Design report – Darian Irani

Aim: To design adaptors for the Instron 50kN 2580 series Static Load Cell for the 'two-bite test' conducted on a Medicated Chewing Gum (MCG). Each adaptor is designed with three human molar teeth from the maxillary and mandibular jaws. Given that the human maxillary jaw is fixed, three different designs of the mandibular jaw are designed and manufactured for further data analysis of mastication efficiency. These three different designs are to be compared with existing data from past research papers, the humanoid chewing robot and an optimal average Frankfurt-Mandibular (FM) angle of the jaw. Data gathered via the 'two-bite test' experiment on the flat (0 degree) mandibular jaw adaptor will be compared with experiments done in the past by other researchers, the 25 degree angled adaptor will be used for a discussion relating to the optimal FM angle, and data gathered by the 29.1 degree angled adaptor will be compared to existing data from the humanoid chewing robot.

Design process and modifications: The molar teeth and adaptors for the Instron machine need to be manufactured in stainless steel/aluminum before conducting the two-bite test. An initial CAD design of the adaptors and its teeth was first created on Siemens NX software. The design of the teeth was provided by Dr. Kazem Alemzadeh and the dimensions of each adaptor was found through many measurements conducted on the Instron machine. Vernier calipers were used to accurately measure dimensions such as the adaptor shaft diameter, pin hole diameter, etc. as seen in Figure 1.

Figure 1: Instron 50kN 2580 series Static Load Cell

Once the dimensions of the adaptors were recorded, a CAD design was made on NX, the next step was to correctly align the mandibular and maxillary jaw adaptors via 'assembly modelling' on NX, as seen in Figure 2. Both adaptors were aligned through trial and error via many assembly constraints, a CAD representation of an MCG with its respective dimensions was also made and assembled onto the teeth to visualize the alignment with better accuracy. This step was very important as mis-aligned teeth could lead to inaccurate force readings on the MCG or the teeth from both adaptors could come in contact, leading to permanent damage of the teeth. The teeth were designed to sit in the adaptor with an interference fit to prevent any unwanted movement or rattling while the experiment took place. As a result, the 'assembly cut' feature was used on NX to make sure the design mitigated any risks of incorrect fit, as seen in figure 3.

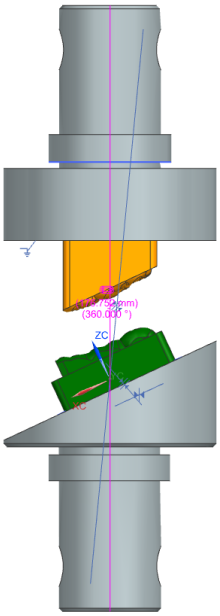

Figure 2: Alignment of maxillary and mandibular adaptor assembly

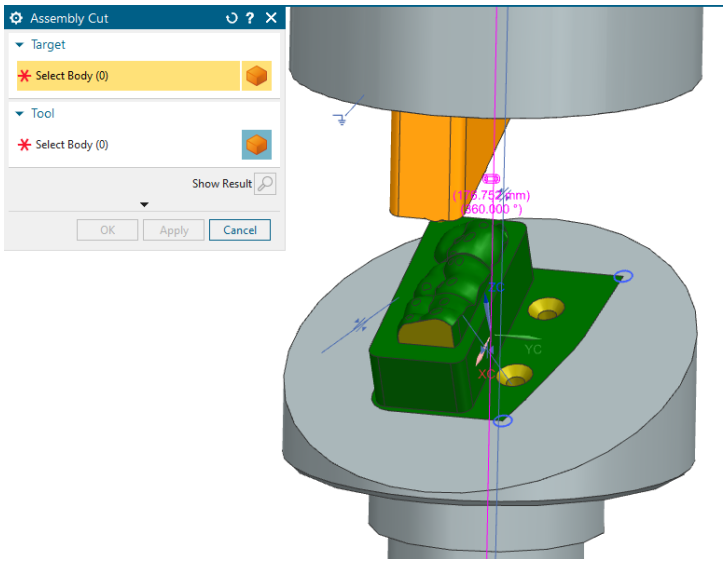

Figure 3: Assembly cut of teeth into the surface of the adaptor to mimic an interference fit

After the assembly of both adaptors on NX, a rapid prototyping stage was needed to validate the integrity of the chosen dimensions for the adaptors and teeth before the engineering drawings were produced. As a result, 3D printed models of all 3 designs of the adaptors and its teeth were printed for it to be fitted on the Intron machine to check for correct fitting, as seen in figure 4.

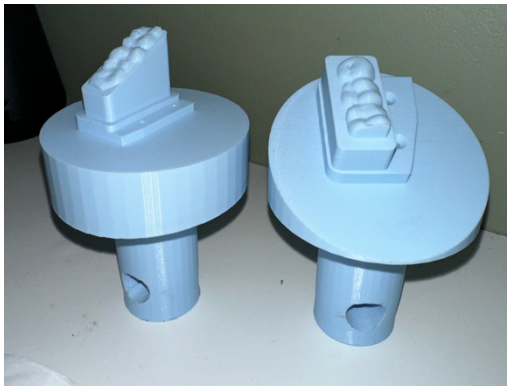

Figure 4: 3D printed model of maxillary and 29.1 degree mandibular adaptors

Upon testing the fit of the 3D printed 25 and 29.1 degree adaptors on the Instron machine, it was found that an edge of both sets of teeth collide with each other before an MCG can be properly compressed, as seen in Figure 5. The pin diameter was also designed to be smaller than it should be. Lastly, the engraved part of the adaptors which fits the teeth was made to be too big for the teeth and as a result the teeth sat too loosely in the adaptor cavity. Figure 6 displays the errors in preliminary design through the need for a bit of paper to lock the teeth in the adaptor cavity, and the use of a pencil instead of an Instron machine pin to prevent the adaptors from rotating too much.

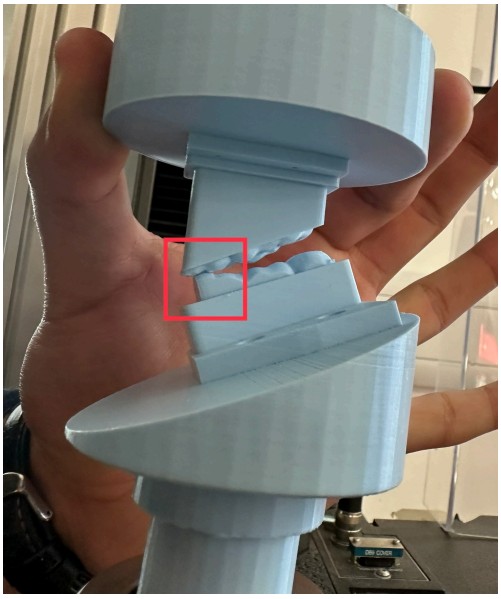

Figure 5: Collision of teeth on the 25 degree mandibular and maxillary adaptors

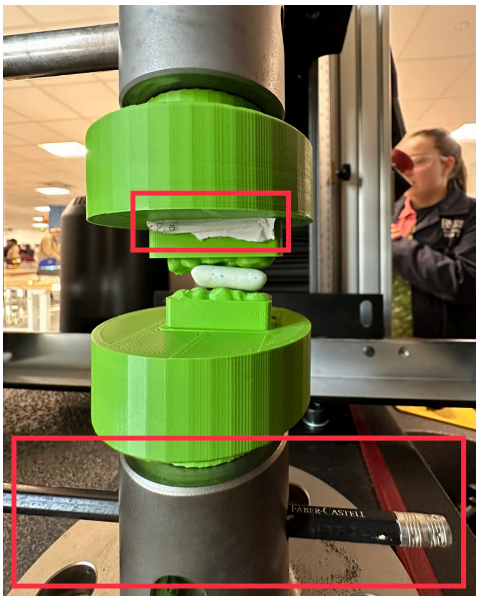

Figure 6: Irregular fitting of Instron pin on adaptor and loose fit of teeth on adaptor

The errors were fixed on NX and then correct versions of the adaptors were re-printed and tested for fitting again. The next step was to identify up to what length the Instron machine is to compress the MCG for the two-bite test. Based on past experiments, if the MCG is 75% compressed it is considered as a valid 'bite'. Figure 7 displays the preliminary tests conducted on different MCGs using the Instron machine to determine what 75% compression looks like. This preliminary test was important to determine at what displacement value the Instron machine is meant to stop from datum. An incorrect setting of the displacement value mimicking the 'bite' could result in inaccurate force readings or damage of the teeth.

Figure 8 displays a summary of the design process in the making of both mandibular and maxillary jaw adaptors for the Instron machine.

Figure 7: Compressed MCGs

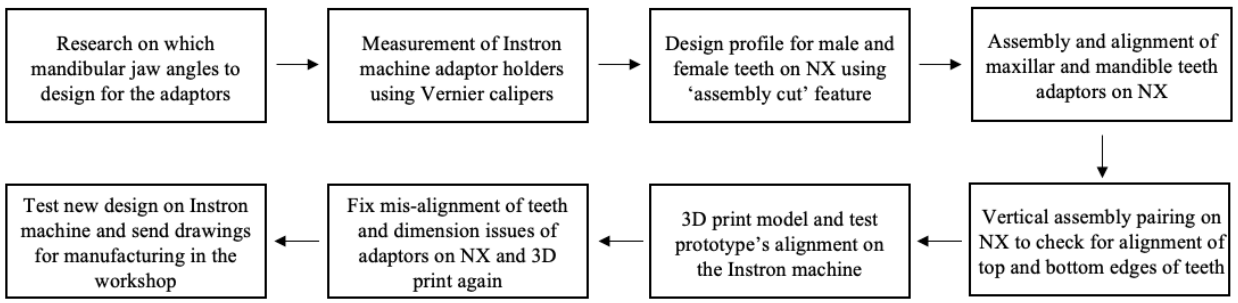

Figure 8: Overall design process