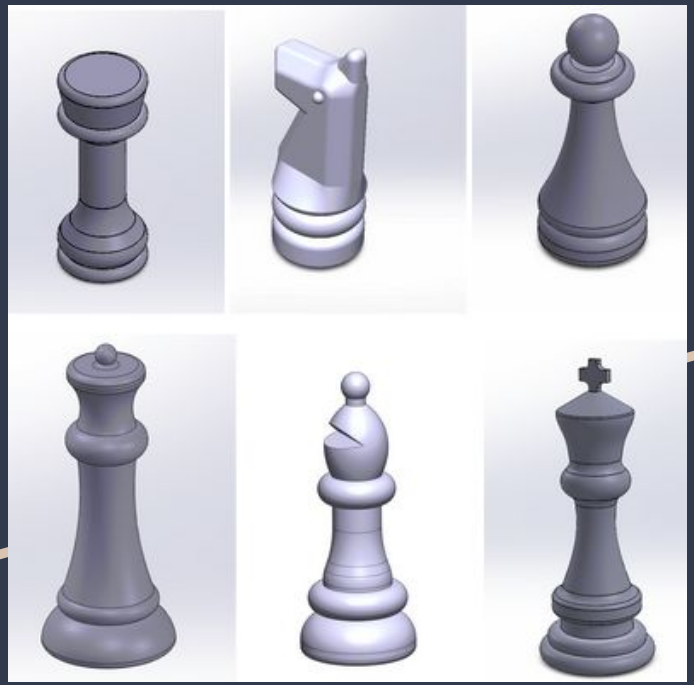
Creating Chess Piece Molds:

A MECH 460 Project Presentation

GROUP 2:
Arden Low - V00900253
August Carson - V00951060

GROUP 10:
Blaine Tubungbanua - V00918128
Colm Molder - V00937879
Connor Fedrigo - V00920849

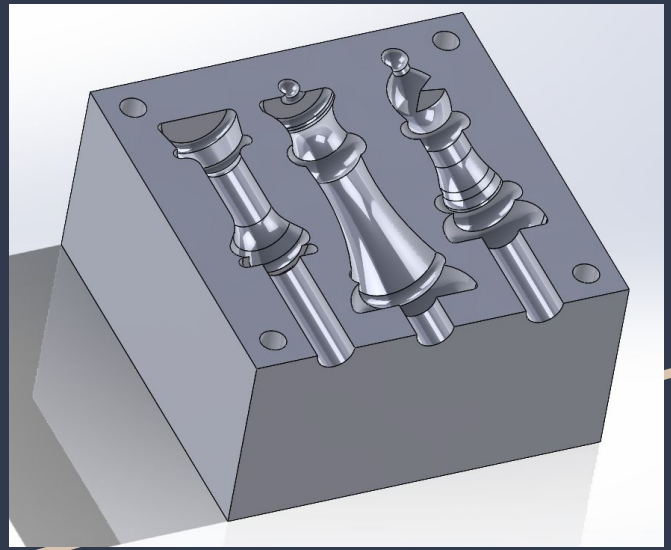
Background and Project Details



- The team was required to create a mold for a part which would fit in a 3.75”x3.75”x4” volume
- The mold was to be machined using HDPE plastic
- NC code was generated after optimizing toolpaths in Mastercam
- VERICUT was used to verify code before machining

- The parts selected by our team were the 6 unique chess pieces found in a chess set
- 2 molds were produced, with 3 pieces in each mold
- Each mold included a 1/16” surface planing, 4 dowel pin holes for alignment, and pour holes at the base of each cavity

CAM Profile 1

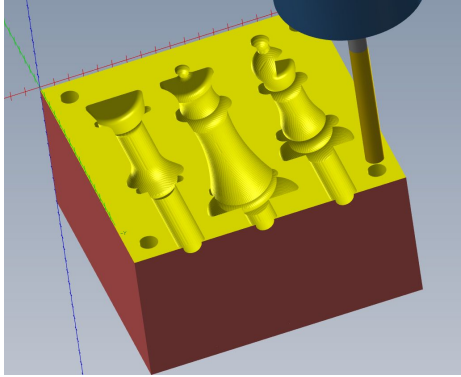


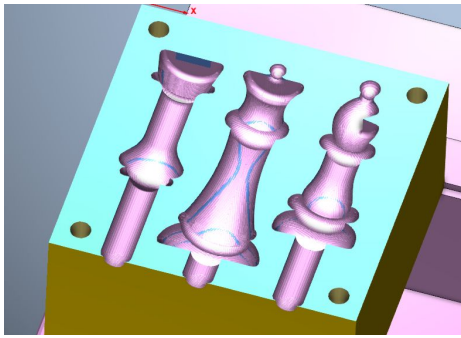
Surface Rough Parallel
- Tool #1: ½” flat end mill
- Feed rate: 40 in/min
- Spindle speed: 3000 rpm

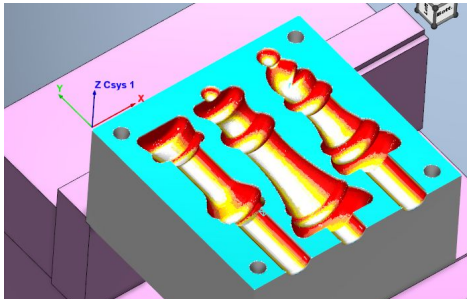
Surface High Speed, Area Roughing
- Tool #5: ¼” ball end mill
- Feed rate: 40 in/min
- Spindle Speed: 5000 rpm
- Stepdown: 0.125
- Clearance plae: 0.2
- Output feed move: Minimum Distance: 500
- Total Tolerance: 0.001

Surface High Speed, Equal Scallop
- Tool #6: ⅛” ball end mill
- Feed rate: 25 in/min
- Spindle Speed: 6000 rpm
- Stepover: 0.02
- Clearance plane: 0.2
- Output feed move: Minimum Distance: 500
- Total Tolerance: 0.0001

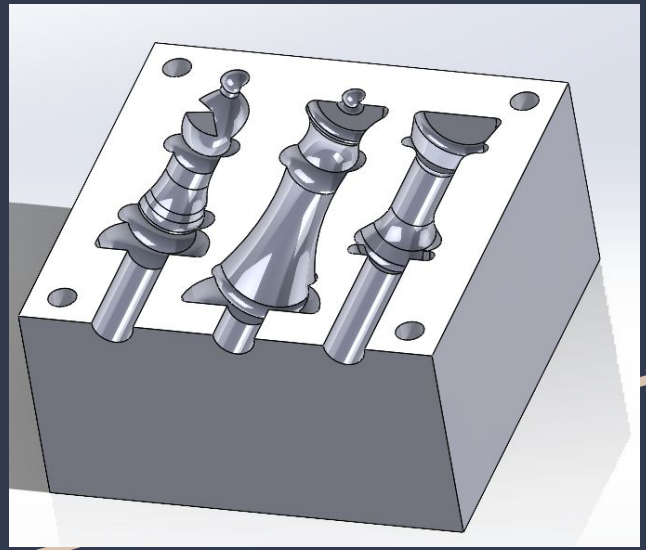
Drill Path
- Tool #7: ¼” drill
- Feed rate 30 in/min
- Spindle speed: 1500 rpm
- Depth: -0.5
- Tip comp







CAM Profile 2

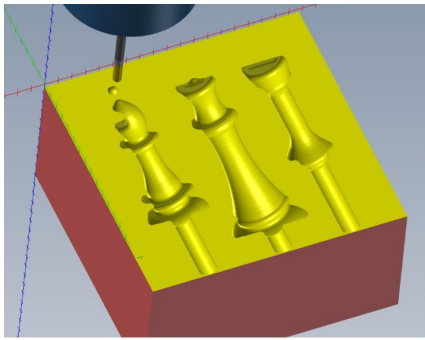


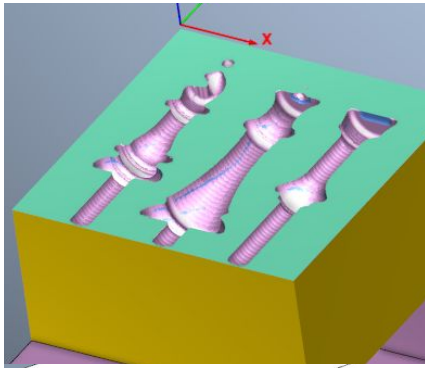
Surface Rough Parallel
- Tool #1: ½” flat end mill
- Feed rate: 40 in/min
- Spindle speed: 3000 rpm

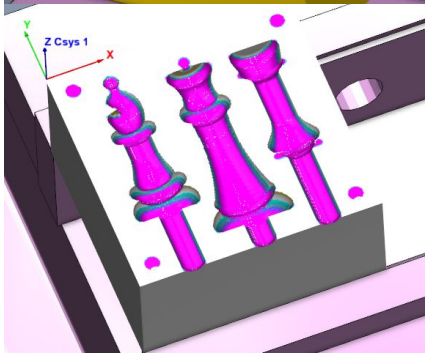
Surface High Speed, Area Roughing
- Tool #5: ¼” ball end mill
- Feed rate: 40 in/min
- Spindle Speed: 5000 rpm
- Stepdown: 0.125
- Clearance plae: 0.2
- Output feed move: Minimum Distance: 500
- Total Tolerance: 0.001

Surface High Speed, Raster
- Tool #6: ⅛” ball end mill
- Feed rate: 25 in/min
- Spindle Speed: 6000 rpm
- Stepover: 0.0125
- Clearance plae: 0.2
- Output feed move: Minimum Distance: 500
- Total Tolerance: 0.0001

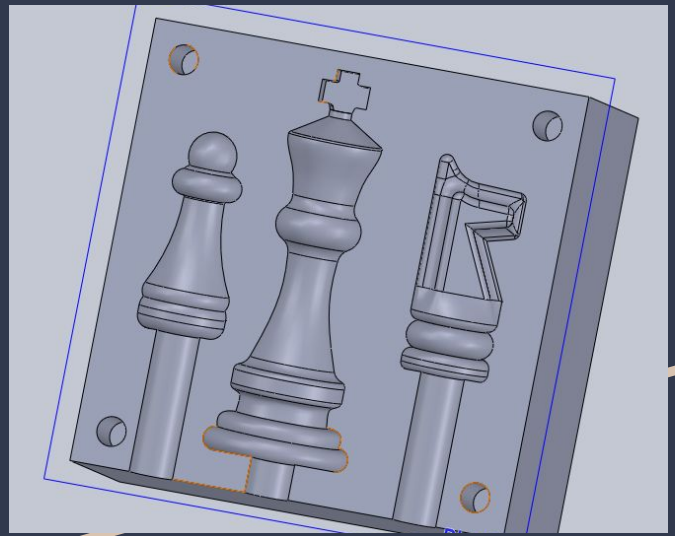
Drill Path
- Tool #7: ¼” drill
- Feed rate 30 in/min
- Spindle speed: 1500 rpm
- Depth: -0.5
- Tip comp







CAM Profile 3



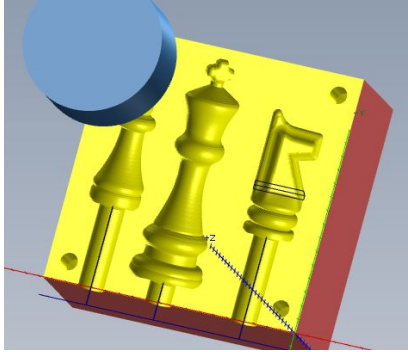
Surface Rough Parallel
- Tool #1: ½” flat end mill
- Feed rate: 40 in/min
- Spindle speed: 3500 rpm
- Stepover: 0.4”

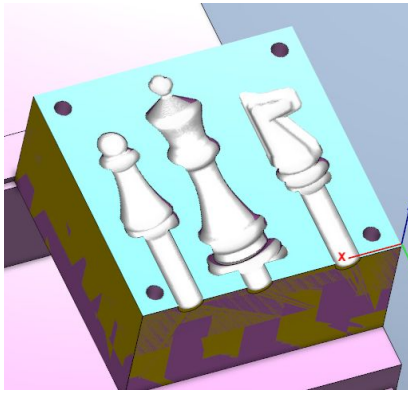
Drill Path
- Tool #7: ¼” drill
- Feed rate 10 in/min
- Spindle speed: 3000 rpm
- Depth: -0.5”
- Tip comp

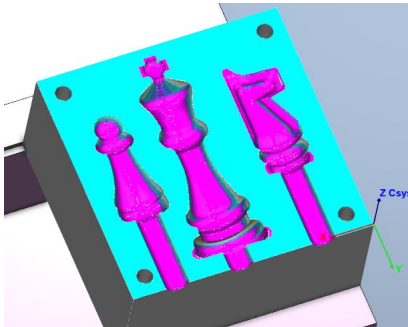
2D Toolpaths, Contour
- Tool #2: ⅜” ball end mill
- Feed rate: 45 in/min
- Spindle Speed: 3500 rpm
- Stepdown: 0.09375”

Surface High Speed, Area Roughing
- Tool #5: ¼” ball end mill
- Feed rate: 40 in/min
- Spindle Speed: 4500 rpm
- Stepdown: 0.125”
- Stepover: 0.25”

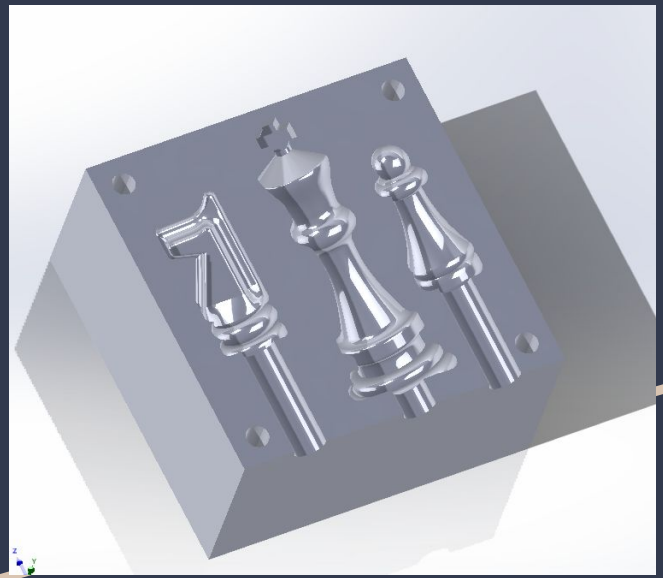
Surface High Speed, Raster
- Tool #6: ⅛” ball end mill
- Feed rate: 35 in/min
- Spindle Speed: 5200 rpm
- Stepover: 0.01”







CAM Profile 4



Surface Rough Parallel
- Tool #1: ½” flat end mill
- Feed rate: 35 in/min
- Spindle speed: 3500 rpm
- Stepover: 0.25”
- Material removed both directions

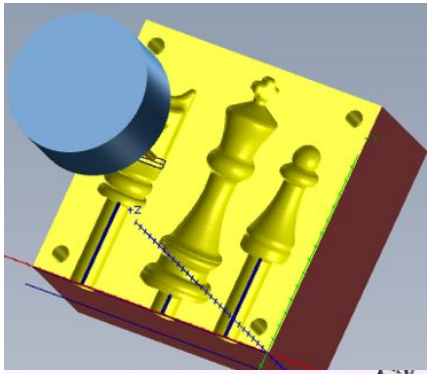
Drill Path
- Tool #7: ¼” drill
- Feed rate 10 in/min
- Spindle speed: 3000 rpm
- Depth: -0.5”
- Tip comp

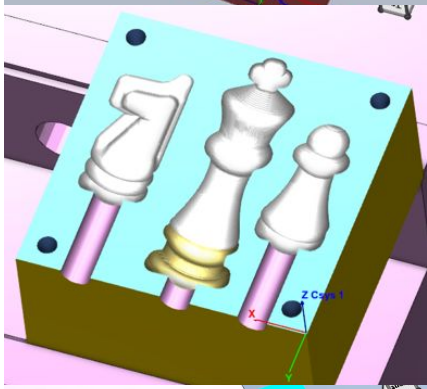
2D Toolpaths, Contour
- Tool #2: ⅜” ball end mill
- Feed rate: 45 in/min
- Spindle Speed: 3500 rpm
- Stepdown: 0.09375”

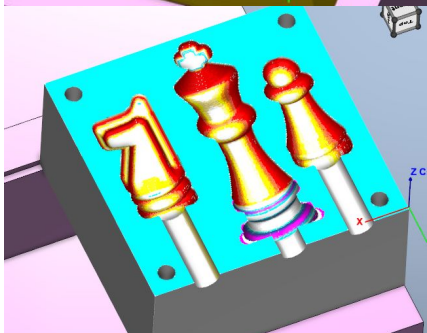
Surface High Speed, Area Roughing
- Tool #5: ¼” ball end mill
- Feed rate: 45 in/min
- Spindle Speed: 4500 rpm
- Stepdown: 0.1”
- Stepover: 0.15”

Surface High Speed, Raster 1
- Tool #5: ¼” ball end mill
- Feed rate: 32 in/min
- Spindle Speed: 4500 rpm

Surface High Speed, Scallop & Raster 2
- Tool #6: ⅛” ball end mill
- Feed rate: 32 in/min
- Spindle Speed: 5200 rpm
- Stepover: 0.015”







CAM Profile Selection

Main Selection Criteria:

- Estimated Machining Time
  - Profile 1 required 33 mins
  - Profile 2 required 37 mins
  - Profile 3 required 31 mins
  - Profile 4 required 28 mins
- Expected Surface Finish
  - Profile 2 was eliminated since it would have resulted in an incomplete part
  - Profiles 3 and 4 were similar

For the first mold that had cavities for the bishop, rook, and queen, CAM profile 1 was selected. This profile was selected over CAM profile 2 due to profile 2 being unable to machine the tight tolerances of the balls on top of the queen and bishop cavities.

CAM profile 4 was selected for the second mold with the pawn, knight and king. The decision was made based on superior surface finish compared to profile 3.

Selected Profiles:

- For Mold 1: CAM Profile 1
- For Mold 2: CAM Profile 4

Machined Results - Set 1

Post processing required:

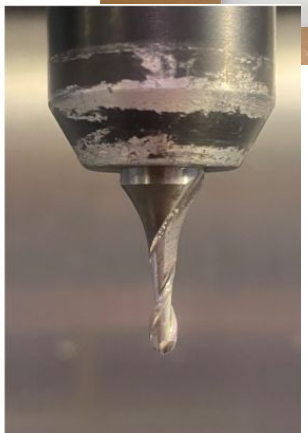
- Rough uncut chips after finishing pass
- Pour holes not fully machined

Tool collision:

- ⅛” Ball end mill collision not seen on Mastercam or Vericut simulations
    - Caused by deep radius cut of the base of the Queen

Tolerances

- Main chess piece dimensions within 0.005”
- Mold edges out of alignment



Machined Results - Set 2

Post processing required:

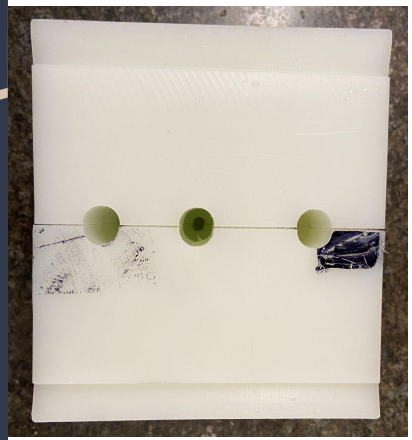
- Some deburring on the edges of the cavities
- Changing machining strategy for the fill holes eliminated excess material in that area

Tool collision:

- Tool collision avoided by using longer ¼” ball end mill in deepest area

Tolerances:

- Tolerances are within 0.005” except for base of king, with the diameter undersized by around 0.015”, due to change in tool used.



Conclusion

- Profiles 1 and 4 resulted in adequately machined parts

- <u>Suggested improvements:</u>
  - Using a smaller step for facing
  - Designing pieces for larger tools
  - Review code to reduce wasted time
  - Provide extra time for machining
  - Manually clean up pieces