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3 Axis Cnc Programme Generation of Cover Plate

B Naga Pavan Kumar Reddy[1], Shaik Abzal Basha[2], A. Vidyasagar[3]
[1]P.G. Scholar, [2]Guide, Asst. Professor, [3]Head Of The Department
[1,2,3] BRANCH : Mechanical Engineering (CAD/CAM)
[1,2,3]Geethanjali College Of Engineering & Technology
Email : [1] bugganapavan@gmail.com,[2] shaikabzalbasha777@gmail.com

ABSTRACT

Cover plate is used to hold the amplifiers, resistors and other circuit parts in electrical circuit box. It is clamped to entire circuit box like cap. The component requires both inside and outside machining. So it needs a special type of fixture to hold the component rigidly. For this, the component is top clamped. This process done in CNC Machines.

Process planning is function within the manufacturing facility that establishes which processes and parameters are to be used (as well as those machines capable of performing these processes) to convert a work piece to a finished part from its initial form to the final one predetermined in a engineering drawing.

The main aim of this project is to optimize the machining time of electronic cover plate. This process done by developing fixture for manufacturing of cover plate. NX-CAD is used for developing design of cover plate and fixture and NX-CAM is used for performing manufacturing process and generating NC program for cover plate.

INTRODUCTION

Cover plate is used to hold the amplifiers, resistors and other circuit parts in electrical circuit box. It is clamped to entire circuit box like cap. It receives the incoming power from the utility company and distributes it to each of the circuits that supply the various lights, outlets, appliances, and other devices throughout the house. Everything but the incoming utility power can be shut off and turned on at the main service panel.

A service panel is a steel box with a hinged door or lift-up panel on the front. With the door open, you can access all the circuit breakers in the panel. Typically, one panel feeds the entire house, but there can also be another, smaller panel, called a *subpanel*, which may be used to serve a specific area, such as an addition, a large kitchen, or a detached garage. A subpanel works just like a main service panel but is supplied by the home's main panel rather than directly by the utility lines.

Each circuit breaker is controlled with a lever that can be set manually to an ON or OFF position. If a circuit breaker trips, usually due to an overload or other problem with the circuit, the lever will automatically move to a third position between ON and OFF. Breakers should be labeled to identify the main area or appliance served by the breaker's circuit. Labels may be stickers or hand-written words next to breakers or on a sheet adhered to the inside of the panel door.

1.2 PROCESS PLANNING

Process planning is a production organization activity that transforms a product design into a set of instruction (sequence, machine tool setup etc.) to manufacture machined part economically and competitively. The information provided in design includes dimensional specification (geometric shape and its feature) and technical specification (tolerance, surface finish etc.)

The component can be either designed in UG or can be retrieved from any other CAD software. Then sequence of

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programs such as modeling the component, selection of tools according to the sequence of operations and sizes, generating the tool path, at last the generated NC part program is verified and sent to the required CNC machine to manufacture the particular component. Finally the required surface finish has been obtained by machining the component at optimum speeds and feeds and the cost of machining is also optimized by choosing optimal machining process and machine tools.

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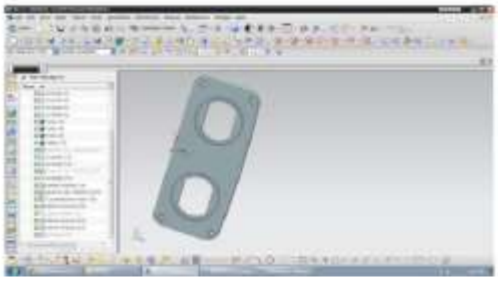
Process planning is that facet of manufacturing engineering which covers the translation of engineering design data into the most efficient method of part manufacturing. Process planning is function within the manufacturing facility that establishes which processes and parameters are to be used (as well as those machines capable of performing these processes) to convert a work piece to a finished part from its initial form to the final one predetermined in a engineering drawing.

Our project deals with the design and tool path generation for "COVER PLATE" component using CAM software ('UG NX-7.5' which is a CAD/CAM software used to generate part program by designing and feeding the geometry of the component) and defining the proper tool path and thus transferring the generated part program to the required CNC machine with the help of DNC lines. Then the program is executed with suitable requirements.



1.3 COMPUTER AIDED DESIGN

CAD implementations have evolved dramatically since then. Initially, with 3D in the 1970s, it was typically limited to producing drawings similar to hand-drafted drawings. Advances in programming and computer hardware, notably solid modeling in the 1980s, have allowed more versatile applications of computers in design activities.

Computer-aided design (CAD), also known as computer-aided design and drafting (CADD), is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. Computer-aided drafting describes the process of creating a technical drawing with the use of computer software. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print or machining operations. CAD software uses either vector based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects.

Computer-aided design (CAD) is defined as the application of computers and graphics software to aid or enhance the product design from conceptualization to documentation. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system. Computer-aided design systems are powerful tools and in the mechanical design and geometric modeling of products and components.

CAD is concerned with the mathematical description of the geometry of an object. This is the first and synthesis phase of product design. The basic operations of the modeling stage are generating basic geometric elements such as points, lines, circles, primitives such as cubes and functions such as scaling, rotation, transformation, joining, wire frame representation and solid modeling.

Throughout the history of our industrial society, many inventions have been patented and whole new technologies have evolved. Perhaps the single development that has impacted manufacturing more quickly and significantly than any previous technology is the digital computer. Computers are being used increasingly for both design and detailing of engineering components in the drawing office.

COMPUTER AIDED MANUFATURING

Integration of CAD with other components of CAD/CAM/CAE Product lifecycle management (PLM) environment requires an effective CAD data exchange. Usually it had been necessary to force the CAD operator to export the data in one of the common data formats, such as IGES or STL, that are supported by a wide variety of software. The output from the CAM software is usually a simple text file of G-code, sometimes many thousands of commands long, that is then transferred to a machine tool using a direct numerical control (DNC) program.

Computer-aided manufacturing (CAM) is defined as the effective use computer technology in manufacturing planning and control. CAM is most closely associated with functions in manufacturing engineering, such as process and production planning, machining, scheduling, management, quality control, and numerical control (NC) part programming. Computer-aided design and computer-aided manufacturing are often combined CAD/CAM systems.

CAM packages could not, and still cannot, reason as a machinist can. They could not optimize tool paths to the extent required of mass production. Users would select the type of tool, machining process and paths to be used. While an engineer may have a working knowledge of G-code programming, small optimization and wear issues compound over time. Mass-produced items that require machining are often initially created through casting or some other non-machine method. This enables hand-written, short, and highly optimized G-code that could not be produced in a CAM package.

The combination of CAD/CAM allows the transfer of information from the design into the stage of planning for the manufacturing of a product, without the need to reenter the data on part geometry manually. The database developed during CAD is stored; then it is processed further, by CAM, into the necessary data and instructions for operating and controlling production machinery, material handling equipment, and automated testing and inspection for product quality.

NUMERICAL CONTROL

Numerical control is a technique involving coded, numerical instructions for the automatic control and performance of a machine tool. It is a method of controlling machine tool movements with the aid of a number language. The number language is usually applied to a piece of tape in the form of machine-punched holes.

The development of "NUMERICAL CONTROL" technology has brought about the concept of a "Machine Centre" on which a wide variety of machining tasks can be accomplished on the same machine tool.A machining centre is the most capable of versatile NC machine tool, which can perform milling, drilling, boring, reaming, and tapping operations. A general objective behind the development of NC technology has been the reduction of production cost by reducing production time. Numerical control can be applied to milling, lathes, grinding, boring machines, flame cutting machine etc…The punched tape is the precise input medium used to control moving members of a machine tool "automatically" as opposed to "manually". Organized numerical information properly placed on an input medium, usually tape, functions as a series of sequenced machine tool operating commands. The operating commands are executed automatically with amazing speed, accuracy, efficiency, and repeatability.

Innovations of numerical control have contributed to revolutionary practices in manufacturing technology which have had a dynamic impact on the automatic control of machining procedures. N/C involvement has grown from a limited aerospace production to one including a wide variety of manufacturing industries. Knowledgeable men in numerical control activities have formed societies to study and promote N/C.

COMPUTER NUMERICAL CONTROL

In CNC (Computer Numerical Control), the instructions are stored as a program in a micro-computer attached to the machine. The computer will also handle much of the control logic of the machine, making it more adaptable than earlier hard-wired controllers.

In a CNC machine the slides moves electric servomotors attached to each moving axes. And these motors are directly coupled with lead screws command, for these motors come from computer control, which is the brain of the system. In a conventional machine hands achieve these axis movements and control is done by brain. Servomotors and computer control replace this use of brain and hands for operation of a conventional machine.

Importance of CNC:

- Increase production throughput
- Improve the quality and accuracy of manufactured parts
- Stabilize manufacturing costs
- Manufacture complex or otherwise impossible jobs-2D and 3D contours.

Advantages of CNC:

- Flexibility of operation is improved, as is the ability to produce complex shapes with good dimensional accuracy, repeatability, reduced scrap loss, and high production rates, productivity, and product quality.
- Tooling costs are reduced, since templates and other fixtures are not required.

- Machine adjustments are easy to make with microcomputers and digital readouts.
- More operations can be performed with each setup, and less lead time for setup and machining is required compared to conventional methods. Design changes are facilitated, and inventory is reduced.
- Programs can be prepared rapidly and can be recalled at any time utilizing microprocessors. Less paperwork is involved.
- Faster prototype production is possible.
- Required operator skill is less than that for a qualified machinist, and the operator has more time to attend to other tasks in the work area.

INTRODUCTION TO UNIGRAPHICS

NX, also known as NX Unigraphics or usually just U-G, is an advanced CAD/CAM/CAE software package developed by Siemens PLM Software.

It is used, among other tasks, for:

- Design (parametric and direct solid/surface modeling)
- Engineering analysis (static, dynamic, electro-magnetic, thermal, using the Finite Element Method, and fluid using the finite volume method).
- Manufacturing finished design by using included machining modules

First release of the new "Next Generation" version of Unigraphics and I-deas, called NX. This will eventually bring the functionality and capabilities of both Unigraphics and I-DEAS together into a single consolidated product.

Increasing complexity of products, development processes and design teams is challenging companies to find new tools and methods to deliver greater innovation and higher quality at lower cost. Leading-edge technology from Siemens PLM software delivers greater power for today's design challenge. From innovative Synchronous Technology that unites parametric and history-free modeling, to NX Active Mockup for multi-CAD assembly design, NX delivers breakthrough technology that sets new standards for speed, performance, and ease of use.

NX automates and simplifies design by leveraging the product and process knowledge that companies gain from experience and from industry best practices. It includes tools that designers can use to capture knowledge to automated repetitive tasks. The result is reduced cost and cycle time and improved quality.

LITERATRE REVIEW

1. **MaithamAlibrahemyabc, SébastienDurifab PhilippeBressoletteab AbdelhamidBouchaïrab:** Finite Element Analysis of Cover Plate Joint under Ultimate Loading. This paper presents a parametric study to investigate the mechanical behavior of bolted connection plates based on finite element analysis (FEA). Different parameters as end distances, bolt spacing, and plate thickness. EC3 (Eurocode 3) and AISC-LRFD (American Institute for Steel Construction - Load and Resistance Factor Design) specifications design ultimate loads are compared with finite elements results. Many failure modes are observed such as curling, bearing, net section failure, edge tearing of the connected plate etc. The comparisons showed the differences between the finite element results and the analytical formulae of design codes for each specimen.

Dr Nicos Bilalis: Computer Aided Design-CAD is defined the use of information technology (IT) in the Design process. A CAD system consists of IT hardware (H/W), specialised software (S/W) (depending on the particular area of application) and peripherals, which in certain applications are quite specialized.

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The core of a CAD system is the S/W, which makes use of graphics for product representation; databases for storing the product model and drives the peripherals for product presentation. Its use does not change the nature of the design process but as the name states it aids the product designer. The designer is the main actor in the process, in all phases from problem identification to the implementation phase.
Miltiadis A. Boboulos: CAD-CAM systems are probably the most significant development in the field of new technology related to engineering, design and drafting in all technical spheres.

DESIGNING OF COVER PLATE

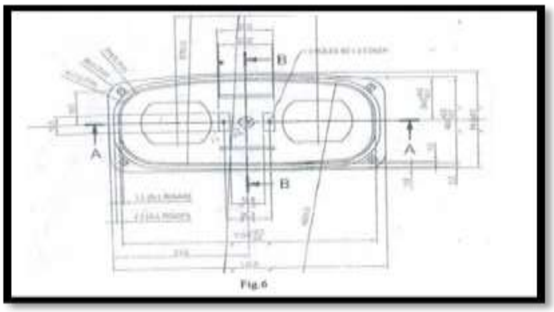
3.1 INPUT FOR THE PROJECT

2D Drawing

A 2D drawing is used to design a 3D model for our component using Unigraphics NX 7.5 CAD software.

Below shows the 2D drawings of the Cover Plate with all the required dimensions and GD&T representations the suits the best for manufacturing the component without any errors.

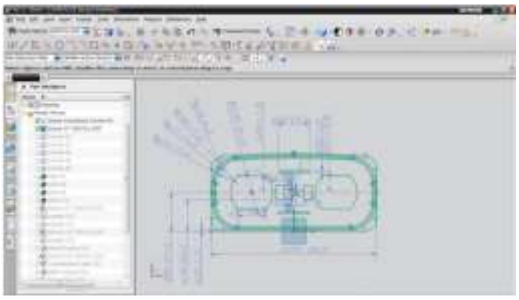
3 AXIS CNC PROGRAMME GENERATION OF COVER PLATE



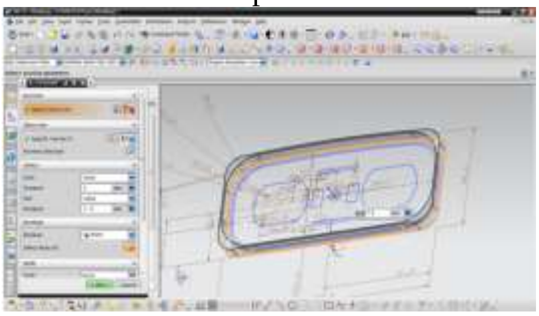
3.2 STEPS INVOLVED IN 3d MODELING

Sketching

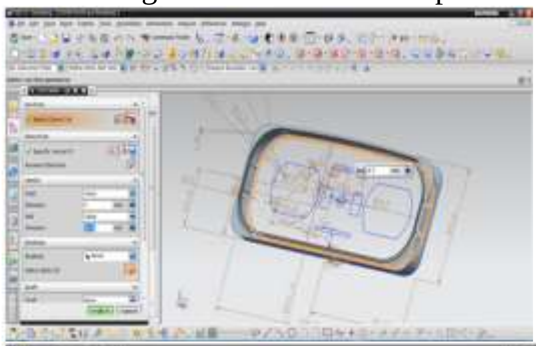
Below is the sketch required to obtain the 3D model of the mount nozzle plate drive from the above 2D drawing.
Below image shows the sketch of the cover plate.

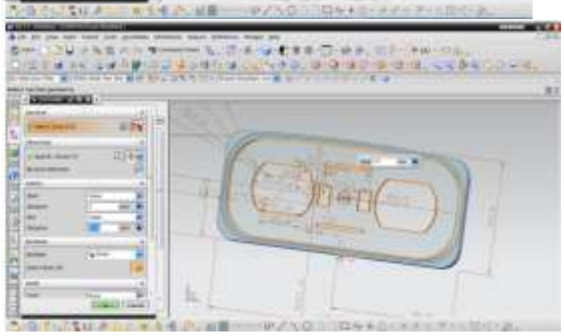


Below image shows the extrude option for outer wall of cover plate.



Below image shows the extrude option.





Below image shows the extrude option for the inner slots.

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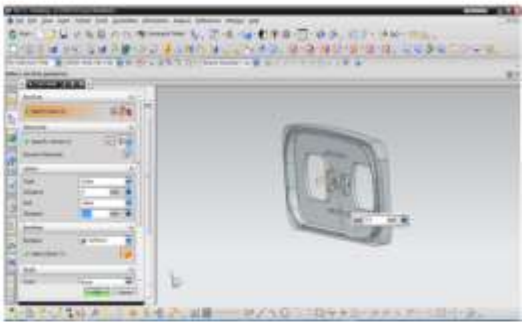
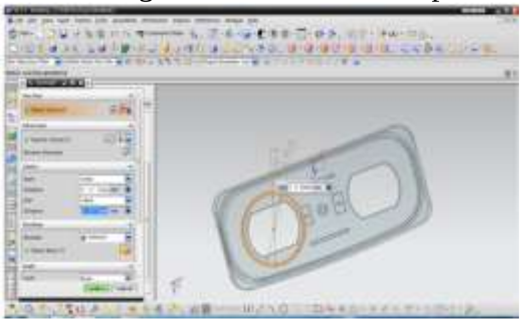
Below image shows the extrude option for the holes.



Below image shows the extrude option.



Below image shows the counter bore hole option.

Below image shows the mirror option for counter bore.

Below image shows the 3D component of cover plate.

MANUFACTURING OF COVER PLATE WITH FIXTRE

4.1 IDENTIFY SUITABLE MACHINE.

TYPES OF CNC MACHINE USED IN THIS PROJECT:

MORI SEIKI 4-AXIS CNC turning machine is used for machining spike support. DMG MORI SEIKI offers the industry's best lineup of high-performance lathes with better precision and rigidity, greater multi-axis compatibility and smaller footprints.

High rigidity with Integrated Turning Spindle. Spindle is directly coupled with motor. Rigid Turret with BIM (Built In Motor) Technology. Directly coupled Integrated driven tools. Is a patent technology. Y-axis machining,Up to 100mm (+/- 50). 4-axes simultaneous machining, C-axis with 360 deg and Y-axis, Machine accuracies, Positional Accuracy +/- 0.005mm, Repeatability +/- 0.003mm. In 4-axis turning machine, Axis represents as work piece rotation and spindle movement in x, y, z directions.

Fig: 4-axis CNC MORI SIEKI Turn-mill machine

4.2 SETUP 1 TOOLING LIST

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We need to select/create a tool for each of the Machining operations. In the Project Manager, you can create and automatically assign new tools to tool stations in the Tools view. You can also create tools from the Machining menu.

TOOLING LIST

Milling Tools

TOOL NAME	DESCRIPTION	DIAMETER	COR RAD	FLUTE LEN	ADJ REG
FACE_MILL_D65	Milling Tool-5 Parameters	65.0000	1.0000	25.0000	0
FACE_MILL_D40	Milling Tool-5 Parameters	40.0000	1.0000	25.0000	0
MILL_D6	Milling Tool-5 Parameters	6.0000	0.0000	25.0000	0
MILL_D10	Milling Tool-5 Parameters	10.0000	0.0300	25.0000	0
MILL_D4	Milling Tool-5 Parameters	4.0000	0.0000	50.0000	0
MILL_D8	Milling Tool-5 Parameters	8.0000	0.0300	25.0000	0
MILL_D1	Milling Tool-5 Parameters	1.0000	0.0000	10.0000	0
MILL_D2	Milling Tool-5 Parameters	2.0000	0.0000	10.0000	0
MILL	Milling Tool-5 Parameters	30.0000	0.0000	50.0000	0
DRILLING_TOOL_D3	Milling Tool-5 Parameters	3.0000	0.0000	20.0000	0

4.3 SETUP 2 TOOLING LIST

We need to select/create a tool for each of the Machining operations. In the Project Manager, you can create and automatically assign new tools to tool stations in the Tools view. You can also create tools from the Machining menu.

TOOLING LIST

Drilling Tools

TOOL NAME	DESCRIPTION	DIAMETER	TIP ANG	FLUTE LEN	ADJ REG
DRILLING_TOOL_D3.4	Drilling Tool	12.0000	118.0000	35.0000	0
DRILLING_TOOLD3.4	Drilling Tool	3.4000	118.0000	20.0000	0
COUNTER_BORE_6.2	Counterbore	10.0000	0.0000	0.0000	0

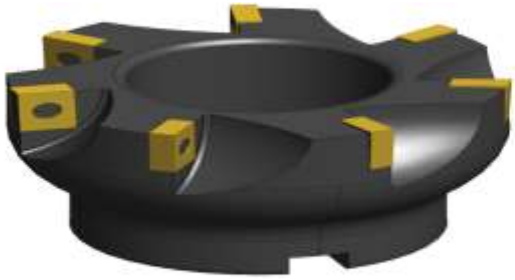
TOOL NAME	DESCRIPTION	DIAMETER	COR RAD	FLUTE LEN	ADJ REG
FACE_MILL_D40	Milling Tool-5 Parameters	40.0000	1.0000	25.0000	0
MILL_D6	Milling Tool-5 Parameters	6.0000	0.0000	50.0000	0
MILL_D10	Milling Tool-5 Parameters	10.0000	0.0000	50.0000	0
MILL_D4	Milling Tool-5 Parameters	4.0000	0.0000	50.0000	0
MILL_D8	Milling Tool-5 Parameters	8.0000	0.0000	50.0000	0
MILL_D1	Milling Tool-5 Parameters	1.0000	0.0000	10.0000	0
MILL_D2	Milling Tool-5 Parameters	2.0000	0.0000	10.0000	0
MILL_D1.4	Milling Tool-5 Parameters	1.4000	0.0000	20.0000	0
MILL_D6.2	Milling Tool-5 Parameters	6.2000	0.0000	20.0000	0

TOOL DESCRIPTION

END MILL

End mills (middle row in image) are those tools which have cutting teeth at one end, as well as on the sides. The words end mill is generally used to refer to flat bottomed cutters, but also include rounded cutters (referred to as ball nosed) and radiuses cutters (referred to as bull nose or torus). They are usually made from high speed steel (HSS) or carbide, and have one or more flutes. They are the most common tool used in a vertical mill.

FACE MILL



A face mill consists of a cutter body (with the appropriate machine taper) that is designed to hold multiple disposable carbide or ceramic tips or inserts, often golden in color. The tips are not designed to be re sharpened and are selected from a range of types that may be determined by various criteria, some of which may be: tip shape, cutting action required, and material being cut. When the tips are blunt, they may be removed, rotated (indexed) and replaced to present a fresh, sharp face to the work piece. This increases the life of the tip and thus its economical cutting life.

DRILL BITS

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Drill bits are cutting tools used to create cylindrical holes, almost always of circular cross-section. Bits are held in a tool called a drill, which rotates them and provides torque and axial force to create the hole. Specialized bits are also available for non-cylindrical-shaped holes.

The shank is the part of the drill bit grasped by the chuck of a drill. The cutting edges of the drill bit are at one end, and the shank is at the other. Drill bits come in standard sizes.

4.4 MACHINE SETUP OPERATIONS

SETUP 1	SETUP 2
Face milling	Face milling
Profile milling	Profile milling
Cavity milling	Drilling
Drilling	Counter bore

4.5 FIXTURE MODELLING

3-2-1 PRINCIPLE

One method of reducing manufacturing cost per component is to reduce machining cycle time. The manufacturing cycle time can be reduced by reducing nonproductive time like loading, unloading, and the placing of work piece onto the machine. Here jig and fixture design has important role to play. Productive time for a machine is the time required for metal cutting operation by the machine.

In short, the fixture is a tool that ensures correct and quick clamping (or loading) of the work piece with respect to the machine tool.For a fixture designer, the major portion of design time is spent deciding how to locate the work piece in the fixture.

You know that any free body has a total of twelve degrees of freedom as below:

6 translational degrees of freedom**: +X, -X, +Y, -Y, +Z, -Z**

And 6 rotational degrees of freedom:

– Clockwise around X axis (**CROT-X**)

– Anticlockwise around X axis (**ACROT-X**)

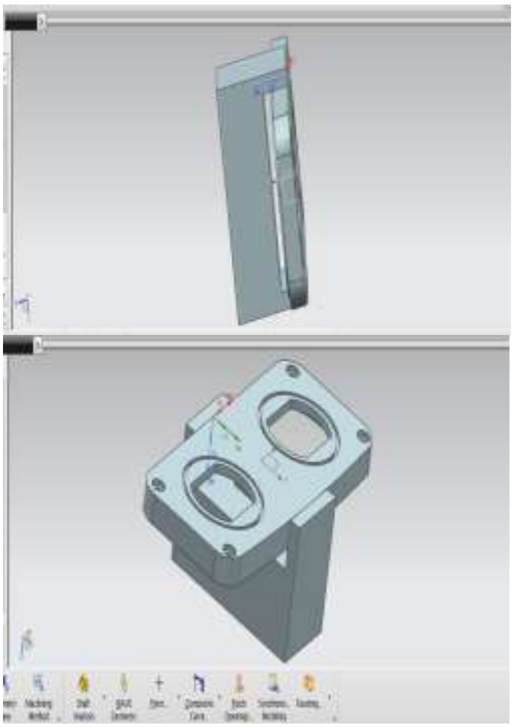
– Clockwise around Y axis (**CROT-Y**)

– Anticlockwise around Y axis (**ACROT-Y**)

– Clockwise around Z axis (**CROT-Z**)

– Anticlockwise around Z axis (**ACROT-Z**)

You must fix all the 12 degrees of freedom except the three transitional degrees of freedom (-X, -Y and -Z) in order to locate the work piece in the fixture. So, 9 degrees of freedom of the work piece need to be fixed.



4.1 Fixture with required part

4.6 CAM GENERATION

4.6.1 SETUP 1 OPERATIONS

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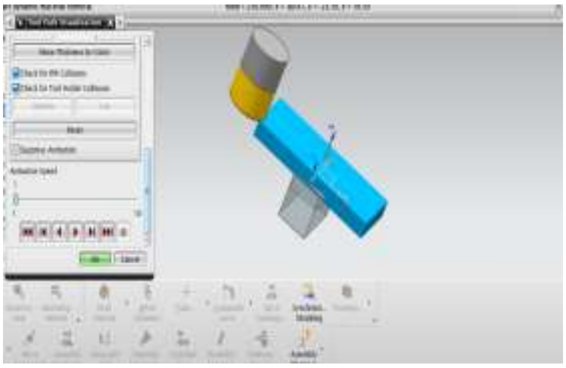

4.2 Face milling operation

4.3 Profile milling operation

4.4 Profile milling operation

4.5 Cavity milling operation

4.6 Cavity milling operation

4.7 Profile milling operation

4.8 Profile milling operation

4.9 Profile milling operation

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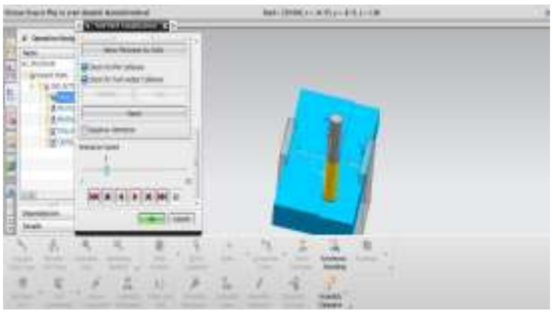
4.10 Profile milling operation

4.11 Drilling operation

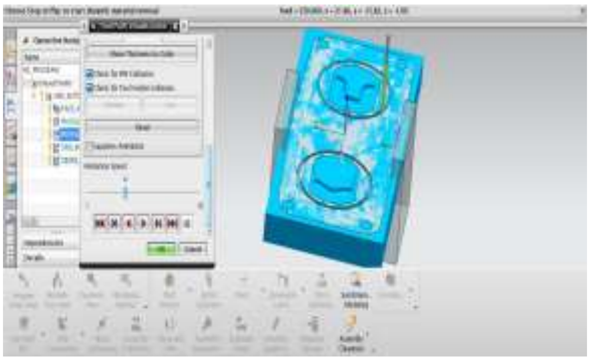
4.12 Drilling operation

4.6.2 SETUP 2 OPERATIONS

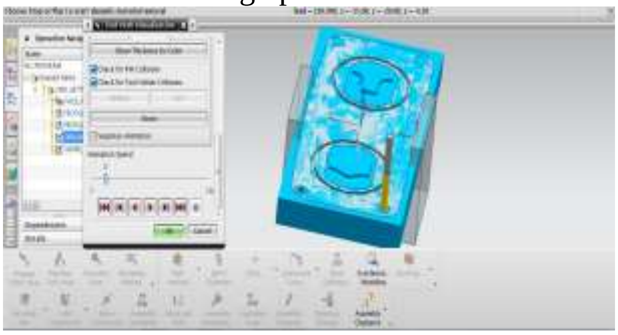


4.13 Face milling operation

4.14 Profile milling operation



4.15 Profile milling operation



4.16 Drilling operation

4.17 Drilling operation

4.7 CONVERT TO NC CODE

Using the post processor we have to convert CL file data into machine specified NC part program

1. In the Project Manager, select the first operation on the Operations page, then hold down the Shift key and select the last operation. All the cutting operations are selected.
2. Press the right mouse button and select NC Code from the menu.
3. Select a Machine Format file from the pull down list (3-Axis/5-Axis).
4. Select Apply.

Operation No.	Machining Operation	Tools Used	Spindle Speed(rpm)	Cutting Feed(mm/min)	Setup time
10	Face Milling	Face mill ϕ 65 mm	1000	350	240/5
20	Profile milling	End mill ϕ10 mm	600	150 to 200	320/15
30	Cavity milling	End mill ϕ40 mm	1000	150	250/12
40	Drilling	Drill tool	800	150 to 200	240/5

PROCESS SHEET FOR SETUP 1

PROCESS SHEET FOR SETUP 2

Operation No.	Machining Operation	Tools Used	Spindle Speed(rpm)	Cutting Feed(mm/min)	Setup time
10	Face Milling	Face mill ϕ 40 mm	1000	350	240/5
20	Profile milling	End mill ϕ10 mm	600	150 to 200	320/15
30	Drilling	Drill tool ϕ12 mm ϕ3.4 mm	1000	150	250/12
40	Counter bore	Drill ϕ 10 mm	800	150 to 200	240/5

NC PROGRAM

5.1 SETUP1 PROGRAM

```
%
N0010 G40 G17 G94 G90 G70
()
N0020 G91 G28 Z0.0
:0030 T00 M06
N0040 G0 G90 X3.9642 Y-.9252
A0.0 B0.0 S10000 M03
N0050 G43 Z.8465 H00
N0060 Z.5512
N0070 G1 Z.4331 F9.8 M08
N0080 X3.1683
N0090 X-3.1683
N0100 G2 X-3.189 Y-.7087
I1.1211 J.2165
N0110 G1 Y0.0
N0120 X3.189
N0130 Y.6316
N0140 G3 X3.1506 Y.9252 I-
1.1418 J0.0
N0150 G1 X-3.1506
N0160 X-3.9539
N0170 Z.5512
N0180 G0 Z.8465
N0190 X3.9642 Y-.9252
N0200 Z.5315
N0210 G1 Z.4134
N0220 X3.1683
N0230 X-3.1683
N0240 G2 X-3.189 Y-.7087
I1.1211 J.2165
N0250 G1 Y0.0
N0260 X3.189
N0270 Y.6316
N0280 G3 X3.1506 Y.9252 I-
1.1418 J0.0
N0290 G1 X-3.1506
N0300 X-3.9539
N0310 Z.5315
N0320 G0 Z.8465
N0330 X3.9642 Y-.9252
N0340 Z.5118
N0350 G1 Z.3937
N0360 X3.1683
N0370 X-3.1683
N0380 G2 X-3.189 Y-.7087
I1.1211 J.2165
N0390 G1 Y0.0
N0400 X3.189
N0410 Y.6316
N0420 G3 X3.1506 Y.9252 I-
1.1418 J0.0
N0430 G1 X-3.1506
N0440 X-3.9539
N0450 Z.5118
N0460 G0 Z.8465
N0470 X3.9642 Y-.9252
N0480 Z.4921
N0490 G1 Z.374
N0500 X3.1683
N0510 X-3.1683
N0520 G2 X-3.189 Y-.7087
I1.1211 J.2165
N0530 G1 Y0.0
N0540 X3.189
N0550 Y.6316
N0560 G3 X3.1506 Y.9252 I-
1.1418 J0.0
N0570 G1 X-3.1506
```

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N0580 X-3.9539
N0590 Z.4921
N1380 X-1.1477 Y-.0684
N1390 Z.374
N1400 G3 X-1.2205 Y-.0972
Z.2165 I-.0728 J.0775 K.0285
N1410 G1 X-.985
N1420 G3 Y.0972 I-.2355
J.0972
N1430 G1 X-1.4559
N1440 G3 Y-.0972 I.2354 J-
.0972
N1450 G1 X-1.2205
N1460 Y-.2154
N1470 X-.9161
N1480 G3 Y.2154 I-.3044
J.2154
N1490 G1 X-1.5248
N1500 G3 Y-.2154 I.3043 J-
.2154
N1510 G1 X-1.2205
N1520 Y-.3335
N1530 X-.8602
N1540 G3 Y.3335 I-.3603
J.3335
N1550 G1 X-1.5808
N1560 G3 Y-.3335 I.3603 J-
.3335
N1570 G1 X-1.2205
N1580 Y-.2154
N1590 Z.3346
N1600 G0 Z.7283
N1610 X-1.1477 Y-.0684
N1620 Z.3346
N1630 G3 X-1.2205 Y-.0972
Z.1772 I-.0728 J.0775 K.0285
N1640 G1 X-.985
N1650 G3 Y.0972 I-.2355
J.0972
N1660 G1 X-1.4559
N1670 G3 Y-.0972 I.2354 J-
.0972
N1680 G1 X-1.2205
N1690 Y-.2154
N1700 X-.9161
N1710 G3 Y.2154 I-.3044
J.2154
N1720 G1 X-1.5248
N1730 G3 Y-.2154 I.3043 J-
.2154
N1740 G1 X-1.2205
N1750 Y-.3335
N1760 X-.8602
N1770 G3 Y.3335 I-.3603
J.3335
N1780 G1 X-1.5808
N1790 G3 Y-.3335 I.3603 J-
.3335
N1800 G1 X-1.2205
N1810 Y-.2154
N1820 Z.2953
N1830 G0 Z.7283
N1840 X-1.1477 Y-.0684
N1850 Z.2953
N1860 G3 X-1.2205 Y-.0972
Z.1378 I-.0728 J.0775 K.0285
N1870 G1 X-.985
N1880 G3 Y.0972 I-.2355
J.0972
N1890 G1 X-1.4559
N1900 G3 Y-.0972 I.2354 J-
.0972
N1910 G1 X-1.2205
N1920 Y-.2154
N1930 X-.9161
N1940 G3 Y.2154 I-.3044
J.2154
N1950 G1 X-1.5248
N1960 G3 Y-.2154 I.3043 J-
.2154
N1970 G1 X-1.2205
N1980 Y-.3335
N1990 X-.8602
N2000 G3 Y.3335 I-.3603
J.3335
N2010 G1 X-1.5808
N2020 G3 Y-.3335 I.3603 J-
.3335
N2030 G1 X-1.2205
N2040 Y-.2154
N2050 Z.2559
N2060 G0 Z.7283
N2070 X-1.1477 Y-.0684
N2080 Z.2559
N2090 G3 X-1.2205 Y-.0972
Z.0984 I-.0728 J.0775 K.0285
```

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N2100 G1 X-.985
N2110 G3 Y.0972 I-.2355 J.0972
N2120 G1 X-1.4559
N2130 G3 Y-.0972 I.2354 J-.0972
N2140 G1 X-1.2205
N2150 Y-.2154
N2160 X-.9161
N2170 G3 Y.2154 I-.3044 J.2154
N2180 G1 X-1.5248
N2190 G3 Y-.2154 I.3043 J-.2154
N2200 G1 X-1.2205
N2210 Y-.3335
N2220 X-.8602
N2230 G3 Y.3335 I-.3603 J.3335
N2240 G1 X-1.5808
N2250 G3 Y-.3335 I.3603 J-.3335
N2260 G1 X-1.2205
N2270 Y-.2154
N2280 Z.2165
N2290 G0 Z.7283
N2300 X-1.1477 Y-.0684
N2310 Z.2165
N2320 G3 X-1.2205 Y-.0972 Z.0591 I-.0728 J.0775 K.0285
N2330 G1 X-.985
N2340 G3 Y.0972 I-.2355 J.0972
N2350 G1 X-1.4559
N2360 G3 Y-.0972 I.2354 J-.0972
N2370 G1 X-1.2205
N2380 Y-.2154
N2390 X-.9161
N2400 G3 Y.2154 I-.3044 J.2154
N2410 G1 X-1.5248
N2420 G3 Y-.2154 I.3043 J-.2154
N2430 G1 X-1.2205
N2440 Y-.3335
N2450 X-.8602
N2460 G3 Y.3335 I-.3603 J.3335
N2470 G1 X-1.5808
N2480 G3 Y-.3335 I.3603 J-.3335
N2490 G1 X-1.2205
N2500 Y-.2154
N2510 Z.1772
N2520 G0 Z.7283
N2530 X-1.1477 Y-.0684
N2540 Z.1772
N2550 G3 X-1.2205 Y-.0972 Z.0197 I-.0728 J.0775 K.0285
N2560 G1 X-.985
N2570 G3 Y.0972 I-.2355 J.0972
N2580 G1 X-1.4559
N2590 G3 Y-.0972 I.2354 J-.0972
N2600 G1 X-1.2205
N2610 Y-.2154
N2620 X-.9161
N2630 G3 Y.2154 I-.3044 J.2154
N2640 G1 X-1.5248
N2650 G3 Y-.2154 I.3043 J-.2154
N2660 G1 X-1.2205
N2670 Y-.3335
N2680 X-.8602
N2690 G3 Y.3335 I-.3603 J.3335
N2700 G1 X-1.5808
N2710 G3 Y-.3335 I.3603 J-.3335
N2720 G1 X-1.2205
N2730 Y-.2154
N2740 Z.1378
N2750 G0 Z.7283
N2760 X-1.1477 Y-.0684
N2770 Z.1378
N2780 G3 X-1.2205 Y-.0972 Z-.0197 I-.0728 J.0775 K.0285
N2790 G1 X-.985
N2800 G3 Y.0972 I-.2355 J.0972
N2810 G1 X-1.4559
```

```
N2820 G3 Y-.0972 I.2354 J-.0972
N2830 G1 X-1.2205
N2840 Y-.2154
N2850 X-.9161
N2860 G3 Y.2154 I-.3044 J.2154
N2870 G1 X-1.5248
N2880 G3 Y-.2154 I.3043 J-.2154
N2890 G1 X-1.2205
N2900 Y-.3335
N2910 X-.8602
N2920 G3 Y.3335 I-.3603 J.3335
N2930 G1 X-1.5808
N2940 G3 Y-.3335 I.3603 J-.3335
N2950 G1 X-1.2205
N2960 Y-.2154
N2970 Z.0984
N2980 G0 Z.7283
N2990 X-1.115 Y-.0042
N3000 Z.0984
N3010 G3 X-1.2205 Y-.0972 Z-.0394 I-.1055 J.0133 K.0285
N3020 G1 X-.985
N3030 G3 Y.0972 I-.2355 J.0972
N3040 G1 X-1.4559
N3050 G3 Y-.0972 I.2354 J-.0972
N3060 G1 X-1.2205
N3070 Y-.2154
N3080 X-.9161
N3090 G3 Y.2154 I-.3044 J.2154
N3100 G1 X-1.5248
N3110 G3 Y-.2154 I.3043 J-.2154
N3120 G1 X-1.2205
N3130 Y-.3335
N3140 X-.8602
N3150 G3 Y.3335 I-.3603 J.3335
N3160 G1 X-1.5808
N3170 G3 Y-.3335 I.3603 J-.3335
N3180 G1 X-1.2205
N3190 Y-.2154
N3200 Z.0787
N3210 G0 Z.7283
N3220 G0 X1.2933 Y-.0684 A0.0 B0.0 S2500 M03
N3230 Z.4528
N3240 G3 X1.2205 Y-.0972 Z.2953 I-.0728 J.0775 K.0285 F9.8
N3250 G1 X1.4559
N3260 G3 Y.0972 I-.2354 J.0972
N3270 G1 X.985
N3280 G3 Y-.0972 I.2355 J-.0972
N3290 G1 X1.2205
N3300 Y-.2154
N3310 X1.5248
N3320 G3 Y.2154 I-.3043 J.2154
N3330 G1 X.9161
N3340 G3 Y-.2154 I.3044 J-.2154
N3350 G1 X1.2205
N3360 Y-.3335
N3370 X1.5808
N3380 G3 Y.3335 I-.3603 J.3335
N3390 G1 X.8602
N3400 G3 Y-.3335 I.3603 J-.3335
N3410 G1 X1.2205
N3420 Y-.2154
N3430 Z.4134
N3440 G0 Z.7283
N3450 X1.2933 Y-.0684
N3460 Z.4134
N3470 G3 X1.2205 Y-.0972 Z.2559 I-.0728 J.0775 K.0285
N3480 G1 X1.4559
N3490 G3 Y.0972 I-.2354 J.0972
N3500 G1 X.985
N3510 G3 Y-.0972 I.2355 J-.0972
N3520 G1 X1.2205
N3530 Y-.2154
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N3540 X1.5248
N3550 G3 Y.2154 I-.3043 J.2154
N3560 G1 X.9161
N3570 G3 Y-.2154 I.3044 J-.2154
N3580 G1 X1.2205
N3590 Y-.3335
N3600 X1.5808
N3610 G3 Y.3335 I-.3603 J.3335
N3620 G1 X.8602
N3630 G3 Y-.3335 I.3603 J-.3335
N3640 G1 X1.2205
N3650 Y-.2154
N3660 Z.374
N3670 G0 Z.7283
N3680 X1.2933 Y-.0684
N3690 Z.374
N3700 G3 X1.2205 Y-.0972 Z.2165 I-.0728 J.0775 K.0285
N3710 G1 X1.4559
N3720 G3 Y.0972 I-.2354 J.0972
N3730 G1 X.985
N3740 G3 Y-.0972 I.2355 J-.0972
N3750 G1 X1.2205
N3760 Y-.2154
N3770 X1.5248
N3780 G3 Y.2154 I-.3043 J.2154
N3790 G1 X.9161
N3800 G3 Y-.2154 I.3044 J-.2154
N3810 G1 X1.2205
N3820 Y-.3335
N3830 X1.5808
N3840 G3 Y.3335 I-.3603 J.3335
N3850 G1 X.8602
N3860 G3 Y-.3335 I.3603 J-.3335
N3870 G1 X1.2205
N3880 Y-.2154
N3890 Z.3346
N3900 G0 Z.7283
N3910 X1.2933 Y-.0684
N3920 Z.3346
N3930 G3 X1.2205 Y-.0972 Z.1772 I-.0728 J.0775 K.0285
N3940 G1 X1.4559
N3950 G3 Y.0972 I-.2354 J.0972
N3960 G1 X.985
N3970 G3 Y-.0972 I.2355 J-.0972
N3980 G1 X1.2205
N3990 Y-.2154
N4000 X1.5248
N4010 G3 Y.2154 I-.3043 J.2154
N4020 G1 X.9161
N4030 G3 Y-.2154 I.3044 J-.2154
N4040 G1 X1.2205
N4050 Y-.3335
N4060 X1.5808
N4070 G3 Y.3335 I-.3603 J.3335
N4080 G1 X.8602
N4090 G3 Y-.3335 I.3603 J-.3335
N4100 G1 X1.2205
N4110 Y-.2154
N4120 Z.2953
N4130 G0 Z.7283
N4140 X1.2933 Y-.0684
N4150 Z.2953
N4160 G3 X1.2205 Y-.0972 Z.1378 I-.0728 J.0775 K.0285
N4170 G1 X1.4559
N4180 G3 Y.0972 I-.2354 J.0972
N4190 G1 X.985
N4200 G3 Y-.0972 I.2355 J-.0972
N4210 G1 X1.2205
N4220 Y-.2154
N4230 X1.5248
N4240 G3 Y.2154 I-.3043 J.2154
N4250 G1 X.9161
N4260 G3 Y-.2154 I.3044 J-.2154
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N4270 G1 X1.2205
N4280 Y-.3335
N4290 X1.5808
N4300 G3 Y.3335 I-.3603 J.3335
N4310 G1 X.8602
N4320 G3 Y-.3335 I.3603 J-.3335
N4330 G1 X1.2205
N4340 Y-.2154
N4350 Z.2559
N4360 G0 Z.7283
N4370 X1.2933 Y-.0684
N4380 Z.2559
N4390 G3 X1.2205 Y-.0972 Z.0984 I-.0728 J.0775 K.0285
N4400 G1 X1.4559
N4410 G3 Y.0972 I-.2354 J.0972
N4420 G1 X.985
N4430 G3 Y-.0972 I.2355 J-.0972
N4440 G1 X1.2205
N4450 Y-.2154
N4460 X1.5248
N4470 G3 Y.2154 I-.3043 J.2154
N4480 G1 X.9161
N4490 G3 Y-.2154 I.3044 J-.2154
N4500 G1 X1.2205
N4510 Y-.3335
N4520 X1.5808
N4530 G3 Y.3335 I-.3603 J.3335
N4540 G1 X.8602
N4550 G3 Y-.3335 I.3603 J-.3335
N4560 G1 X1.2205
N4570 Y-.2154
N4580 Z.2165
N4590 G0 Z.7283
N4600 X1.2933 Y-.0684
N4610 Z.2165
N4620 G3 X1.2205 Y-.0972 Z.0591 I-.0728 J.0775 K.0285
N4630 G1 X1.4559
N4640 G3 Y.0972 I-.2354 J.0972
N4650 G1 X.985
N4660 G3 Y-.0972 I.2355 J-.0972
N4670 G1 X1.2205
N4680 Y-.2154
N4690 X1.5248
N4700 G3 Y.2154 I-.3043 J.2154
N4710 G1 X.9161
N4720 G3 Y-.2154 I.3044 J-.2154
N4730 G1 X1.2205
N4740 Y-.3335
N4750 X1.5808
N4760 G3 Y.3335 I-.3603 J.3335
N4770 G1 X.8602
N4780 G3 Y-.3335 I.3603 J-.3335
N4790 G1 X1.2205
N4800 Y-.2154
N4810 Z.1772
N4820 G0 Z.7283
N4830 X1.2933 Y-.0684
N4840 Z.1772
N4850 G3 X1.2205 Y-.0972 Z.0197 I-.0728 J.0775 K.0285
N4860 G1 X1.4559
N4870 G3 Y.0972 I-.2354 J.0972
N4880 G1 X.985
N4890 G3 Y-.0972 I.2355 J-.0972
N4900 G1 X1.2205
N4910 Y-.2154
N4920 X1.5248
N4930 G3 Y.2154 I-.3043 J.2154
N4940 G1 X.9161
N4950 G3 Y-.2154 I.3044 J-.2154
N4960 G1 X1.2205
N4970 Y-.3335
N4980 X1.5808
N4990 G3 Y.3335 I-.3603 J.3335
```

```
N5000 G1 X.8602
N5010 G3 Y-.3335 I.3603 J-.3335
N5020 G1 X1.2205
N5030 Y-.2154
N5040 Z.1378
N5050 G0 Z.7283
N5060 X1.2933 Y-.0684
N5070 Z.1378
N5080 G3 X1.2205 Y-.0972 Z-.0197 I-.0728 J.0775 K.0285
N5090 G1 X1.4559
N6460 G2 X-.7412 Y-.4148 I.3149 J0.0
N6470 X-.8287 Y-.1969 I.2274 J.2179
N6480 G1 Y.1969
N6490 G2 X-.7412 Y.4148 I.3149 J0.0
N6500 X-.7677 Y.5413 I.2884 J.1265
N6510 G1 Y.6004
N6520 G2 X-.7675 Y.6112 I.3149 J0.0
N6530 G3 X-1.291 Y.5913 I.7675 J-27.1466
N6540 G1 X-1.2854 Y.4734
N6550 X-1.2995 Y.7683
N6560 G3 X-1.6382 Y.7501 I1.2995 J-27.3037
N6570 X-2.1378 Y.2195 I.0319 J-.5306
N6580 G1 Y-.2677
N6590 G3 X-1.6063 Y-.7992 I.5315 J0.0
N6600 G1 X1.6063
N6610 G3 X2.1378 Y-.2677 I0.0 J.5315
N6620 G1 Y.2195
N6630 G3 X1.6382 Y.7501 I-.5315 J0.0
N6640 X-1.2995 Y.7683 I-1.6382 J-27.2855
N6650 G1 X-1.2854 Y.4734
N6660 Z.2953
N6670 G0 Z.7283
N6680 X-.8842 Y-.5039
N6690 Z.2953
N6700 G1 Z.1772
N6710 X-.7087 Y-.5756
N6720 X-.5906
N6730 Y-.5413
N6740 G2 X-.4528 Y-.4035 I.1378 J0.0
N6750 G1 X.4528
N6760 G2 X.5906 Y-.5413 I0.0 J-.1378
N6770 G1 Y-.6004
N6780 G2 X.4528 Y-.7382 I-.1378 J0.0
N6790 G1 X-.4528
N6800 G2 X-.5906 Y-.6004 I0.0 J.1378
N6810 G1 Y-.5756
N6820 X-.8858
N6830 X-.5646 Y-.4477
N6840 X-.5412 Y-.3319
N6850 G2 X-.6516 Y-.1969 I.0274 J.135
N6860 G1 Y.1969
N6870 G2 X-.5138 Y.3346 I.1378 J0.0
```

5.2 SETUP2 PROGRAM

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==============================
=============================
%
N0010 G40 G17 G94 G90 G70
()
N0020 G91 G28 Z0.0:0030 T00 M06
N0040 G0 G90 X3.9642 Y-.9252 A0.0 B0.0 S1000 M03
N0050 G43 Z.4724 H00
N0060 Z.1575
N0070 G1 Z.0394 F9.8 M08
N0080 X3.1683
N0090 X-3.1683
N0100 G2 X-3.189 Y-.7087 I1.1211 J.2165
N0110 G1 Y0.0
N0120 X3.189
N0130 Y.6316
N0140 G3 X3.1506 Y.9252 I-1.1418 J0.0
N0150 G1 X-3.1506
N0160 X-3.9539
N0170 Z.1575
N0180 G0 Z.4724
N0190 X3.9642 Y-.9252
```

N0200 Z.1181
N0210 G1 Z0.0
N0220 X3.1683
N0230 X-3.1683
N0240 G2 X-3.189 Y-.7087 I1.1211 J.2165
N0250 G1 Y0.0
N0260 X3.189
N0270 Y.6316
N0280 G3 X3.1506 Y.9252 I-1.1418 J0.0
N0290 G1 X-3.1506
N0300 X-3.9539
N0310 Z.1181
N0320 G0 Z.4724
N0330 G91 G28 Z0.0
:0340 T00 M06
N0350 G0 G90 X-.5012 Y0.0 A0.0 B0.0 S0 M03
N0360 G43 Z.3937 H00
N0370 Z.1181
N0380 G1 Z-.0197 F9.8
N0390 G3 I-.7193 J0.0
N0400 G1 Z.0984
N0410 G0 Z.3937
N0420 Z.0984
N0430 G1 Z-.0394
N0440 G3 I-.7193 J0.0
N0450 G1 Z.0787
N0460 G0 Z.3937
N0470 G0 X.5012 Y0.0 A0.0 B0.0 S0 M03
N0480 Z.1181
N0490 G1 Z-.0197 F9.8
N0500 G3 I.7193 J0.0
N0510 G1 Z.0984
N0520 G0 Z.3937
N0530 Z.0984
N0540 G1 Z-.0394
N0550 G3 I.7193 J0.0
N0560 G1 Z.0787
N0570 G0 Z.3937
N0580 G91 G28 Z0.0:0590 T00 M06
N0600 G0 G90 X-2.1654 Y.7874 A0.0 B0.0 S0 M03
N0610 G43 Z.1772 H00
N0620 G1 Z-.1181 F9.8
N0630 G0 Z.1772
N0640 Z-.0689
N0650 G1 Z-.1772
N0660 G0 Z.1772
N0670 Z-.128
N0680 G1 Z-.2362
N0690 G0 Z.1772
N0700 Z-.187
N0710 G1 Z-.2559
N0720 G0 Z.1772
N0730 Y-.7874
N0740 G1 Z-.1181
N0750 G0 Z.1772
N0760 Z-.0689
N0770 G1 Z-.1772
N0780 G0 Z.1772
N0790 Z-.128
N0800 G1 Z-.2362
N0810 G0 Z.1772
N0820 Z-.187
N0830 G1 Z-.2559
N0840 G0 Z.1772
N0850 X2.1654
N0860 Z.0433
N0870 G1 Z-.252
N0880 G0 Z.0433
N0890 Z-.2028
N0900 G1 Z-.311
N0910 G0 Z.0433
N0920 Z-.2618
N0930 G1 Z-.3701
N0940 G0 Z.0433
N0950 Z-.3209
N0960 G1 Z-.3898
N0970 G0 Z.0433
N0980 Z.1772
N0990 Y.7874
N1000 G1 Z-.1181
N1010 G0 Z.1772
N1020 Z-.0689
N1030 G1 Z-.1772
N1040 G0 Z.1772
N1050 Z-.128
N1060 G1 Z-.2362
N1070 G0 Z.1772
N1080 Z-.187
N1090 G1 Z-.2559
N1100 G0 Z.1772
N1110 G91 G28 Z0.0:1120 T00 M06

N1130 G0 G90 X-2.1654 Y.7874 A0.0 B0.0 S0 M03
N1140 G43 Z.2362 H00
N1150 G81 Z-.0591 R.2362 F9.8
N1160 Y-.7874
N1170 X2.1654
N1180 Y.7874
N1190 G80
N1200 M02
%

CONCLUSION

Conclusion:

- 3D model of cover plate is generated by using NX-CAD software.
- 3D model of cover plate's fixture is generated by using NX-CAD software.
- NC program is generated by using NX-CAM software.
- Proper tools are specified which will support for machining thin walled component.
- Machining time tabulated for each operation.

References:

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