جـامـعـة الـدوحـة
للعـلـوم والـتـكـنـولـوجـيـا
UNIVERSITY OF DOHA
FOR SCIENCE & TECHNOLOGY

AEMA4312 Applied CNC & CAM

Fall 2024

PROJECT REPORT

Topic: Design & Manufacturing of Cigarette Model & Ash Tray Using CNC lathe & Milling Machines

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1. Abstract

This project focuses on the design and manufacturing of a cigarette model and an ashtray using the Haas ST10 CNC lathe and the Haas Mini Mill CNC milling machine. The primary objective was to apply the manufacturing skills learned on this course to create machined products. The workflow included CAD modeling in SolidWorks, G-code generation using Fusion 360 CAM, and simulating tool paths in Fusion 360 to check for errors. Tool dimensions were carefully measured, and the data was entered into Fusion 360 CAM to ensure accurate machining. Raw materials were prepared to the required specifications prior to manufacturing. The project faced challenges, such as selecting the right tool for the machining operation and correcting incorrect zero offset settings. Despite these obstacles, the results demonstrate precise machining and the effectiveness of CNC technology in crafting detailed components.

2. Introduction & Background

The project focuses on the design and manufacturing of a cigarette model and an ashtray using advanced CNC machining techniques. These everyday objects serve as practical examples to demonstrate the application of theoretical and hands-on skills learned during the CNC course. The project integrates multiple concepts of CNC machining, including designing 3D CAD models, generating tool paths, and executing machining operations. It emphasizes the importance of precision, surface finish, and efficient manufacturing practices.

Purpose

The primary purpose of this project is to apply the skills acquired in the CNC course, such as understanding program syntax, using various CNC machine functions, taking accurate tool and work offsets, selecting appropriate tools, and executing operations like facing, turning, grooving, and parting-off. These competencies were instrumental in completing the project, providing a solid foundation for advanced machining tasks.

Scope

The project explores the combination of CNC lathe and milling operations to manufacture the cigarette model and ashtray with a focus on precision, quality, and aesthetic appeal. The work also highlights the role of modern CAD/CAM software in improving machine efficiency and reducing errors.

Objectives

- To design a 3D CAD model of a cigarette and an ashtray using SolidWorks, incorporating design considerations for manufacturability.
- To develop a CNC program using Fusion 360 CAM, including G-code generation, tool path simulation, and error checking.
- To ensure proper setup of the CNC machines, including accurate tool and work offsets
- To implement CNC lathe and milling operations using Haas ST10 and Haas Mini Mill machines, ensuring optimal machining strategies for each component.
- To evaluate the quality and precision of machined components through dimensional inspection and surface finish analysis.
- To document and present our project results.

3. Design Process

SolidWorks was used for making detailed 3D models of cigarettes and ashtrays. The design process began with translating concept sketches into digital models. Iterative refinements were made to ensure the optimal balance between manufacturability and aesthetics. This design approach ensured the components were manufacturable and visually appealing, while also adhering to the project's time and resource constraints.

Cigarette Model:

The standard dimensions of a cigarette are a diameter of 11 mm and a length of 70 mm. For the raw material, we selected a 12 mm aluminum rod, allowing sufficient material to perform a turning operation and achieve the desired final diameter. A groove was added near one end of the model with a depth of 1 mm and a width of 3 mm, matching the smallest groove tool size available. A 2mm chamfer was added at the end opposite the groove to enhance the aesthetic appeal of the design.

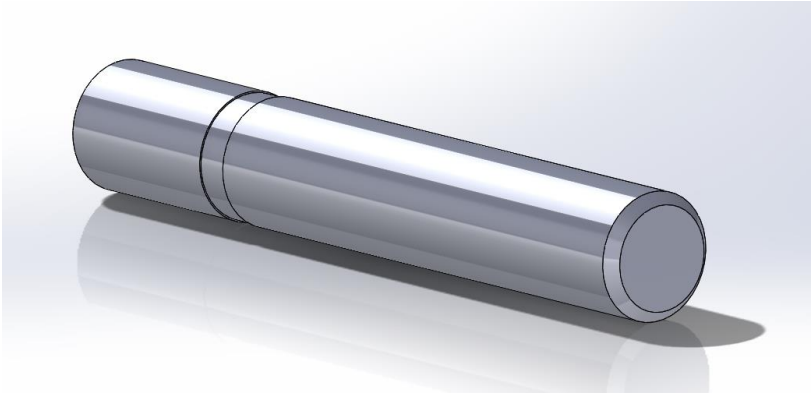

Figure 1 Cigarette CAD Design

Ashtray:

The raw material for the ashtray was a 25 mm (1-inch) thick plastic block with maximum dimensions of 200 × 200 mm. After exploring various ashtray designs, we opted for a square ashtray with dimensions of 100 × 100 mm. The design included a central square pocket and two semi-circular grooves to securely hold cigarettes or cigars. Filleted corners were added to enhance the overall aesthetics and ensure a smooth, visually appealing finish.

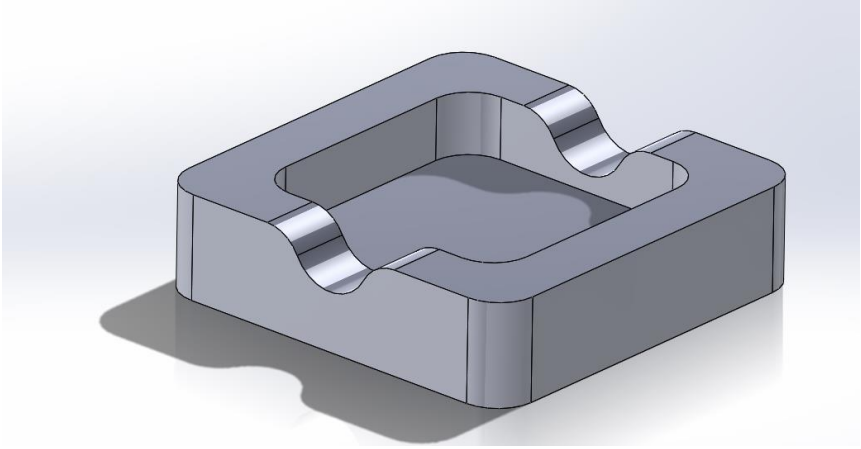

Figure 2 Ash Tray CAD Design

4. Manufacturing Process

- **CNC Machines Setup:**

  Lathe Setup (Haas ST-10):

  The setup process for the Haas ST-10 lathe starts by uploading the tool path to the machine using a USB drive, ensuring that the correct program is loaded for the machining operation. Next, the cutting tools, such as the VNMG160408MP turning insert, are identified and installed into the tool holder, ensuring proper orientation for the cutting operation. After tool installation, the raw material is placed into the machine's chuck. Work offset is carefully calibrated to guarantee accurate cutting and achieve the desired diameter reduction. The spindle speed is set to 5000 rpm, with a feed rate of 5000 mm/min, and coolant is activated to aid in cooling during the operation.

  Mini Mill Setup (Haas Mini Mill):

  For the Haas Mini Mill, the process begins by uploading the tool path to the machine via USB, ensuring that the correct milling program is ready. The appropriate milling tools, such as the Ball End Mill, are identified, installed, and securely fastened in the tool holder. After tool installation, the plastic block is placed in the machine's vice, ensuring it is clamped firmly for precise cutting. The spindle speed is set to 3000 rpm, and the feed rate is adjusted to 2000 mm/min for optimal milling performance. Work offsets are calibrated to ensure precision during the milling operation. Coolant is turned off during this process to maintain clean cutting conditions.

- **Raw Materials Preparation:**

  For the raw materials for the cigarette, we use the bandsaw to cut the 12mm diameter rod to 90mm, using 15-20mm for the clamping and the rest is where the material will be machined. However, for the ash tray we use a plastic material. In which we cut it to 100mm x 100mm using the vertical bandsaw with the guidance of our instructor, Mr. Sridhar.

- **Tooling:**

  Selected Tools

  - **Lathe Tool:**

  Turning insert: **VNMG160408MP**

  This insert is used for turning the outer diameter of the cigarette model. Used to reduce the diameter of the aluminum rod from the of 12mm to 11mm.
  Tool Type: General turning.
  Toolholder: ISO L Right.
  Edge Length: 16.61 mm.
  Nose Radius: 0.8 mm.
  Cutting Orientation: Radial.

- **Milling Cutter:**

Ball End Mill:
Diameter: 11 mm.
Corner Radius: 5.5 mm.
Length: 40 mm.
Number of Flutes: 4.
Purpose: Adaptive clearing for the milling project part.

- **Cutting Parameters**:

Lathe (Turning Parameters):
Spindle Speed: 5000 rpm.
Feed Rate: 5000 mm/min.
Depth of Cut: 0.3 mm
Cutting Distance: 84.89 mm.
Rapid Distance: 220.83 mm.
Machining Time: 3 minutes.
Coolant: Flood.

Milling (Ball End Mill Parameters):
Spindle Speed: 3000 rpm.
Feed Rate: 2000 mm/min.
Depth of Cut: Max stepdown 5 mm.
Cutting Distance: 11392.57 mm.
Rapid Distance: 9492.01 mm.
Machining Time: 48 minutes 52 seconds.
Coolant: Off.

5. Testing and Quality Control

Important measurements, such as the cigarette model's diameter, length, and groove depth, as well as the ashtray's pocket and groove dimensions, were taken using a Vernier caliper. To ensure precision within acceptable tolerances, measurements were compared to Fusion360 specifications. In addition, to prevent any error, we made sure more than one person read the vernier caliper and both get the same measurements. To assess surface smoothness and find any machining marks or flaws, visual testing was performed out. To confirm the dimensions and design alignment, the cigarette model was tested to ensure it fit well in the ashtray's grooves.

6. Results and Discussion

It was important to choose the right tools for each task, particularly when machining minute features like the cigarette model's groove. Careful calibration was necessary to ensure that the tools could cut precisely and leave a nice surface finish, where we use ball mill cutter for the ashtray model.

Initially, there were problems with setting the correct tool and work offsets, which led to some parts being machined inaccurately. Additional calibration and a thorough recheck of the offset settings before running the programs will help resolve these problems.

Several suggestions for future projects might be made because of the results and difficulties met. For every machining operation, more consideration should be given to the tool geometries and materials. Preventive maintenance and routine tool wear inspections can increase accuracy.

Improved clamping techniques should be evaluated for projects requiring softer materials, such as plastic, to reduce warping and material movement during machining. Stability may be increased by using specific fittings or softer jaws. Especially for complicated designs, more thorough tool path simulations in Fusion 360 may be able to help detect any problems prior to the machining process. This would decrease the possibility of mistakes brought on by improper tool selection or offsets.

Figure 3: Machined Ash Tray

Figure 4: Machined Cigarette

7. Conclusion

To sum up the report, CNC focuses on designing and manufacturing a 3D model with the use of SolidWorks software or any other software that can be used for 3D modelling. To utilize Fusion 360 software for generating the code that will be transferred to the CNC machines for manufacturing process. Applying the skills and knowledge learned from the CNC course, the project was conducted as proof of learning. This project also helps learn the importance of CNC in the industries where it requires to make thousands of identical pieces, which helps companies improve efficiency, increase profit and increase material saving.

8. References

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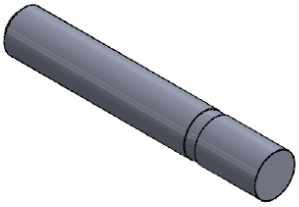
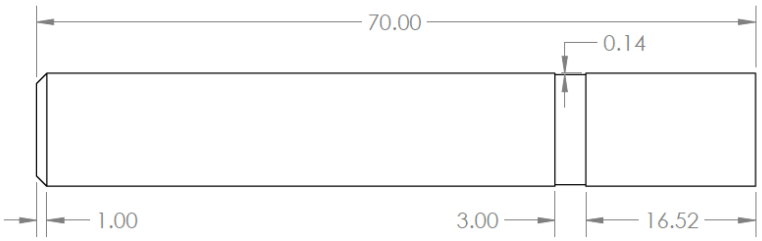
9. Appendices

Attached Files:

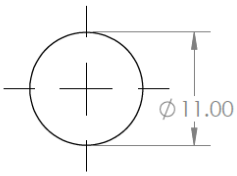
- SolidWorks CAD Drawing
- G – Code generated using Fusion360
- Fusion360 Generated Report
- Fusion360 Tool Path Simulation



ISOMETRIC VIEW



FRONT VIEW



SIDE VIEW

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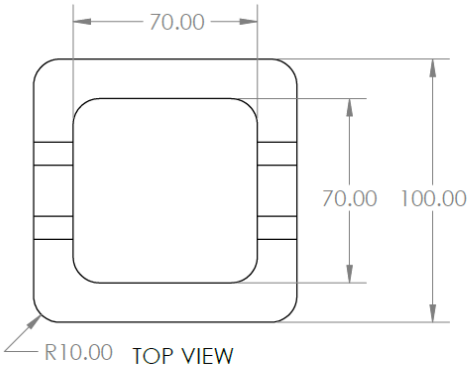
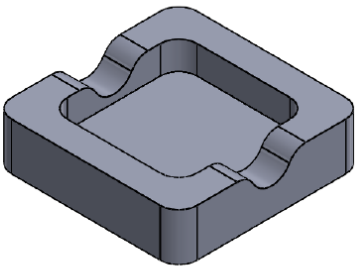
PROJECT
CIGARETTE CAD DRAWING



TOP VIEW



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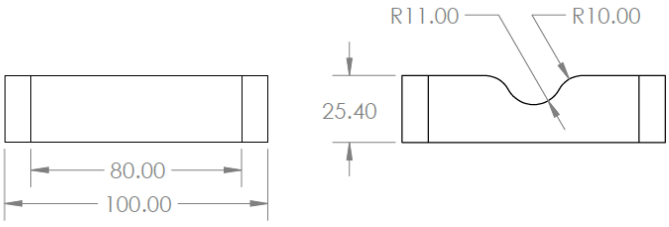


FRONT VIEW

SIDE VIEW

AEMA 4312 APPLIED CNC & CAM
FALL 2024

PROJECT
ASHTRAY CAD DRAWING

CNC Lathe Machine Program		CNC Milling Machine Program
%	G1 Z-0.431 F1.	%
O57635	X9.6 Z-0.627	O98760
G98 G18	X11.6 Z0.373	(Using high feed G1 F650. instead of G0.)
G21	G0 Z0.15	(T1 D=11. CR=5.5 - ZMIN=-15.4 - ball end
G50 S6000	X8.814	mill)
G53 G0 X0.	G1 Z-0.234 F1.	N10 G90 G94 G17
G53 Z0.	X9.207 Z-0.431	N15 G21
	X11.207 Z0.569	N20 G53 G0 Z0.
(Profile Roughing2)	G0 X32.	
T101	Z5.	(Adaptive1)
G99	G97	N25 T1 M6
G18	S995 M3	N30 S3000 M3
G97		N35 G17 G90 G94
S995 M3	M9	N40 G54
G54	G53 X0.	N45 G1 X15.61 Y-7.196 F650.
M8	G53 Z0.	N50 G0 G43 Z15. H1
G0 Z5.	M5	N55 G0 Z5.
X32.		N60 Z-2.8
G50 S3000	M30	N65 G1 Z-3.9 F2000.
G96	%	N70 X15.603 Y-7.194 Z-4.023
S100 M3		N75 X15.584 Y-7.186 Z-4.145
Z0.15		N80 X15.552 Y-7.175 Z-4.263
X11.4		N85 X15.507 Y-7.159 Z-4.377
G1 Z-70.8 F1.		N90 X15.451 Y-7.138 Z-4.485
X12.		N95 X15.384 Y-7.114 Z-4.586
X14. Z-69.8		N100 X15.307 Y-7.086 Z-4.678
G0 Z0.15		N105 X15.22 Y-7.054 Z-4.76
X10.8		N110 X15.126 Y-7.02 Z-4.831
G1 Z-1.227 F1.		N115 X15.024 Y-6.983 Z-4.891
X11.2 Z-1.427		N120 X14.917 Y-6.944 Z-4.938
Z-51.662		N125 X14.806 Y-6.903 Z-4.972
X10.92 Z-51.779		N130 X14.692 Y-6.862 Z-4.993
Z-53.729		N135 X14.576 Y-6.82 Z-5.
X11.2		N140 G3 X8.701 Y-5.376 I-9.601 J-26.39
Z-70.8		....
X11.4		....
X13.4 Z-69.8		....
G0 Z0.15		
X10.2		N77610 M5
G1 Z-0.927 F1.		N77615 G53 G0 Z0.
X10.8 Z-1.227		N77620 G53 G0 X0. Y0.
X12.8 Z-0.227		N77625 M30
G0 Z0.15		
X9.6		%
G1 Z-0.627 F1.		*Note: Too lengthy to copy the full program.*
X10.2 Z-0.927		
X12.2 Z0.073		
G0 Z0.15		
X9.207		

Setup Sheet for Program 1001

Job Description: Setup1
Document Path: LATHE PROJECT PART v1

Setup

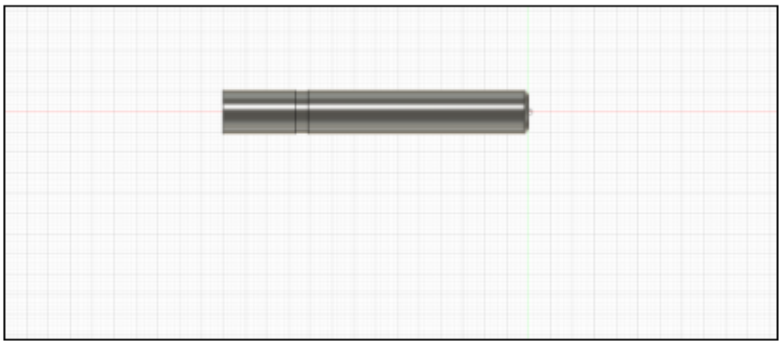
WCS: #0

Stock:
DX: 12mm
DY: 12mm
DZ: 70mm

Part:
DX: 11mm
DY: 11mm
DZ: 70mm

Stock Lower in WCS #0:
X: -6mm
Y: -6mm
Z: -70mm

Stock Upper in WCS #0:
X: 6mm
Y: 6mm
Z: 0mm



Total

Number Of Operations: 1
Number Of Tools: 1
Tools: T1
Maximum Z: 10mm
Minimum Z: -70.8mm
Maximum Feedrate: 5000mm/min
Maximum Spindle Speed: 5000rpm
Cutting Distance: 84.89mm
Rapid Distance: 220.83mm
Estimated Cycle Time: 19s

Tools

T1 D1

Type: general turning
Insert: ISO V 35deg
Edge length: 16.61mm
Nose radius: 0.8mm
Cross section: G
Tolerance: M
Relief: N 0deg
Compensation: Tip tangent

Tool Orientation in Turret: Radial
Minimum Z: -70.8mm
Maximum Feed: 5000mm/min
Maximum Spindle Speed: 5000rpm
Cutting Distance: 84.89mm
Rapid Distance: 220.83mm
Estimated Cycle Time: 4s

Holder: ISO L Right

Operations

Operation 1/1
Description: Profile Roughing1
WCS: #0
Tolerance: 0.01mm
Maximum stepover: 1.2mm

Maximum Z: 10mm
Minimum Z: -70.8mm
Surface Speed: 200m/min
Feedrate per Rev: 1mm
Cutting Distance: 84.89mm
Rapid Distance: 220.83mm
Estimated Cycle Time: 4s
Coolant: Flood

T1 D1
Type: general turning
Insert: ISO V 35deg
Edge length: 16.61mm
Nose radius: 0.8mm
Cross section: G
Tolerance: M
Relief: N 0deg
Compensation: Tip tangent

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Setup Sheet for Program 98760

Job Description: Setup8
Document Path: MILLING PROJECT PART (v3~recovered)

Setup

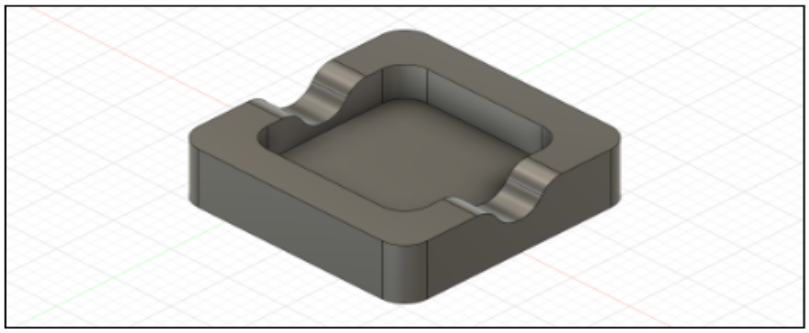
WCS: #0

Stock:
DX: 100mm
DY: 100mm
DZ: 25.4mm

Part:
DX: 100mm
DY: 100mm
DZ: 25.4mm

Stock Lower in WCS #0:
X: 0mm
Y: 0mm
Z: -25.4mm

Stock Upper in WCS #0:
X: 100mm
Y: 100mm
Z: 0mm



Total

Number Of Operations: 1
Number Of Tools: 1
Tools: T1
Maximum Z: 15mm
Minimum Z: -15.4mm
Maximum Feedrate: 2000mm/min
Maximum Spindle Speed: 3000rpm
Cutting Distance: 11392.57mm
Rapid Distance: 9492.01mm
Estimated Cycle Time: 8m:7s

Tools

T1 D1 L1
Type: ball end mill
Diameter: 11mm
Corner Radius: 5.5mm
Length: 40mm
Flutes: 4

Minimum Z: -15.4mm
Maximum Feed: 2000mm/min
Maximum Spindle Speed: 3000rpm
Cutting Distance: 11392.57mm
Rapid Distance: 9492.01mm
Estimated Cycle Time: 7m:52s

Operations

Operation 1/1
Description: Adaptive1
Strategy: Adaptive
WCS: #0
Tolerance: 0.1mm
Stock to Leave: 0mm
Maximum stepdown: 5mm
Optimal load: 4mm
Load deviation: 0.4mm

Maximum Z: 15mm
Minimum Z: -15.4mm
Maximum Spindle Speed: 3000rpm
Maximum Feedrate: 2000mm/min
Cutting Distance: 11392.57mm
Rapid Distance: 9492.01mm
Estimated Cycle Time: 7m:52s
Coolant: Off

T1 D1 L1
Type: ball end mill
Diameter: 11mm
Corner Radius: 5.5mm
Length: 40mm
Flutes: 4

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