



A study of Computer Numerical Control (CNC) toolpath and profile milling on CAM software

¹Zoya Rizvi, ²Adeel Khan, ³Parshva khatadia, ⁴Devang Jadhav, ⁵Daksh Bafna

¹Assistant Professor, ²Student, ³Student, ⁴Student, ⁵Student

¹Mechanical Department, ²Mechanical Department, ³Mechanical Department, ⁴Mechanical Department, ⁵Mechanical Department
¹NMIMS University, MPSTME, Mumbai, India

Abstract: CNC (Computer Numerical Control) is a machine controlled by a computer with command data code numbers, letters and symbols, according to standard ISO. It aims to generate, parse, execute sequential actions that describes the behavior of the end effector. CNC machine tools help in mass production in industries where it is required high level of complexity and can reduce human intervention during machine operation. The main objective of this paper is to study generating a Computer numerical control (CNC) milling machine processing codes to make the object. Manually the codes can be written for any object desired to be machined and can be milled on a conventional NC machine. But to get desired finish a software generated code can be used for high finished output. This paper also reports the steps involved in extracting these CNC codes on Fusion 360(Autodesk).

Index Terms - CNC Machine, milling, Fusion360 CAM, G-code and M-code

I. INTRODUCTION

CNC (Computerized Numerical Control) manufacturing technologies such as milling, turning and drilling are used to transform a digital model into a machined component. A CNC machine tool created the component from a stock model, cutters, and NC programs. Important business objectives are to produce components economically, accurately and on time. Today's design components have increasing complexity and sophistication, and as such, manufacturing companies need a powerful CAM (computer-aided manufacturing) system in order to be able to meet these requirements. By using CAM software, NC programmers make a key contribution to return on investment for CAM software and the CNC machine tools companies invest in to meet their objectives. [1]

Initially used by Douglas T. Ross, the term 'computer-aided design' was introduced in the early 1950s. Ross, a researcher at the Massachusetts Institute of Technology (MIT), was working with military radar technology and computer display systems. Ross worked on projects that pioneered early CAD technology – such as Automatically Programmed Tools (APT), which led to the creation of AED (Automated Engineering Design). Ross would host conferences at MIT to discuss the expanding technologies with other early practitioners in the industry. One of the first uses of what might be called CAD was deployed by Patrick Hanratty at the General Motors Research Laboratories. Hanratty developed Design Automated by Computer (DAC), which is thought to be the first CAD system that involved interactive graphics. This was the first commercial CAD/CAM software system, and involved a numerical control programming tool named PRONTO, which he developed in 1957. As such, Hanratty is often referred to as 'the father of CAD/CAM. The first true CAD software was called Sketchpad, developed by Ivan Sutherland in the early 1960s as part of his PhD thesis at MIT (Massachusetts Institute of Technology). Sketchpad was especially innovative CAD software because the designer interacted with the computer graphically by using a light pen to draw on the computer's monitor. Computer-aided manufacturing was also developed in the 1950s, when computers were used to create G-code which was in turn translated into punched cards that could control machines. Punch tapes were produced through computer control, which could then increase the speed of both instruction creation and manufacturing. The tools and machines directed by these codes vary, from plasma cutters to water jets. The earliest commercial applications of CAM lie in the automotive and aerospace industries. CAD and CAM came together when CAM utilized CAD drawings to create its instructions, or toolpaths, to control automated machine tools. These tools could subsequently create physical items directly from design files. Pierre Bezier created the pioneering surface 3D CAD/CAM system, UNISURF, between 1966-1968, while working for the French car manufacturer, Renault. His invention was designed to aid the design and tooling of cars by integrating drawing machines, computer control, interactive free-form curves, surface design and 3D milling for manufacturing clay models and masters. [2]

Computer numerical control (CNC) and g-code has been integrated with Computer- Aided Design (CAD) and Computer Aided Manufacturing (CAM) to achieve high dimensional accuracy and repeatability, coupled with high productivity in the production of complicated parts in high volume manufacturing. CNC milling process [3]. The technology of CNC machining has been used successfully in automated manufacturing that involve integration of computer-aided design (CAD), computer aided manufacturing (CAM) and computer-aided engineering (CAE) to enhance accuracy and productivity [4].

II. LITERATURE REVIEW

PRINCIPLE OF CNC MACHINE

Basic Principles of CNC Milling Machine or machine tool CNC machine tools is that the operation is the process of work-piece by chisels assisted with computer numerical control, or CNC (Computer Numerical Control). To move the chisel on CNC machine tools agreed upon using the coordinate system. Coordinate system on a CNC milling machine is a coordinate system with three axes / axis is the X-, Y- and Z-axis X-axis is defined as moving horizontal axis, Y-axis is defined as an axis which moves transversely, and the Z-axis is defined as the axis moves vertically, Milling is a machining process where the cutting tool or cutting tool rotates

on its spindle and work-piece move toward lengthwise and crosswise cuts as far as desired.

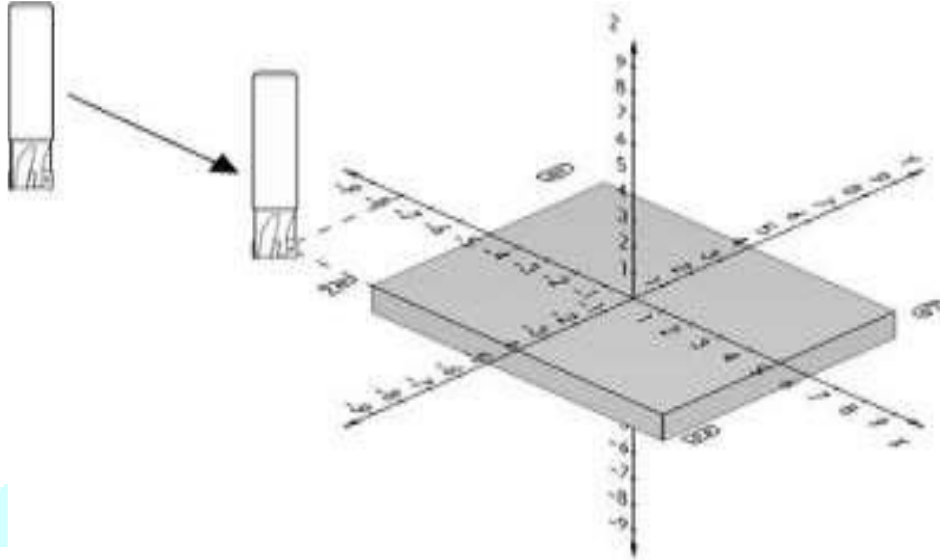


Fig.1.Process CNC Milling

CAM PROFILE MILLING TOOLPATHS

CNC milling toolpaths are typically categorized 2D, 3D, 4-axis, and 5-axis. However, the term 2D is a bit misleading since this toolpath uses the Z-axis to position a tool for depth. For example, in the image below we have a prismatic part whose features all reside at various heights on the XY plane. We can quickly position our tool to depth on the Z axis, and then machine a feature by moving in X and Y.

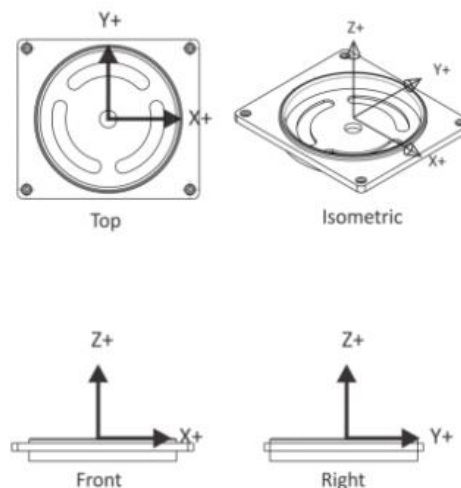


Fig.2. Positioning toolpath

Many new CNC machinists struggle to plan out their toolpaths, especially as features get more complex. Sometimes this problem solving process is clear. Pockets use a 2D Pocket operation, chamfers use Chamfer Milling, and so on. But then you get to the difficult questions that don't have such black and white answers. How are you going to machine the hole in the center of the part above? You could use a drill, contour, or circular pocket toolpath. And which of these features needs to be machined from the top versus the bottom? The answer to these questions requires some fundamental toolpath knowledge.

Toolpath Types and Terminology

Every toolpath has a unique behavior and use case. Familiarize yourself with the toolpaths below, which you'll encounter in Fusion 360 and other CAM solutions.

Table 1 Toolpath styles

Toolpath	Uses
Face	Finishing the face of a part.
Contour	Machining loops, open pockets, stick fonts, dovetails, keysets, or saw cuts.
Chamfer	Deburring and creating chamfers using either a tapered mill or center drill.
Fillet	Creating fillets using a Corner Rounding Tool.
Pocket	Roughing or finishing pockets of various shapes and sizes.
Slot Mill	Machining straight slots or arc slots.
Drill	Creating spot drill, tapped, bore, or reamed holes.
Bore	Making holes, typically greater than .75in diameter.
Thread Mill	Machining ID threads over .75in diameter, milled OD threads of any size, or custom threads.

There is also some toolpath lingo that you will want to get acquainted with. You will find the terms below referenced in nearly every CAM software package.

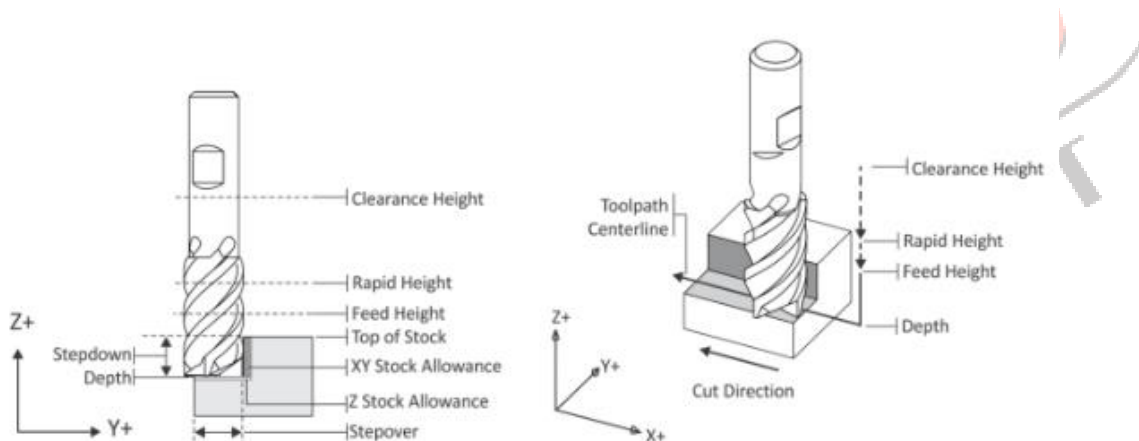


Fig.3. Stock removal

- **X, Y, and Z Allowance** is the amount of material remaining on either the finished wall (XY) or floor (Z) of a part that needs to be removed in future operations. Sometimes also called “Stock to Leave.”
- **Stepover** determines how much material is removed radially, or left and right, by a tool each time it passes in the XY direction.
- **Stepdown** is the amount of material that gets removed axially, or vertically, with each pass of your cutting tool. Multiple passes may be needed to get to a final depth.
- **Top of Stock** designates the top face of the stock being used to make the part, which can be used as a reference point for machining processes.
- **Feed Height** is the height a tool will position itself to before starting to feed at the cut feedrate before it enters the material, usually set to some safe distance above the top of stock.
- **Retract Height** is the height a tool will retract to between moves within the same operation, usually set some safe distance above the feed height.
- **Clearance Height** is the height a tool moves at between individual operations, usually set to 1.000in above the top of a stock.

- **Tool path Centreline** is the path the tool will take as it moves along a toolpath. The diameter of the tool needs to be taken into consideration to make sure that the tool cuts at the desired

All of these terms and toolpath types come together in the planning of a 2D machining process.

Cutter Diameter Compensation (CDC)

CDC adjusts a toolpath to account for tool wear that can cause inaccuracies in a part. This will basically align your tool either slightly to the left or right of the originally programmed toolpath. You can find your compensation value by subtracting actual dimensions from desired dimensions of a part feature.

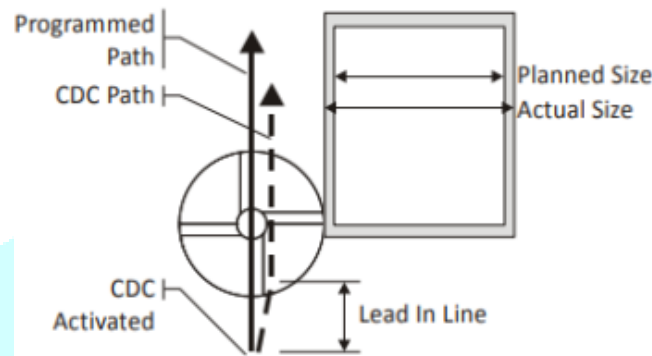


Fig. 4. Cutter diameter compensation

CNC program structure

There are four basic terms used in CNC programming. These are as follows:

Character -> Word -> Block -> Program

- Character is the smallest unit of CNC program. It can have Digit / Letter / Symbol.
- Word is a combination of alpha-numerical characters. This creates a single instruction to the CNC machine. Each word begins with a capital letter, followed by a numeral. These are used to represent axes positions, feedrate, speed, preparatory commands, and miscellaneous functions.
- A program block may contain multiple words, sequenced in a logical order of processing.
- The program comprises of multiple lines of instructions, 'blocks' which will be executed by the machine control unit (MCU).

Figure 5. shows a sample CNC program. It has basically three sections viz. initial commands section; main section and end commands section. In the initial commands section, the program number, its ID, initial safety preparatory codes such as 'cancel all the activated cycles by previous program' are to be specified. In the main section, commands/instructions related to the machine tool axes movements, tool change etc. are to be mentioned. At the end, the commands instructing cancellation of cycles, homing the tool and program end are to be provided.

```

%                               //% symbol
00012                           //Program number and ID
(Sample program structure for demonstration) //Program description
N10 G21                         //Units setting
N20 G40 G80 G49                 //Initial commands
N30 T01                         //Tool T01 in waiting position
N40 M06                         //replace present tool at spindle by T01
.
.
.
N100 G01 X20.0 Y34.0           //Linear interpolation
N110 Y100.0                    //Linear interpolation
N120 G00 X100.0                //Linear interpolation: rapid mode
N130 G01 Y20.0                 //Linear interpolation at given feed rate
.
.
.
N200 G80 Z40.0 M09             //Cycle cancel
N210 G28 Z40.0 M05            //Home in z only
N220 G28 X... Y...            //Home in XY only
N240 M30                       //End of program
%                               //Stop code

```

Fig. 5. CNC Program Sample

The address G identifies a preparatory command, often called G-code. This is used to preset or to prepare the control system to a certain desired condition or to a certain mode or a state of operation. For example G01 presets linear interpolation at given feed but does not move any axis. The address M in a CNC program specifies miscellaneous function. It is also called as machine function. These functions instruct the machine tool for various operations such as: spindle rotation, gear range change, automatic tool change, coolant operation, etc.

The G and M codes are controller manufacturers' specific. In this course, we will be following the G and M codes used for FANUC, Japan controller. Other controllers such as SINUMERIC, MITSUBISHI etc. are also being used in CNC technology.

Equations

Since we are using coated carbide tool

We can find RPM for face milling tool

$$\text{RPM} = \frac{320 V}{D}$$

$$= \frac{320 * 55}{50}$$

$$= 995 \text{ RPM}$$

Profile milling equation

Based on recent trend studies we can say tool has a velocity V of 155 mm/min.

I. RESEARCH METHODOLOGY

The methodology section outlines the plan and method that how the study is conducted. This includes Universe of the study, sample of the study, Data and Sources of Data, study's variables and analytical framework. The details are as follows;

3.1 3D Model Sample

This model is developed using Solidworks software based on pre-decided parameters. The various views on a 2D standard format was extracted for reading purpose. 4 pockets are to be milled using pocket milling machining centre. The thickness of slab is 15 mm and the slot of pocket is 10 mm deep.

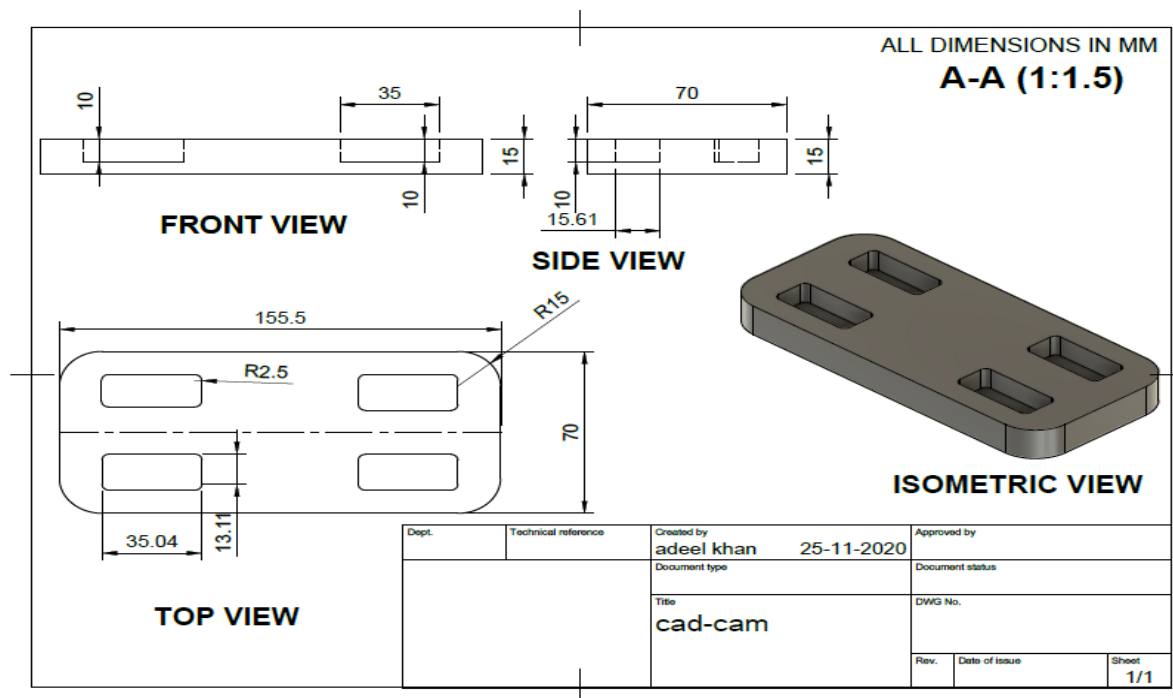


Fig. No. Standard 2D Views

3.3 Theoretical framework

Program development for CNC includes firstly 3D model development in any 3D software like Solidworks, Catia etc. This model is inserted into CAM software for extracting G and M codes. The program file can be directly on any modern CNC machine to develop the block by using Milling/pocket milling processes. The variable involved are direct type and independent. The study involved pre-specified method for the selection of variables.

IV. RESULTS AND DISCUSSION

The below codes are extracted from Fusion 360 CAM. Autodesk® Fusion 360™ is the only tool that connects entire product development process into a single CAD / CAM / CAE cloud-based platform.

```
%
O01001
(Using high feed G1 F5000. instead of G0.)
(T1 D=50. CR=0. - ZMIN=-1. - face mill)
(T2 D=8. CR=0. - ZMIN=-11. - flat end mill)
(T3 D=8. CR=0. - ZMIN=-17. - flat end mill)
N10 G90 G94 G17
N15 G21
N20 G53 G0 Z0.
```

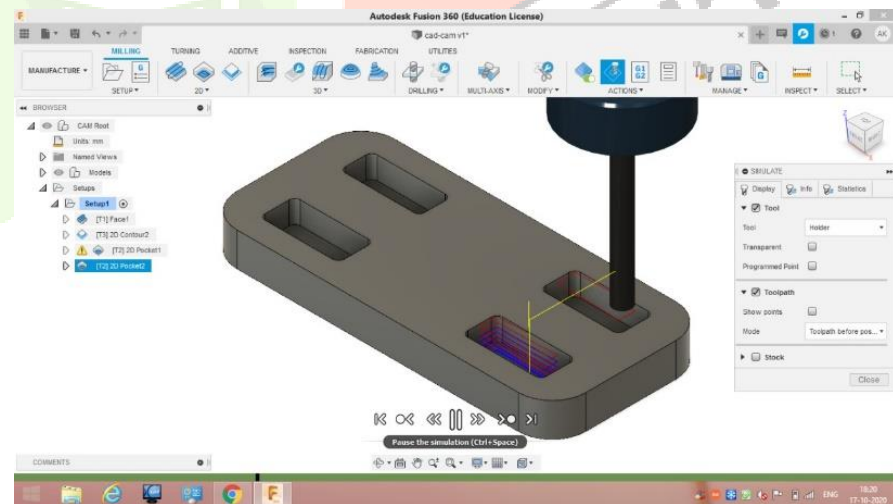
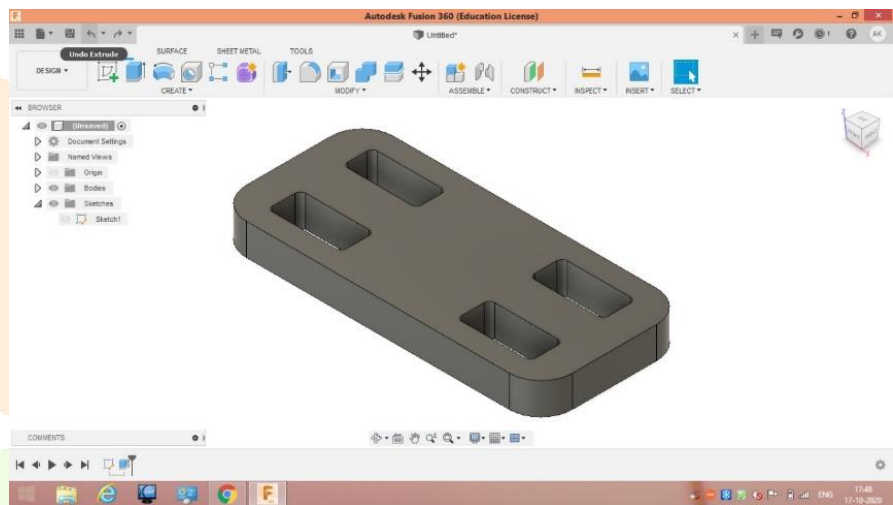
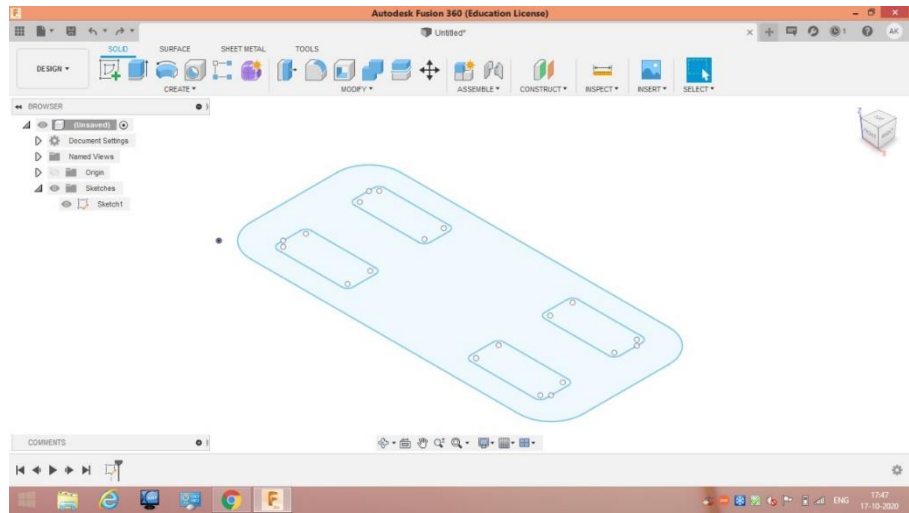
```
(Face1)
N25 T1 M6
N30 S955 M3
N35 G54
N40 M11
N45 G0 A0.
N50 M10
N55 M8
N60 G0 X111. Y-24.375
N65 G43 Z15. H1
N70 T3
N75 G0 Z5.
N80 G1 Z4. F460.
N85 G18 G3 X106. Z-1. I-5. K0.
N90 G1 X83.5
N95 X-83.5
N100 G17 G2 Y11.775 I0. J18.075
N105 G1 X83.5
N110 G18 G2 X88.5 Z4. I0. K5.
N115 G0 Z15.
N120 M9
N125 M5
N130 G53 G0 Z0.
```

```
(2D Contour2)
N135 M1
N140 T3 M6
N145 S3000 M3
N150 G54
N155 M11
N160 G0 A0.
```

- N165 M10
- N170 M8
- N175 G17
- N180 G0 X61.545 Y-41.4
- N185 G43 Z15. H3
- N190 T2
- N195 G0 Z5.
- N200 G1 Z1. F400.
- N205 Z-16.2
- N210 G19 G3 Y-40.6 Z-17. J0.8 K0.
- N215 G1 Y-39.8
- N220 G17 G3 X60.745 Y-39. I-0.8 J0.
- N225 G1 X-62.5 F800.
- N230 G2 X-81.5 Y-20. I0. J19.
- N235 G1 Y20.
- N240 G2 X-62.5 Y39. I19. J0.
- N245 G1 X62.5
- N250 G2 X81.5 Y20. I0. J-19.
- N255 G1 Y-20.
- N260 G2 X62.5 Y-39. I-19. J0.
- N265 G1 X60.745
- N270 G3 X59.945 Y-39.8 I0. J-0.8
- N275 G1 Y-40.6
- N280 G19 G2 Y-41.4 Z-16.2 J0. K0.8
- N285 G0 Z15.
- N290 M9
- N295 M5
- N300 G53 G0 Z0.

(2D Pocket 2)

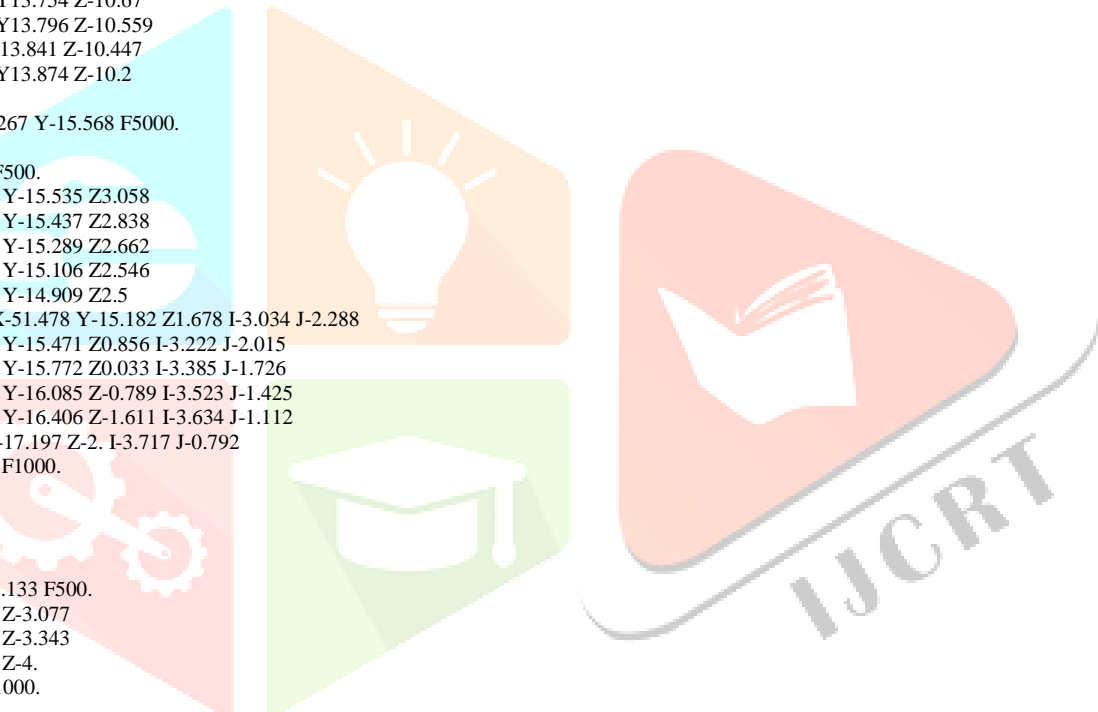
- N305 M1
- N310 T2 M6
- N315 S5000 M3
- N320 G54
- N325 M11
- N330 G0 A0.
- N335 M10
- N340 M8
- N345 G17
- N350 G0 X45.705 Y-13.515
- N355 G43 Z15. H2
- N360 T1
- N365 G0 Z5.
- N370 G1 Z3.3 F500.
- N375 G18 G3 X44.933 Z2.5 I-0.8 K0.
- N380 G1 X31.503 Z2.031
- N385 Y-21. Z1.77
- N390 X58.5 Z0.827
- N395 Y-13.515 Z0.565
- N400 X31.503 Z-0.377
- N405 Y-21. Z-0.639
- N410 X58.5 Z-1.581
- N415 Y-13.515 Z-1.843
- N420 X53.998 Z-2.
- N425 X31.503 F1000.
- N430 Y-21.
- N435 X58.5
- N440 Y-13.515
- N445 X53.998
- N450 X31.503 Z-2.786 F500.
- N455 Y-21. Z-3.047
- N460 X58.5 Z-3.99
- N465 Y-20.704 Z-4.
- N470 Y-13.515 F1000.
- N475 X31.503
- N480 Y-21.
- N485 X58.5
- N490 Y-20.704
- N495 Y-13.515 Z-4.251 F500.
- N500 X31.503 Z-5.194
- N505 Y-21. Z-5.455
- N510 X47.105 Z-6.
- N515 X58.5 F1000.
- N520 Y-13.515
- N525 X31.503
- N530 Y-21.
- N535 X47.105
- N540 X58.5 Z-6.398 F500.
- N545 Y-13.515 Z-6.659
- N550 X31.503 Z-7.602
- N555 Y-21. Z-7.863
- N560 X35.414 Z-8.
- N565 X47.105 F1000.
- N570 X58.5
- N575 Y-13.515
- N580 X31.503
- N585 Y-21.



N590 X35.414
 N595 X58.5 Z-8.806 F500.
 N600 Y-13.515 Z-9.068
 N605 X31.798 Z-10.
 N610 X31.503 F1000.
 N615 Y-21.
 N620 X58.5
 N625 Y-13.515
 N630 X31.798
 N635 X31.503 Z-10.01 F500.
 N640 Y-21. Z-10.272
 N645 X46.632 Z-10.8
 N650 X58.5 F1000.
 N655 Y-13.515
 N660 X31.798
 N665 X31.503
 N670 Y-21.
 N675 X46.632
 N680 X52.359 Z-11. F500.
 N685 X58.5 F1000.
 N690 Y-13.515
 N695 X31.503
 N700 Y-21.
 N705 X46.632
 N710 X52.359
 N715 X52.441 Y-20.996 Z-10.987
 N720 X52.523 Y-20.983 Z-10.974
 N725 X52.602 Y-20.962 Z-10.961
 N730 X52.706 Y-20.921 Z-10.904
 N735 X52.803 Y-20.866 Z-10.847
 N740 X52.873 Y-20.813 Z-10.759
 N745 X52.938 Y-20.752 Z-10.67
 N750 X52.976 Y-20.71 Z-10.559
 N755 X53.01 Y-20.665 Z-10.447
 N760 X53.032 Y-20.632 Z-10.2
 N765 G0 Z15.
 N770 G1 X53.385 Y21. F5000.
 N775 G0 Z5.
 N780 G1 Z3.3 F500.
 N785 G3 X52.613 Z2.5 I-0.8 K0.
 N790 G1 X31.56 Z1.765
 N795 Y13.506 Z1.503
 N800 X58.5 Z0.562
 N805 Y21. Z0.301
 N810 X31.56 Z-0.64
 N815 Y13.506 Z-0.902
 N820 X58.5 Z-1.843
 N825 Y18.013 Z-2.
 N830 Y21. F1000.
 N835 X31.56
 N840 Y13.506
 N845 X58.5
 N850 Y18.013
 N855 Y21. Z-2.104 F500.
 N860 X31.56 Z-3.045
 N865 Y13.506 Z-3.307
 N870 X51.411 Z-4.
 N875 X58.5 F1000.
 N880 Y18.013
 N885 Y21.
 N890 X31.56
 N895 Y13.506
 N900 X51.411
 N905 X58.5 Z-4.248 F500.
 N910 Y21. Z-4.509
 N915 X31.56 Z-5.45
 N920 Y13.506 Z-5.712
 N925 X39.815 Z-6.
 N930 X51.411 F1000.
 N935 X58.5
 N940 Y21.
 N945 X31.56
 N950 Y13.506
 N955 X39.815
 N960 X58.5 Z-6.653 F500.
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 N970 X31.56 Z-7.855
 N975 Y16.847 Z-8.
 N980 Y13.506 F1000.
 N985 X58.5
 N990 Y21.
 N995 X31.56
 N1000 Y16.847
 N1005 Y13.506 Z-8.117 F500.
 N1010 X58.5 Z-9.057
 N1015 Y21. Z-9.319
 N1020 X39.003 Z-10.



N1025 X31.56 F1000.
 N1030 Y16.847
 N1035 Y13.506
 N1040 X58.5
 N1045 Y21.
 N1050 X39.003
 N1055 X31.56 Z-10.26 F500.
 N1060 Y13.506 Z-10.522
 N1065 X39.531 Z-10.8
 N1070 X58.5 F1000.
 N1075 Y21.
 N1080 X39.003
 N1085 X31.56
 N1090 Y13.506
 N1095 X39.531
 N1100 X45.259 Z-11. F500.
 N1105 X58.5 F1000.
 N1110 Y21.
 N1115 X31.56
 N1120 Y13.506
 N1125 X39.531
 N1130 X45.259
 N1135 X45.341 Y13.51 Z-10.987
 N1140 X45.422 Y13.523 Z-10.974
 N1145 X45.502 Y13.544 Z-10.961
 N1150 X45.605 Y13.585 Z-10.904
 N1155 X45.702 Y13.64 Z-10.847
 N1160 X45.773 Y13.693 Z-10.759
 N1165 X45.837 Y13.754 Z-10.67
 N1170 X45.875 Y13.796 Z-10.559
 N1175 X45.91 Y13.841 Z-10.447
 N1180 X45.932 Y13.874 Z-10.2
 N1185 G0 Z15.
 N1190 G1 X-51.267 Y-15.568 F5000.
 N1195 G0 Z5.
 N1200 G1 Z3.3 F500.
 N1205 X-51.283 Y-15.535 Z3.058
 N1210 X-51.332 Y-15.437 Z2.838
 N1215 X-51.414 Y-15.289 Z2.662
 N1220 X-51.527 Y-15.106 Z2.546
 N1225 X-51.666 Y-14.909 Z2.5
 N1230 G17 G3 X-51.478 Y-15.182 Z1.678 I-3.034 J-2.288
 N1235 X-51.315 Y-15.471 Z0.856 I-3.222 J-2.015
 N1240 X-51.177 Y-15.772 Z0.033 I-3.385 J-1.726
 N1245 X-51.066 Y-16.085 Z-0.789 I-3.523 J-1.425
 N1250 X-50.983 Y-16.406 Z-1.611 I-3.634 J-1.112
 N1255 X-58.5 Y-17.197 Z-2. I-3.717 J-0.792
 N1260 G1 Y-21. F1000.
 N1265 X-31.457
 N1270 Y-13.394
 N1275 X-58.5
 N1280 Y-17.197
 N1285 Y-21. Z-2.133 F500.
 N1290 X-31.457 Z-3.077
 N1295 Y-13.394 Z-3.343
 N1300 X-50.278 Z-4.
 N1305 X-58.5 F1000.
 N1310 Y-17.197
 N1315 Y-21.
 N1320 X-31.457
 N1325 Y-13.394
 N1330 X-50.278
 N1335 X-58.5 Z-4.287 F500.
 N1340 Y-21. Z-4.553
 N1345 X-31.457 Z-5.497
 N1350 Y-13.394 Z-5.763
 N1355 X-38.254 Z-6.
 N1360 X-50.278 F1000.
 N1365 X-58.5
 N1370 Y-21.
 N1375 X-31.457
 N1380 Y-13.394
 N1385 X-38.254
 N1390 X-58.5 Z-6.707 F500.
 N1395 Y-21. Z-6.973
 N1400 X-31.457 Z-7.917
 N1405 Y-18.622 Z-8.
 N1410 Y-13.394 F1000.
 N1415 X-58.5
 N1420 Y-21.
 N1425 X-31.457
 N1430 Y-18.622
 N1435 Y-13.394 Z-8.183 F500.
 N1440 X-58.5 Z-9.127
 N1445 Y-21. Z-9.393
 N1450 X-41.104 Z-10.
 N1455 X-31.457 F1000.



N1460 Y-13.394
 N1465 X-58.5
 N1470 Y-21.
 N1475 X-41.104
 N1480 X-31.457 Z-10.337 F500.
 N1485 Y-13.394 Z-10.602
 N1490 X-37.114 Z-10.8
 N1495 X-58.5 F1000.
 N1500 Y-21.
 N1505 X-41.104
 N1510 X-31.457
 N1515 Y-13.394
 N1520 X-37.114
 N1525 X-42.841 Z-11. F500.
 N1530 X-58.5 F1000.
 N1535 Y-21.
 N1540 X-31.457
 N1545 Y-13.394
 N1550 X-42.841
 N1555 X-42.924 Y-13.399 Z-10.987
 N1560 X-43.005 Y-13.411 Z-10.974
 N1565 X-43.085 Y-13.432 Z-10.961
 N1570 X-43.188 Y-13.474 Z-10.904
 N1575 X-43.285 Y-13.529 Z-10.847
 N1580 X-43.356 Y-13.582 Z-10.759
 N1585 X-43.42 Y-13.642 Z-10.67
 N1590 X-43.458 Y-13.685 Z-10.559
 N1595 X-43.493 Y-13.73 Z-10.447
 N1600 X-43.515 Y-13.762 Z-10.2
 N1605 G0 Z5.
 N1610 G1 X-32.34 Y21. F5000.
 N1615 Z3.3 F500.
 N1620 G18 G3 X-33.113 Z2.5 I-0.8 K0.
 N1625 G1 X-58.699 Z1.607
 N1630 Y14.985 Z1.396
 N1635 X-31.544 Z0.448
 N1640 Y21. Z0.238
 N1645 X-58.699 Z-0.71
 N1650 Y14.985 Z-0.92
 N1655 X-31.544 Z-1.868
 N1660 Y18.753 Z-2.
 N1665 Y21. F1000.
 N1670 X-58.699
 N1675 Y14.985
 N1680 X-31.544
 N1685 Y18.753
 N1690 Y21. Z-2.078 F500.
 N1695 X-58.699 Z-3.027
 N1700 Y14.985 Z-3.237
 N1705 X-36.843 Z-4.
 N1710 X-31.544 F1000.
 N1715 Y18.753
 N1720 Y21.
 N1725 X-58.699
 N1730 Y14.985
 N1735 X-36.843
 N1740 X-31.544 Z-4.185 F500.
 N1745 Y21. Z-4.395
 N1750 X-58.699 Z-5.343
 N1755 Y14.985 Z-5.553
 N1760 X-45.911 Z-6.
 N1765 X-36.843 F1000.
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 N1775 Y21.
 N1780 X-58.699
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 N1790 X-45.911
 N1795 X-31.544 Z-6.502 F500.
 N1800 Y21. Z-6.712
 N1805 X-58.699 Z-7.66
 N1810 Y14.985 Z-7.87
 N1815 X-54.978 Z-8.
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 N1825 Y21.
 N1830 X-58.699
 N1835 Y14.985
 N1840 X-54.978
 N1845 X-31.544 Z-8.818 F500.
 N1850 Y21. Z-9.028
 N1855 X-58.699 Z-9.977
 N1860 Y20.332 Z-10.
 N1865 Y14.985 F1000.
 N1870 X-31.544
 N1875 Y21.
 N1880 X-58.699
 N1885 Y20.332
 N1890 Y14.985 Z-10.187 F500.



N1895 X-41.136 Z-10.8
 N1900 X-31.544 F1000.
 N1905 Y21.
 N1910 X-58.699
 N1915 Y14.985
 N1920 X-41.136
 N1925 X-35.409 Z-11. F500.
 N1930 X-31.544 F1000.
 N1935 Y21.
 N1940 X-58.699
 N1945 Y14.985
 N1950 X-41.136
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 N1960 X-35.327 Y14.989 Z-10.987
 N1965 X-35.245 Y15.002 Z-10.974
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 N2010 G0 Z15.

N2015 M5
 N2020 M9
 N2025 G53 G0 Z0.
 N2030 M11
 N2035 G0 A0.
 N2040 M10
 N2045 X0.
 N2050 G53 G0 Y0.
 N2055 M30

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