RMIT University

School of Science, Engineering & Technology (SSET)

MANU2474 – Computer Integrated Manufacturing

MANU2474 - Group Project
CAM works

Topic: Blow Molding Water Bottle Design

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1) Introduction

In our final group project, it is the requirement to construct blow-molding molds to create the plastic bottles. The bottles would be independently selected by each group, on the condition that the volume of bottle is between 100 ml (about 3.38 oz) to 330 ml (about 11.16 oz).

Blow - Molding is the process of manufacturing hollow objects by pushing air to flatten the object inside molds. The steps of blow molding method are elaborately discussed below [1]:

- Melt the materials, which are plastic.
- Reshape the molten plastic into parison.
- Close the two ends of molds, leave the small area for air to go in.
- Flatten the plastic in the desired shape.
- Cool the product, then remove it from molds.
- Cut the redundant parts of product if necessary.

The lifespan of mold depends on the rate of production and the maintenance. It can last up to 20 years if it is well-preserved [2]. There is another method called Injection Molding, but it cannot be used in creating large bottles, so the Blow Molding method is more popular. PET (Polyethylene Terephthalate) is the common choice of material.

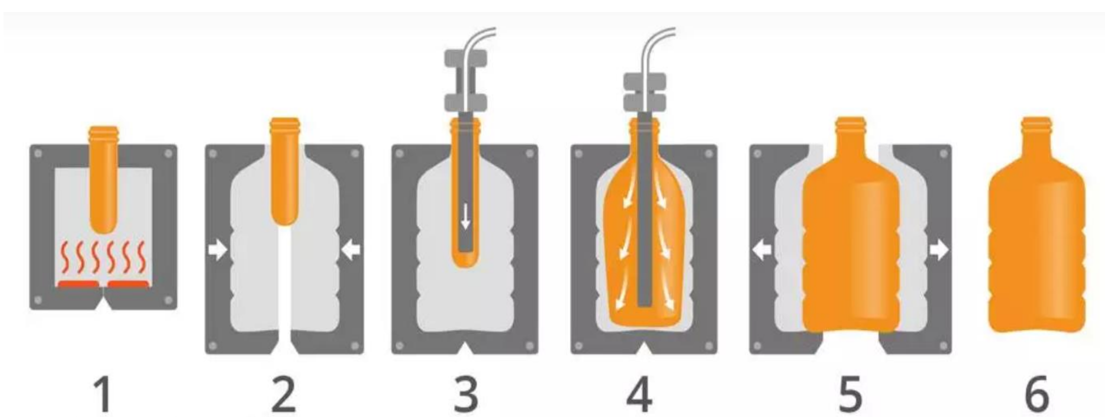

Figure 1. Extrusion blow molding for a 2-part mold

In this report, the main purpose is to invent the G-code language to manufacture molds, including the description about the estimated time and cost during the processing operation.

The other steps of the process such as melting plastic materials, cooling the final product, etc. will not be discussed so far in this document. The chosen bottle to be machined is Fujiwara water bottle, which has the capacity of 330 ml (Figure 2).

2) Bottle design

Figure 2. 300ml Fujiwa Water Bottle

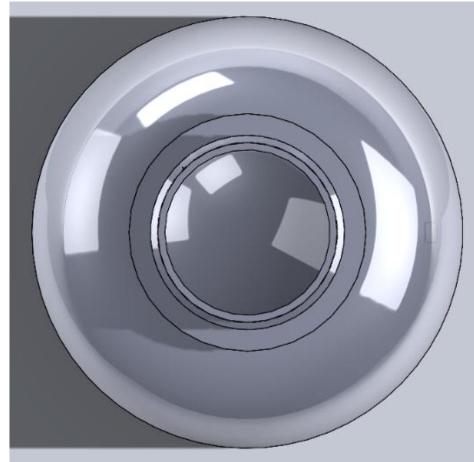

Figure 3. Top view of the bottle

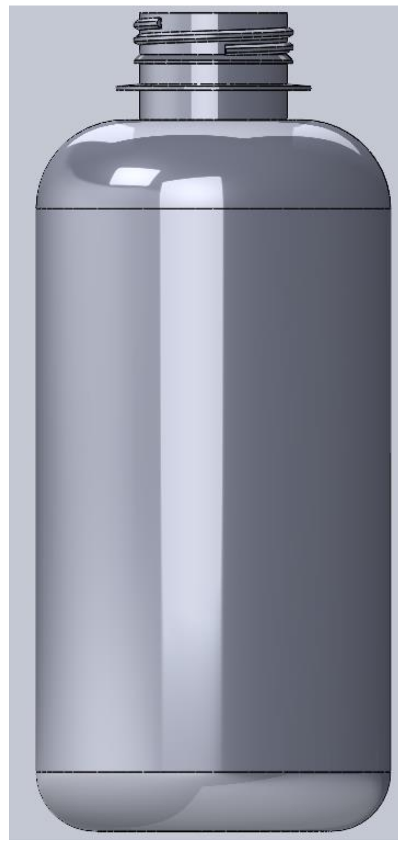

Figure 4. Front view of the bottle

Figure 5 Isometric view of the bottle

The design of the bottle is very simple, which can be separately divided into two main sections: the body and the cap. The main body is 120mm in height, with the diameter is 60 mm. The top part of bottle where the cap is placed is 18mm in height and 25mm in diameter. Therefore, the total height of the bottle is 138mm. The thread of the cap has the dimension of pitch of 2.5mm and the dimension of the revolution of 1.85. The thickness of the bottle is manually measured, which is around 0.05mm, same as most of the bottle design nowadays [3]. Nonetheless, the thickness of the bottle must be less than a placeholder, since it is depended on the Parison thickness and the configuration data of blow machine. Figure 3,4 and 5 above illustrate clearly the design of the Fujiwa bottle in SolidWorks software.

3) Mold Design

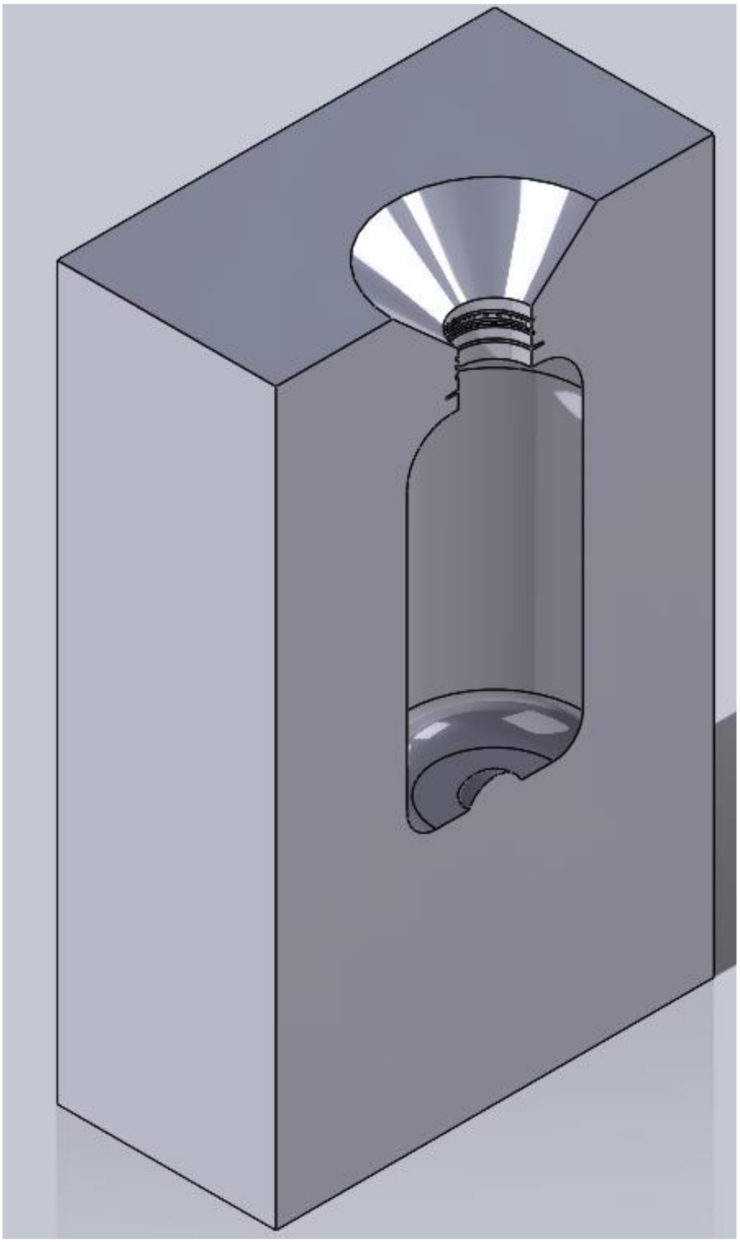

Figure 6 Isometric view of the mold 1

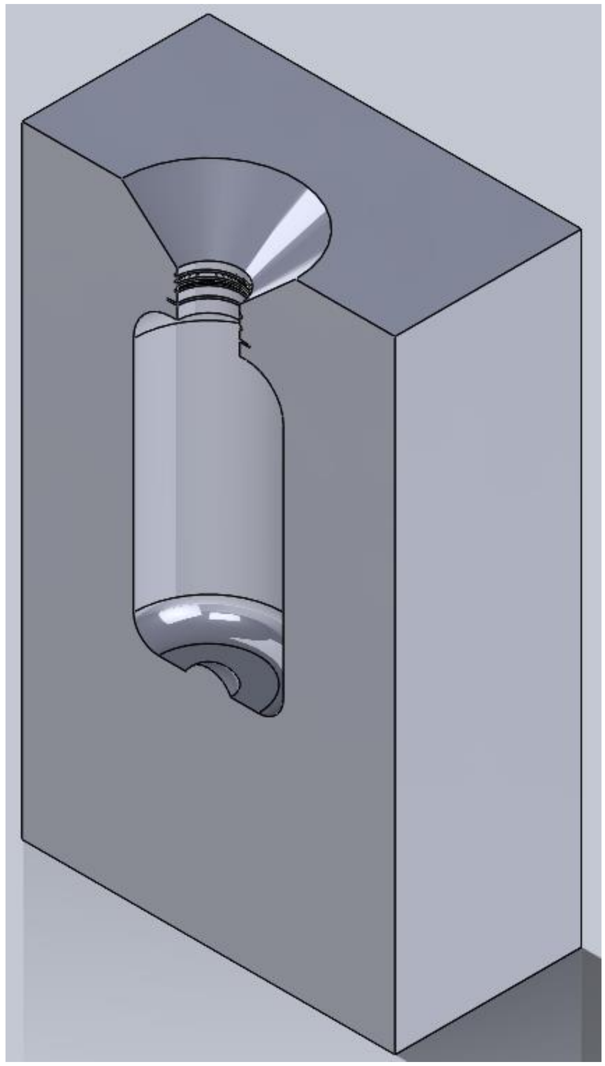

Figure 7. Isometric view of mold 2

When completing the drawing of the bottle in SolidWorks, we need to machine the molds. The mold consists of two parts, and each part must be smaller than the 150 mm x 150 mm x 250 mm rectangular block. With the requirement of the shrinkage coefficient of 0.4% when cooling, the size of the mold needs to be scaled up to 1.004 compared to the original size. In addition, a 70-millimeter diameter hole for placeholder and parison is created. Then, the CAD design of mold will be produced based on the design of bottle.

The process of drawing mold is quite straightforward, except for the contour shape of the mold requires the subtraction function in combination with the extrusion feature. Then, the finished CAD design of mold is extracted to SolidWorks CAM software to simulate the milling process and generate the G-code language. Overall, left mold and right mold have the same dimensions of 150mm in width, 75mm in length, and 250mm in height.

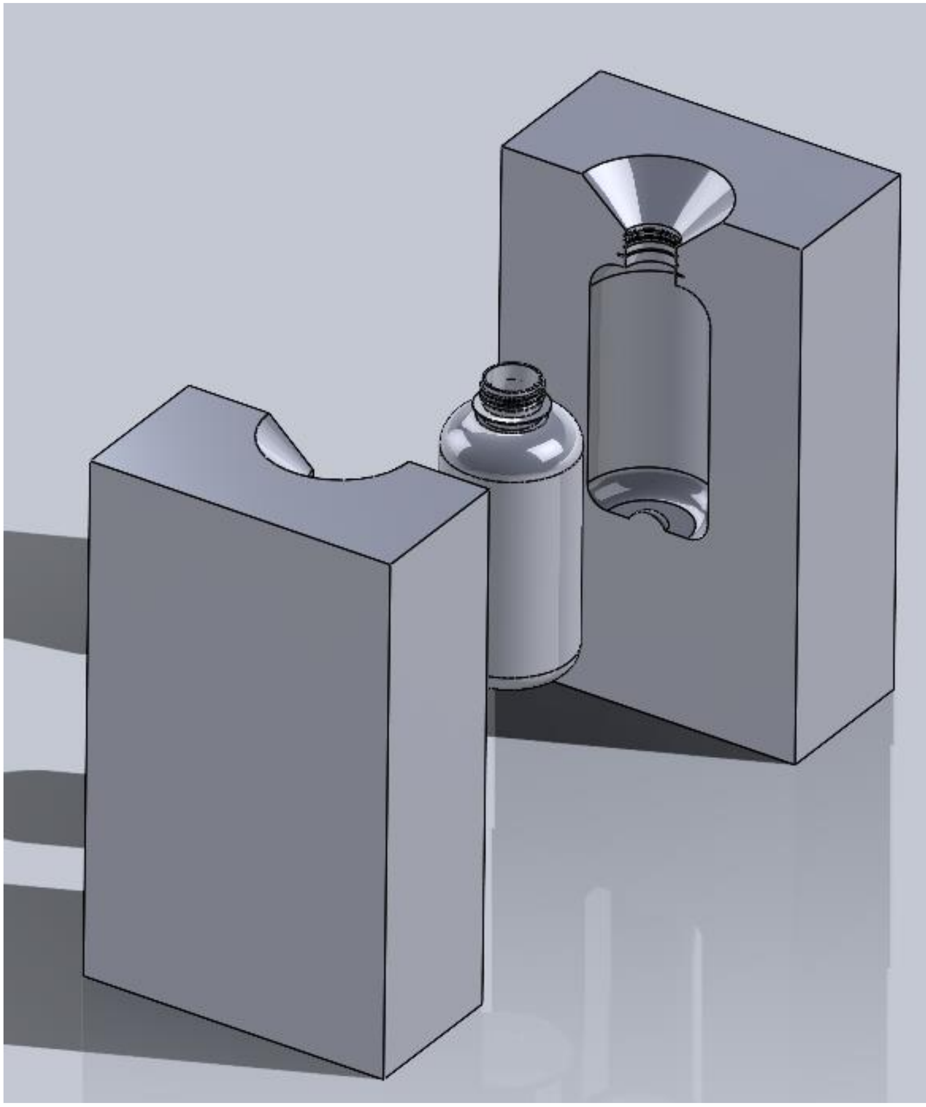

Figure 8. Bottle and molds design

4) SolidWorks CAM

Due to its offer of multiple HSM (High–speed machining) and HSR (High-speed Roughing), the official SolidWorks CAM is our primary tool in developing CAM design for our project. Moreover, this tool also provides us an improved Calculation, Updated stock, and fine-tuning features, all of which are very useful in visualizing and furthering the process. Because there are no required conditions on the milling operation, the default option "MILL TUTORIAL" will be applied.

Tool used

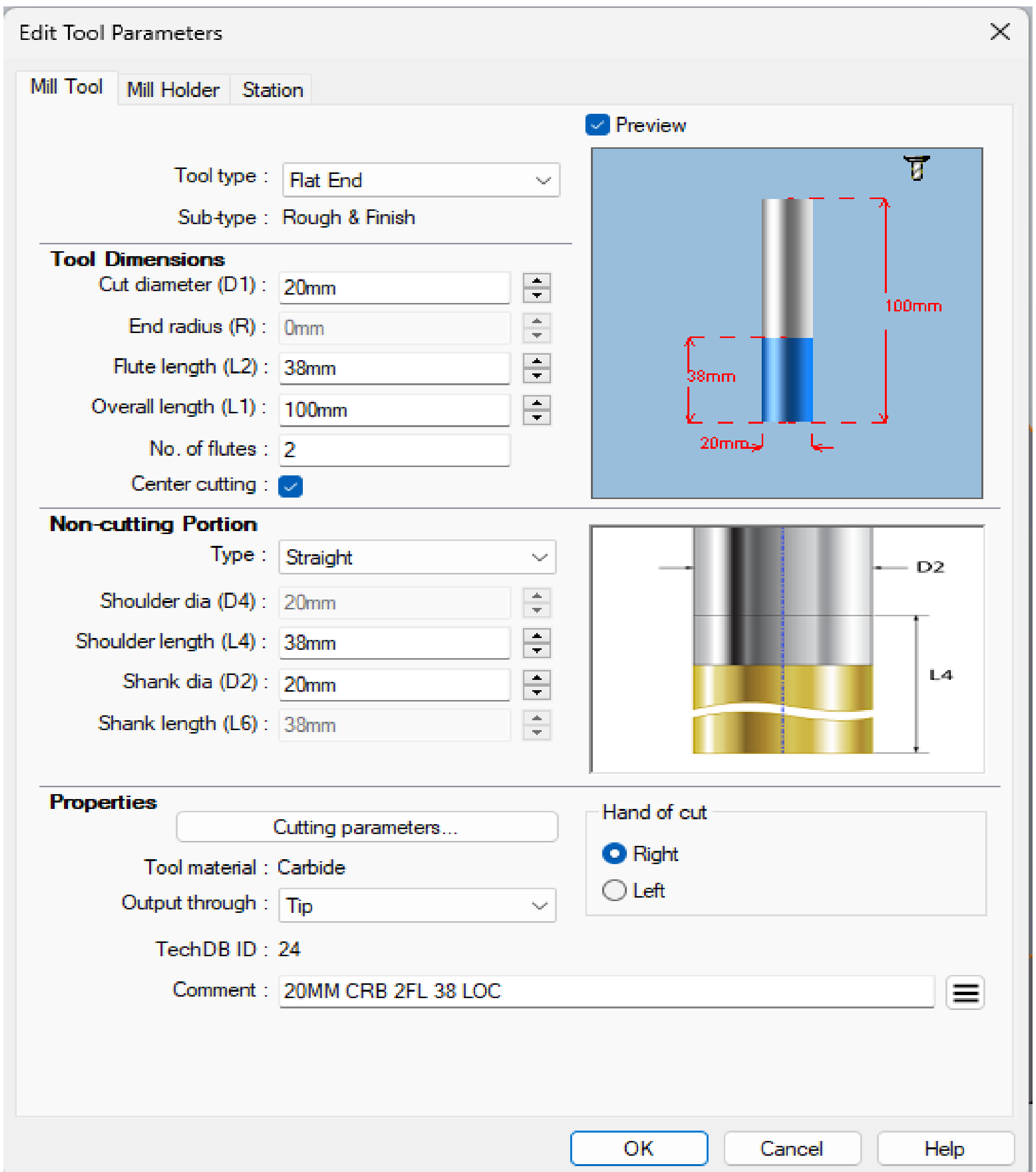

Figure 9. Flat End for Milling

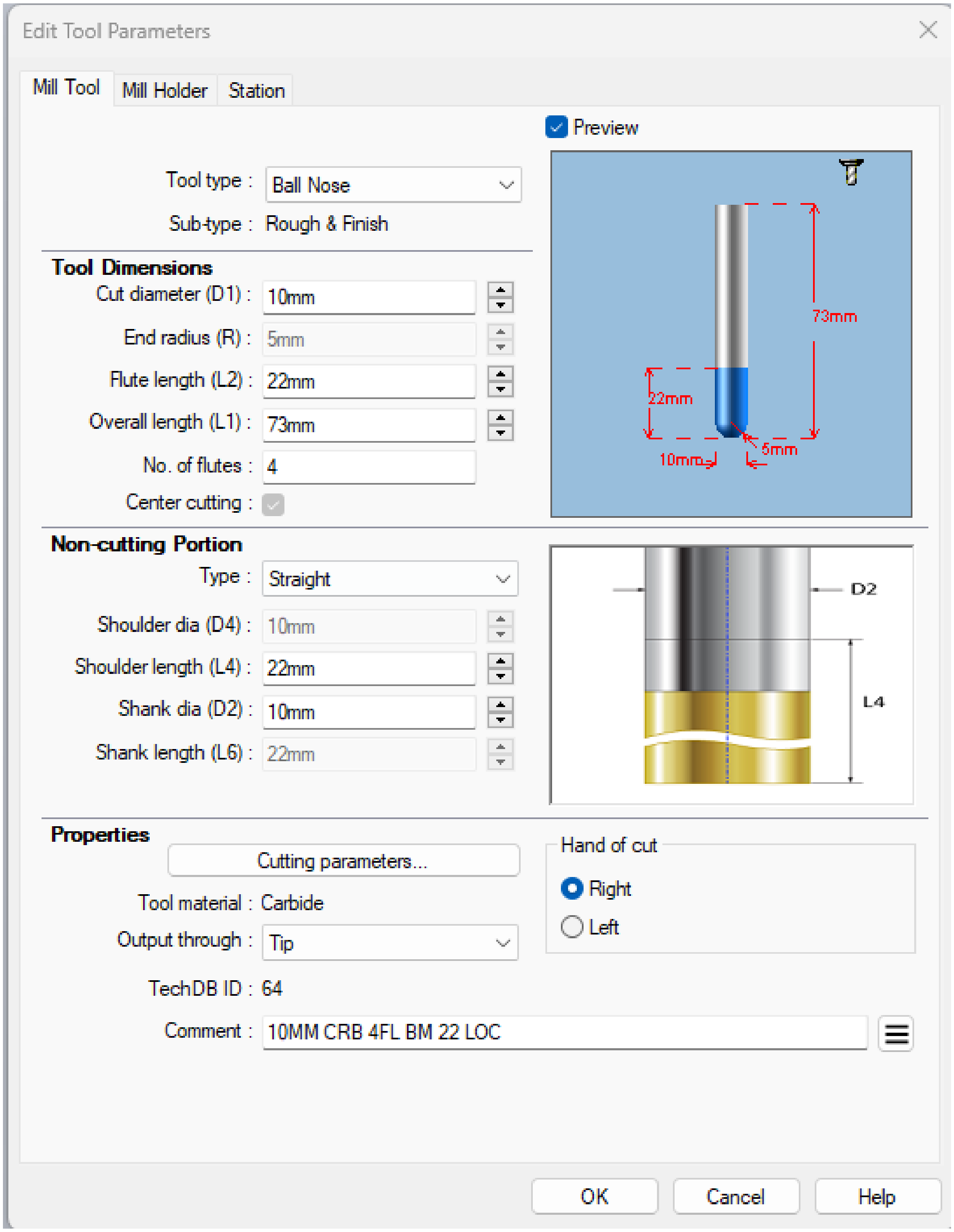

Figure 10. Ball Nose for Finish

Description for choice of tool

To be able to cut the mold properly, we choose material of milling and drilling tool that have a level hardness higher than the mold material.

- For Mill and Finish tool is Carbide, Brinell hardness index for it is 1433 [4].

- For Mold is 6061-T6 aluminum alloy, Brinell hardness index for it is 71 [5].

As can be seen clearly, by using material with higher hardness level, drilling and milling will be easier, and the durability will also be extended.

Milling tool:

- Flat end: The main purpose of this tool is area clearance. We chose flat end miller since our mold design has part where processing areas need to be mill perpendicularly.

- Ball nose: Round end shape is suitable for surface treatment, trimming rough parts and fixing residues that cannot be handled by flat end miller.

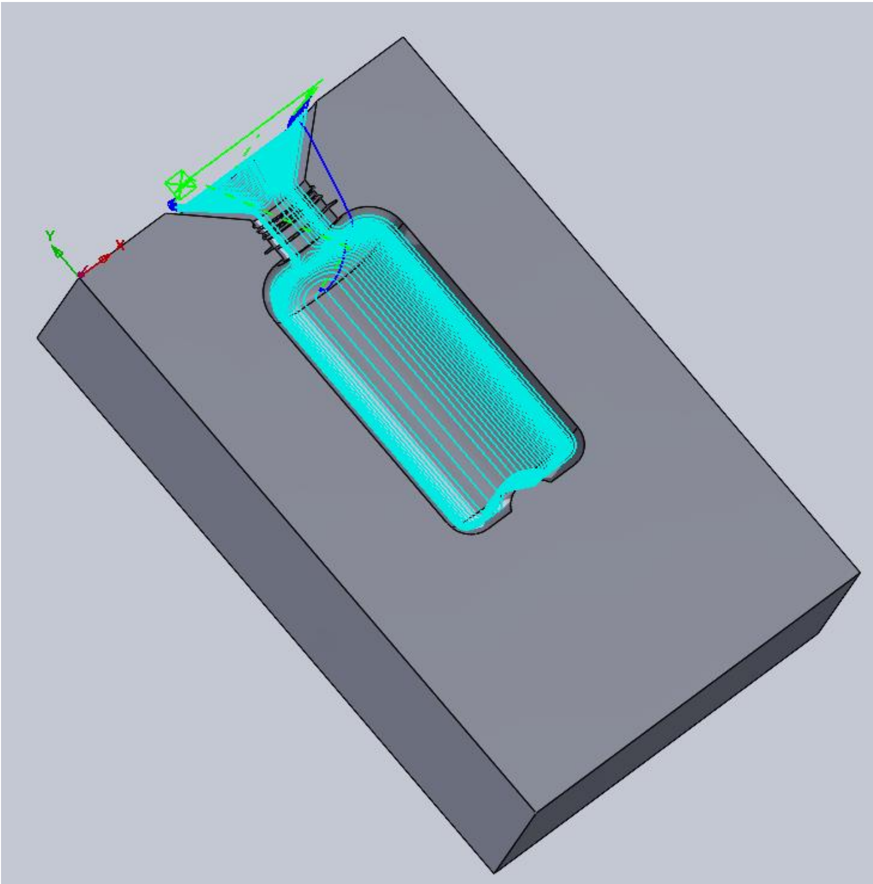

Figure 11 Isometric view of the updated stock

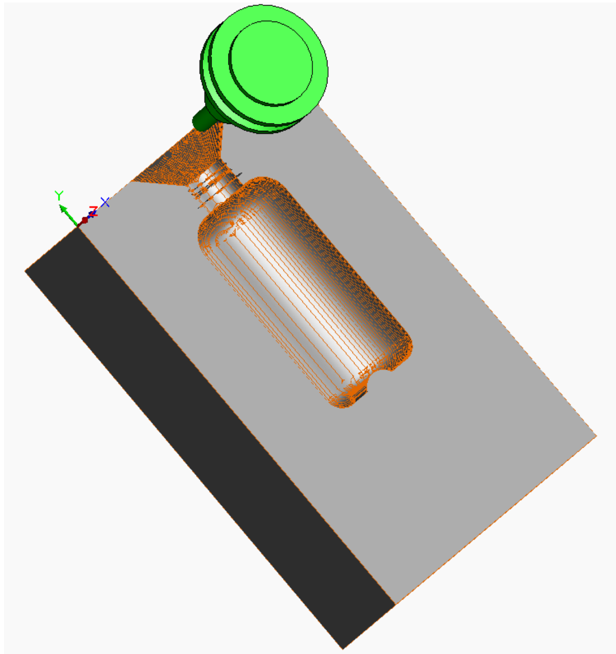

Figure 12 SolidCam simulation

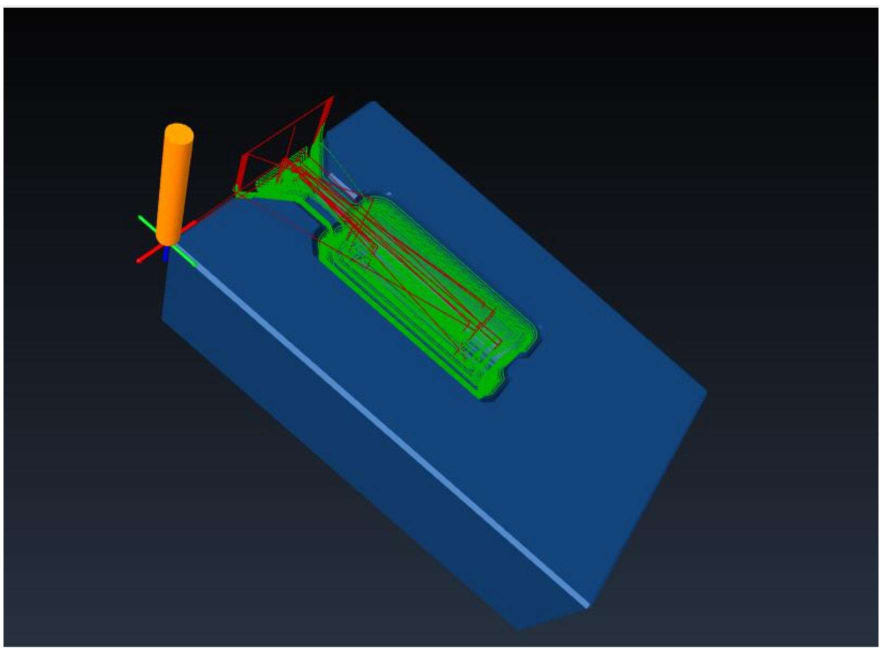

Figure 13.G-code simulation on CAMotics

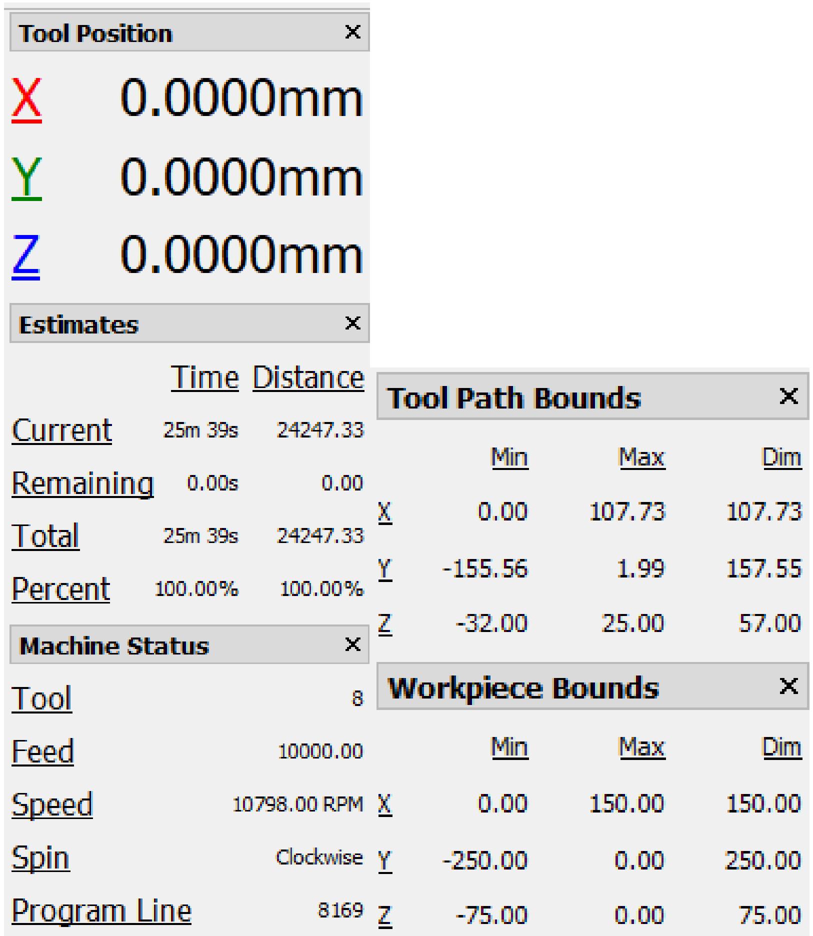

Figure 14. Simulation Data

CAM process is divided into two segments: Drilling and CNC milling. The top surface Coordinate system is set to drill the blow pin hole as well as for the front facing for CNC milling process. The task provides a 12mm twisted drill for drilling process with feed rate of 10000 mm/min. We anticipated a result of 10mm, 12mm and 16mm face end mill at the end of CNC milling process.

Overall, result surface is not smooth as anticipated, there are many spots on the mold that lack of polish. With many attempts to revamp the error to trim the remaining surface, we conclude that a smaller milling tool would develop a smoother mold surface, suggested a typical 6mm end mill can cover the issue.

Moreover, the performance will be examined with caution to avoid any collision. Afterwards, the tool path is exported to G-code files to simulate on CAMotics for a better estimate of finishing time.

In conclusion, the estimated finish time for 1 mold is 25 minutes and 39 seconds. Hence the finishing time for both molds is 51 minutes.

5) Conclusion

In conclusion, the process of machining molds involves two main tasks: design the mold in SolidWorks, and then extract that drawing in the SolidWorks CAM to simulate the CNC and generate the G-code. The total time of simulation for whole concept takes about 4 hours and 48 minutes. This amount of time can vary in real life accordingly on how fast the machine functions and how skilled labor is. In future, the processing time will be shortened, and mold quality will increase due to the variation and better type of machining tools.

6) Reference

[1] "Which blow molding process is ideal for your bottle?," 3 Main Types of Blow Molding Process and Examples | CHIA MING Blow Molding Machine Company, https://www.cm-pet.com/msg/msg58.html#:~:text=Although%20there%20are%20considerable%20differences,air%20can%20enter%3B%20(4) (accessed Sep. 22, 2023).

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[3] M. G. Malhotra, “How to test the wall thickness of PET bottles,” prestogroup. [Online]. Available: https://www.prestogroup.com/articles/how-to-test-the-wall-thickness-of-pet-bottles/. [Accessed: 18-Sep-2022].

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