

# MANU2474 Computer Integrated Manufacturing – CAM Works

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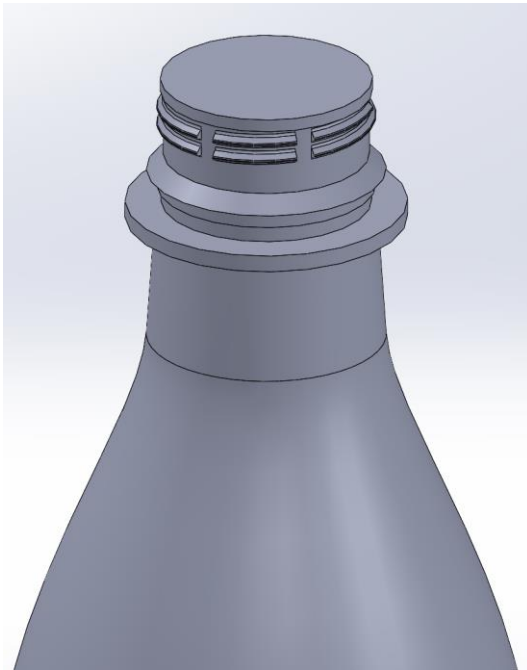
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- **Reverse engineering design of a plastic bottle in Solidworks**

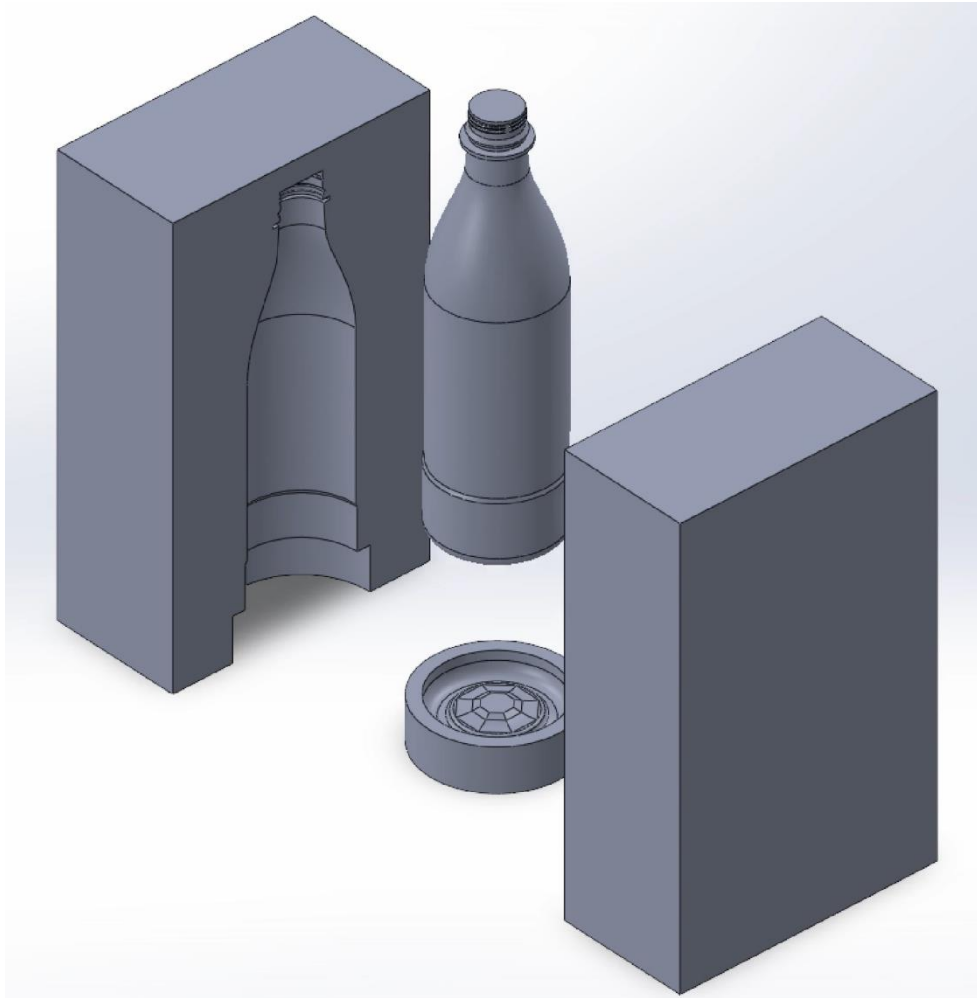
In the first stage of our design, the 3D model of a plastic bottle having a capacity of **500 ml** will be constructed in Solidworks.





- **Final design of molds for the bottle**

The 3D models of molds for the plastic bottle are designed based on the assumption that the bottle is made of PET with a shrinkage coefficient of 0.4% when cooling. Therefore, the molds will have a clearance of 0.4% compared with the actual size of the PET plastic bottle.



## - Tools

Our molds would be made of Aluminum 6061-T6 and machined from a rectangular block of 150mm x 150mm x 250mm. The complex patterns at the bottom, as well as the bottle thread, requires specific tooling products available in the market. These tools are provided in the tables below.

Because the bottle is non-conventional shape or designed with deep, narrow cavities that are difficult to reach, we use 3 axis mill operations.

### Bottom Mold's Tools

No.	Tools	Products	Links	Description
1	Flat end 16 mm 4 flutes	16MM CRB 4FL 32 LOC	<a href="https://www.ebay.co.uk/itm/271596869640">https://www.ebay.co.uk/itm/271596869640</a>	We use the large tool to make space for the smaller tool to cut easier and faster. Hence, it can save time

2	Ball nose 6 mm 4 flutes	6MM CRB 4FL BM 9 LOC	<a href="https://m.vi.aliexpress.com/item/32813382722.html?gatewayAdapt=glo2vnm">https://m.vi.aliexpress.com/item/32813382722.html?gatewayAdapt=glo2vnm</a>	Create details inside the mold and Make the surface of the mold become smoother.
3	Ball nose 4 mm 4 flutes	4MM CRB 4FL BM 14 LOC	<a href="https://www.ebay.com/itm/275425892464">https://www.ebay.com/itm/275425892464</a>	Make the surface of the mold become smoother.
4	Ball nose 1 mm 4 flutes	1MM CRB 4FL BM 4 LOC	<a href="https://vn.misumi-ec.com/vona2/detail/223000580426/?list=PageCategory">https://vn.misumi-ec.com/vona2/detail/223000580426/?list=PageCategory</a>	Make the surface of the mold become smoother, especially the small details that larger tools hard to reach.
5	Hog end tapered 6 degrees 5x1 mm	5MM TAPERED HOGENDMILL 8 DEG TAPER	<a href="https://vn.misumi-ec.com/vona2/detail/223000569423/?list=PageCategory">https://vn.misumi-ec.com/vona2/detail/223000569423/?list=PageCategory</a> <a href="https://vn.misumi-ec.com/vona2/detail/223000580471/?list=PageCategory">https://vn.misumi-ec.com/vona2/detail/223000580471/?list=PageCategory</a> <a href="https://vn.misumi-ec.com/vona2/detail/223000569412/?list=PageCategory">https://vn.misumi-ec.com/vona2/detail/223000569412/?list=PageCategory</a>	Make the surface of the mold become smoother.

### Side Mold 1 Tool

No.	Tools	Products	Link	Description
1	Hog nose tapered 5x1 mm 6 degrees	5MM TAPERED HOGENDMILL 6 DEG TAPER	<a href="https://conicalendmills.com/cutting-tools/special-application-end-mills/tapered-end-mill-hss/6-degree-tapered-end-mill-hss/">https://conicalendmills.com/cutting-tools/special-application-end-mills/tapered-end-mill-hss/6-degree-tapered-end-mill-hss/</a>	Main tool used to create the major portion of the bottle-shaped pocket.

2	Ball nose 3mm 4 flutes	3MM CRB 4FL BM 6 LOC	<a href="https://www.ebay.com/itm/312900498357">https://www.ebay.com/itm/312900498357</a>	Make the surface of the mold become smoother.
3	Bore 1mm	ADJUSTABLE BORE 1MM - 12.7MM	<a href="https://www.amazon.co.uk/Drill-Ground-Drills-AllTrade-Direct/dp/B00S4Z8KPA">https://www.amazon.co.uk/Drill-Ground-Drills-AllTrade-Direct/dp/B00S4Z8KPA</a>	Good length & small diameter to machine the bottle thread
4	0.5mm jobber drill	0.5mm JOBBER DRILL	<a href="https://www.ebay.com/itm/METRIC-Twist-Drills-HSS-10-Each-6-Sizes-0-5mm-1-0mm-Jobber-Drill-Bits-60-Pcs-/190810963818">https://www.ebay.com/itm/METRIC-Twist-Drills-HSS-10-Each-6-Sizes-0-5mm-1-0mm-Jobber-Drill-Bits-60-Pcs-/190810963818</a>	It is used for small and inclined details.
5	Ball nose 2mm	2MM CRB 4FL BM 4 LOC2MM CRB 4FL BM 4 LOC	<a href="https://www.ebay.com.au/itm/263470320009">https://www.ebay.com.au/itm/263470320009</a>	It is used for small details to slightly decrease the machining time.
6	Ball nose 0.5mm	0.5MM CRB 2FL BM 3 LOC	<a href="https://www.ebay.com/itm/264303791215?var=563888136020&amp;noover=1&amp;mkevt=1&amp;mkrid=21581-161791-616585-7&amp;mkcid=2&amp;itemid=563888136020_264303791215&amp;targetid=1706872446233&amp;device=m&amp;mktype=pla&amp;googleloc=1028581&amp;poi=&amp;campaignid=18186401895&amp;mkgroupid=1384619828">https://www.ebay.com/itm/264303791215?var=563888136020&amp;noover=1&amp;mkevt=1&amp;mkrid=21581-161791-616585-7&amp;mkcid=2&amp;itemid=563888136020_264303791215&amp;targetid=1706872446233&amp;device=m&amp;mktype=pla&amp;googleloc=1028581&amp;poi=&amp;campaignid=18186401895&amp;mkgroupid=1384619828</a>	Very high performance for tiny features, in exchange of longer machining time.

			<a href="https://www.ebay.com/itm/1706872446233?abclid=&amp;merchantid=119648210&amp;gbraid=0AAAAADQDh9dcDiRwcFNj7x5MLDOsSkqZ&amp;qclid=CjwKCAjwyaWZBhBGEiwACslQo7b_ixj8kYxgB8lB4IN2RFHeH6dWc-LUm8gmoWkaY_dvOgMC9lfPMhoCrbIQAvD_BwE">97&amp;rlsarget=pla-1706872446233&amp;abclid=&amp;merchantid=119648210&amp;gbraid=0AAAAADQDh9dcDiRwcFNj7x5MLDOsSkqZ&amp;qclid=CjwKCAjwyaWZBhBGEiwACslQo7b_ixj8kYxgB8lB4IN2RFHeH6dWc-LUm8gmoWkaY_dvOgMC9lfPMhoCrbIQAvD_BwE</a>	
7	Ball nose 1mm	1MM CRB 4FL BM 4 LOC	<a href="https://www.ebay.com.au/itm/263470320009">https://www.ebay.com.au/itm/263470320009</a>	It is used for tiny features and more suitable and cleaner than other tools.
8	Flat end 4mm	4MM CRB 4FL 8 LOC	<a href="https://www.amazon.com/Cutting-4Flutes-Tungsten-Endmills-4mmDia%C3%974mmShank%C3%9775mmOAL/dp/B01C5BIYL8">https://www.amazon.com/Cutting-4Flutes-Tungsten-Endmills-4mmDia%C3%974mmShank%C3%9775mmOAL/dp/B01C5BIYL8</a>	It is used for surface smoothing at corners

### Side Mold 2 Tools

No.	Tools	Products	Link	Description
1	Ball nose 3mm 4 flutes	3MM CRB 4FL BM 6 LOC	<a href="https://www.ebay.com/itm/312900498357">https://www.ebay.com/itm/312900498357</a>	It is used for medium features with smoother surface finish.
2	Bore 1mm	ADJUSTABLE	<a href="https://www.amazon.co.uk/Drill-Ground-">https://www.amazon.co.uk/Drill-Ground-</a>	Good length & small diameter

		BORE 1MM - 12.7MM	<a href="https://www.ebay.com/itm/ME-TRIC-Twist-Drills-HSS-10-Each-6-Sizes-0-5mm-1-0mm-Jobber-Drill-Bits-60-Pcs-/190810963818">Drills-AllTrade-Direct/dp/B00S4Z8KPA</a>	to machine the bottle thread.
3	0.5mm jobber drill	0.5mm JOBBER DRILL	<a href="https://www.ebay.com/itm/ME-TRIC-Twist-Drills-HSS-10-Each-6-Sizes-0-5mm-1-0mm-Jobber-Drill-Bits-60-Pcs-/190810963818">https://www.ebay.com/itm/ME-TRIC-Twist-Drills-HSS-10-Each-6-Sizes-0-5mm-1-0mm-Jobber-Drill-Bits-60-Pcs-/190810963818</a>	It is used for obstructed locations with small, inclined features.
4	Hog nose tapered 5x1 mm 6 degrees	5MM TAPERED HOGENDMILL 6 DEG TAPER	<a href="https://conicalendmills.com/cutting-tools/special-application-end-mills/tapered-end-mill-hss/6-degree-tapered-end-mill-hss/">https://conicalendmills.com/cutting-tools/special-application-end-mills/tapered-end-mill-hss/6-degree-tapered-end-mill-hss/</a>	Main tool used to create the major portion of the bottle-shaped pocket.
5	Ball nose 2 mm	2MM CRB 4FL BM 4 LOC	<a href="https://www.ebay.com.au/itm/263470320009">https://www.ebay.com.au/itm/263470320009</a>	It is used for small details to slightly decrease the machining time.
6	Ball nose 0.5x0.25 mm	0.5MM CRB 2FL BM 3 LOC	<a href="https://www.ebay.com/itm/264303791215?var=563888136020&amp;norover=1&amp;mkevt=1&amp;mkrid=21581-161791-616585-7&amp;mkcid=2&amp;itemid=563888136020_264303791215&amp;targetid=1706872446233&amp;device=m&amp;mktype">https://www.ebay.com/itm/264303791215?var=563888136020&amp;norover=1&amp;mkevt=1&amp;mkrid=21581-161791-616585-7&amp;mkcid=2&amp;itemid=563888136020_264303791215&amp;targetid=1706872446233&amp;device=m&amp;mktype</a>	Very high performance for tiny features, in exchange of longer machining time.

			<a href="https://www.google.com/search?q=pla&amp;googlelo c=1028581&amp;p oi=&amp;campaigni d=181864018 95&amp;mkgrou pid=1384619828 97&amp;rlsatarget= pla- 17068724462 33&amp;abcl d=&amp;m erchantid=119 648210&amp;gbrai d=0AAAAAD QDh9dcDiRwc FNj7x5MLDOs sKqZ&amp;gclid=Cj wKCAjwyaWZ BhBGEiwACsl Qo7b_ixj8kYx gB8IB4IN2RF HeH6dWc- LUm8gmoWK aY_dvOgMC9I fPMhoCrbIQA vD_BwE">=pla&amp;googlelo c=1028581&amp;p oi=&amp;campaigni d=181864018 95&amp;mkgrou pid=1384619828 97&amp;rlsatarget= pla- 17068724462 33&amp;abcl d=&amp;m erchantid=119 648210&amp;gbrai d=0AAAAAD QDh9dcDiRwc FNj7x5MLDOs sKqZ&amp;gclid=Cj wKCAjwyaWZ BhBGEiwACsl Qo7b_ixj8kYx gB8IB4IN2RF HeH6dWc- LUm8gmoWK aY_dvOgMC9I fPMhoCrbIQA vD_BwE</a>	
7	Ball nose 1 mm 4 flutes	1MM CRB 4FL BM 4 LOC	<a href="https://www.ebay.com.au/itm/263470320009">https://www.ebay.com.au/itm/263470320009</a>	High performance for tiny features.
8	Flat End 4 mm	4MM CRB 4FL 8 LOC	<a href="https://www.amazon.com/Cutting-4Flutes-Tungsten-Endmills-4mmDia%C3%974mmShank%C3%9775mmOAL/dp/B01C5BIYL8">https://www.amazon.com/Cutting-4Flutes-Tungsten-Endmills-4mmDia%C3%974mmShank%C3%9775mmOAL/dp/B01C5BIYL8</a>	It is used for surface smoothing at corners.

- **Machining Time**

In the last stage, the G-code for machining all molds features will be developed while optimizing the tool path to minimize the total machining time for each part. The estimated machining time for mold parts, resulting from our CNC programs, is provided in the tables below.



### Bottom Mold

Tools	Time (min)
Area Clearance 1	0.22
Z level 1	3.08
Flat Area 1	0.07
Z level 2	4.90
Flat Area 2	2.82
Z level 3	1.82
Z level 4	1.43
Z level 5	5.89
<b>Total</b>	<b>20.23 minutes = 20 minutes : 14 seconds</b>

### Side 1 Mold

Tools	Time (min)
Z level 1	37.68
Z level 2	15.44
Z level 3	26.89
Z level 4	20.54
Z level 5	2.12
Z level 6	1.11
Z level 7	1.97
Flat area1	0.16
<b>Total</b>	<b>105.91 minutes = 1 hour : 45 minutes :55 seconds</b>

### Side 2 Mold

Tools	Time (min)
Z level 1	10.39
Z level 2	15.39
Z level 3	49.75
Z level 4	20.51
Z level 5	1.99
Z level 6	0.33
Z level 7	1.02
Flat area1	0.15
<b>Total</b>	<b>99.53 minutes= 1 hour: 39 minutes : 32 seconds</b>