velocity)}$$

$$T = 4.9\ kgf * cm = 48.969N * cm \text{ (motor's torque)}$$

$$dw = 0.2738\ in = 6.954mm \text{ (worm gear diameter pitch)}$$

$$\varnothing n = 14.5° \text{ (pressure angle)}$$

$$L = 2mm \text{ (worm gear axial pitch)}$$

$$\gamma = \frac{L}{\pi * dw} = \frac{2mm}{\pi * dw} = 5.23° \quad \text{(worm gear lead angle)}$$

$$Vw = \pi * dw * nw = 1354.4913\ mm/min = 0.0225\ m/sec \text{ (linear velocity)}$$

Since the DC motor operates at 12V with a max. current of 38 mA we can calculate our electric power (this power is greater than the actual power provided, because it's the ideal electric power, some power may be lost due to the motor's efficiency):

$$P = 12\,(38\ mA) = 0.384Watts = 0.384\ Nm/sec \text{ (electric power)}$$

$$Wwt = \frac{0.384}{0.0225} = 17.066N \text{ (tangential force)}$$

$$Wwt = W^x = WCos\varnothing nSen\gamma$$

$$17.066 = Wcos\,(14.5)\,Sen\,(5.23) \ \ hence, \ \ W = 193.388N \text{ (total force)}$$

$$Wz = WCos\varnothing nCos\gamma - \frac{9.81*4}{2} = 166.828N$$

$$Wy = WSen\varnothing n = 48.4204N$$

$$Wz\ (in\ kilograms) = \frac{166.828}{9.81} = 17.005\ Kgf \text{ on each worm gear.}$$

$$Factor\ of\ safety = \frac{34.01}{4} = 8.50$$

Conclusion

Based on the obtained calculations it is safe to say that the SPARC machine is able to easily support and operate with the required load of 4 kilograms, in addition, the selected mechanism turned out to be resistant enough for the task, the reason being that the Factor of Safety (F.S.) is greater than 8, which means that it can operate with 8 times the weight of the required load without failing.

However, it is important to keep in mind that the previous calculations do not take into consideration several conditions, such as worm gear bending and friction, which is minimum for this application. Furthermore, the bending produced inside the plaque is not

being taken into consideration as well, so a fracture of the acrylic plaque is possible, that is why we not recommend to exceed the required 4 kilograms.