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STUDY ON PROCESS OF COMPUTER-AIDED MANUFACTURING (CAM) – A CNC APPROACH

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Abstract

The main objective of this paper is to study on process of Computer- Aided Manufacturing (CAM) with the approach of computer Numerical Control (CNC) machine. CAM is the method in which computer and design software are used to design and manufacturing of product. CNC is the method in which the product is manufactured with the given instruction. CAM generates a program for numerical control (NC) programming tool. This paper also includes the study of software for CAM, also includes a NC program for CNC machine. Both CNC and NC program improves the production in order to decrease the production time and minimize the efficiency of production process. Paper includes a NC program for facing and drilling (G150 & G83) respective cycle by writing the program for HAAS controller.

Index Terms: study, Computer-Aided Manufacturing (CAM), Computer Numerical Control (CNC), NC Programming.

1.INTRODUCTION

Computer-Aided Manufacturing (CAM) a use of computer system, software & associated hardware for facilitate and automate manufacturing process. CAM is a follower of Computer-Aided Engineering (CAE) and is frequently used in a pair with Computer-Aided Design (CAD).

CAM increase manufacturing and production efficiency by virtue of with increase production speed, reduce wastages occurs during production and manufacturing as well as energy. CAM is consistence and more precise tooling accuracy.

In 19th century, CAM has been considered as a numerical control (NC) programming tool, where 2-diamentional (2-D) & 3-diamentional (3D) modules which are manufacturing and generated in CAD and import in CAM software via Initial Graphics Exchange Specification (IGES) is a file format which is allows the export a digital file format, digital information to CAM software from CAD software. CAM also be refer the computer to assist in all operations of a manufacturing plant, storage, industrial management, planning, processing. Its main purpose is that faster production process with extreme accuracy. If we not generate the 3-D model on CAD, CAM software itself create 2-D & 3-D model as per requirement and generate CNC Program for machine tool for further manufacturing and production.

1.1 CAM Software

Siemens NX CAM- Siemens NX formerly known as 'UG', Unigraphics NX is advanced high end CAD/CAE/CAM which has owned since 2007 by Siemens PLM software. This software is a parametric and direct solid/surface modelling.

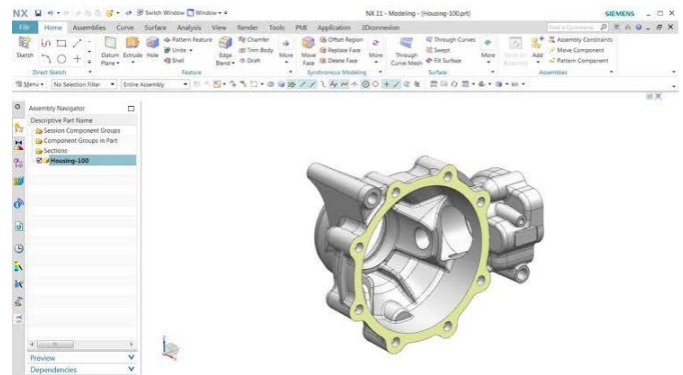


Fig.1.1: Workbench of Siemens NX-11

New release: NX-12

Key functions of NX are: Computer-Aided Design (CAD)

- Free deform surface modelling.
- Computer -Aided Industrial Design.

Issue

- Drafting
- Sheet Metal Design
- Routing for Electrical wiring and mechanical piping

Computer-Aided Engineering (CAE)

- Stress analysis / finite element method (FEM)
- Kinematics
- Computational Fluid Dynamic (CFD)
- Thermal Analysis

Computer -Aided Manufacturing (CAM)

- Numerical Control (NC) Programming

Mastercam – Developer: CNC Software Inc.

First released of mastercam in the year 1980s, it is not only oldest but even one of the most widely used CAM software in universe. It include a powerful CAM solution, mastercam generate the NC program for CNC machine tool.

Features: Design- 3D wireframe geometry creation, various kinds of operation can performed by this software like roughing, finishing, counter, depth cut, drilling etc.

PowerMILL -Developer: Autodesk Inc.

Initial release: 1995.

PowerMILL is 3D CAM software creating a programming for NC machine, for 2 to 5 axis machine. This software used in a number of industries due to its good performance like, it determines the optimum tool path to reduce time & manufacturing cost. Another CAM Software's are:

Fusion 360

HyperMILL

Cimatron

SolidCAM

Now a days it is easy to control the machine tool as compare to old techniques due to the various kinds of CAM software. We create number of different operation as we required like facing, drilling, boring, counter drilling, counter boring, pocketing, engraving, surface high speed, peel mill and many more with accuracy and efficiently. And execute a NC program for required operation. This is proceeding for further manufacturing and production.

1.2How CAM Actually Works

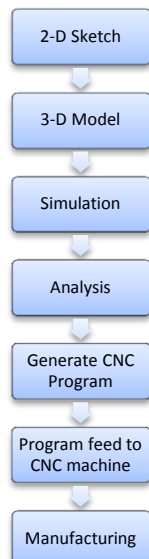


Fig-1.2: figure shows the flow of CAM.

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Create 2D sketch which has been manufacture. Extrude it means create or transfer from 2D sketch to 3D model. After generate 3D model with accurate dimensions, after this give the extra material filament (added a raw material) from all sides of model. Select a tool depending upon which operation can be done. On a single workpiece number of operations can be done. At that time define proper tool for further processes, define tool path and simulate it. Tool automatically moves from where we select tool path as a required depth, cutting speed, feed, etc. After the simulation process, generate the NC program which is feed to CNC machine.

2. CNC MACHINE- INPUT, PROCESS, OUTPUT

CNC is a system in which action are controlled by direct insertion of numerical data at some point.

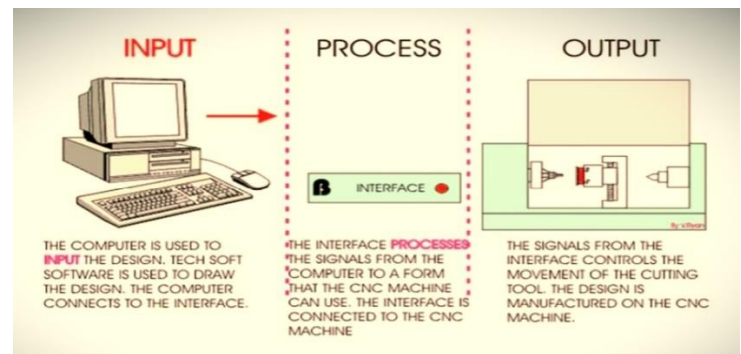


Fig-2.1: Process for CNC machining.

A Computer/ Input

Need of computer is for draw the design. However, the design is only a digital (pictorial) form. But CNC machine cannot use this pictorial form for manufacturing a product. Some CAM software converts this pictorial information to that CNC machine in the form of co-ordinates. And this generating co-ordinate use CNC machine.

The Processor

A computer cannot connect directly to CNC machine, the computer system is connected to an interface. The signal which is coming from computer is converted and transfer to the CNC machine. The signal is in the form of digital.

Computer Numerical Control (CNC) Machine



Fig-2.2: CNC milling machine (courtesy of Mazak)

Issue

The signal controls the motion of machine. The signal determines the movement of axis of machine. Axis moves in 3 direction x, y, z.

X- Moves in horizontal direction (positive and negative)

Y- Moves in vertical direction (positive and negative)

Z- Moves upward – downward (positive and negative)

2.1 Control System

1. Open loop system 2. Close loop system

Open loop system:

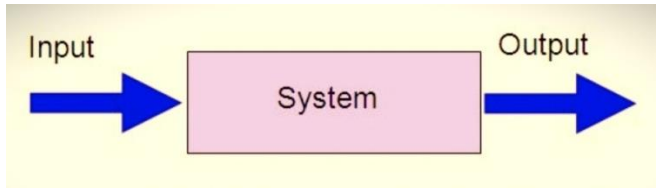


Fig-2.3: Block diagram of open loop system

In open loop system there is no feedback system to the input of system. This system is normally applied only to the case where the output is almost constant and predicible. That's why; Open loop system is unlikely to be used to control machine tools. The cutting force and loading on a machine is never constant.

Close loop system:

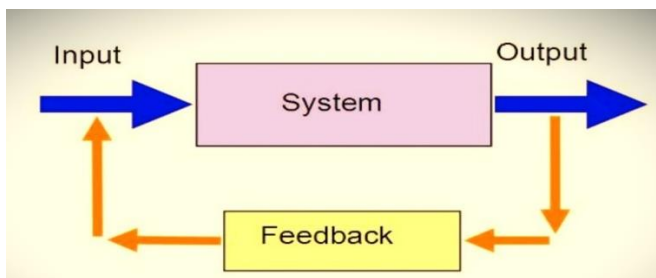


Fig-2.4: Block diagram of close loop system

In close loop system feedback device monitor the output of a system. And if some errors are generated, feedback corrected in the first instances. Therefore, maximum accuracy is achievable. Today, almost all CNC machine are Close loop system.

2.2 Driving system

It is a most important component of CNC machine tool. For the more precise and accuracy depending upon the characteristics and performance of the driving system.

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- DC motor
- AC motor
- Stepper motor
- Linear motor

2.3 Display unit:

Display unit play an important role for machine as well as operator also. It's an interactive device between machine and operator. When machine is running condition display unit display the present running status of machine. Such as position of axis, programming, spindle speed, feed rate etc. graphical simulation also show the display unit. If errors are occurred during running of machine, display unit shows the error message on screen.

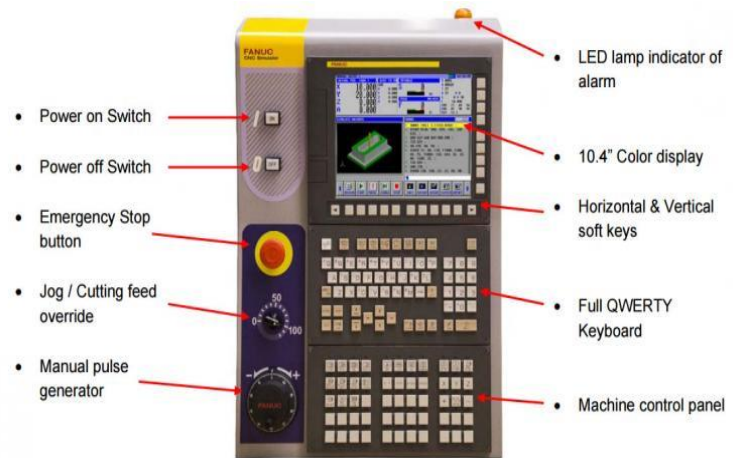


Fig-2.5: Display unit (courtesy of Fanuc)

3. CNC PROGRAMMING

CNC programming (Computer Numerical Control programming) is utilized by manufactures to create a program instruction for computers to control a machine tool.

Word address is the most common programming format used for CNC programming system. This format contains a large number of different codes.

- G-code (Preparatory/ Geometrical) code
- M-code (Miscellaneous/ Machine) code

Generally, G-code is written in and performs by CNC machine processor to operate the motion control parts. M-code operate basic electrical control function such as coolant, tool change, safety position etc.

CAM software's generate a program for CNC machine. CNC machine control the all activity of program which has been feed to the machine and follow those program which is done by CAM software and produce a required size product as per dimensions. But the program which is generate on CAM software is not capable to all kinds of CNC machine (milling, turning) etc. it may be vary from machine to machine (controller to controller).

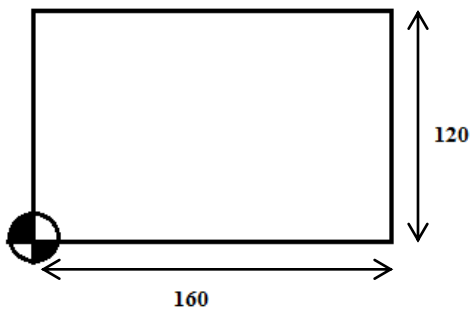
Issue

But apart from this, sometime manual programming is carried out rather than automatic programming. In manual programming it is not possible to create a program for complicated profile but simple program can be create manually like the operations are facing, boring, counter drilling, counter boring, pocketing, engraving, etc.

Following are the basic CNC facing program for Haas controller only, because of here using a (G150) cycle, G150 is associated with only Haas controller not any other controller.

Facing program by using G150 (general purpose pocket milling) cycle.

End mill cutter $\text{Ø}14.0$



All dimensions are in mm.

Sub-program

```
O00001;  
G00 G54 G90 X-7.0 Y-7.0;  
G01 X0.0 Y0.0 F200;  
G01 X160.0 Y0.0;  
G01 X160.0 Y120.0;  
G01 X0.0 Y120.0;  
G01 X0.0 Y0.0;  
M99;
```

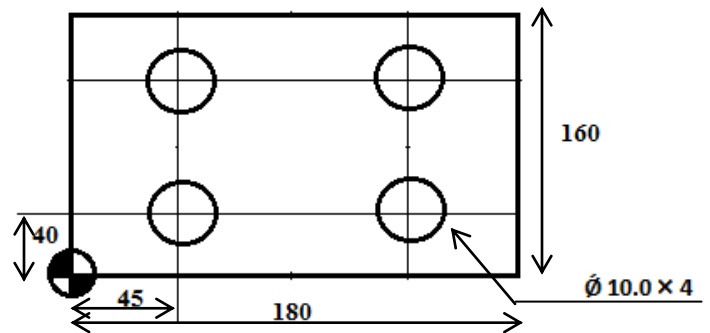
Main Program

```
O00002;  
T1 M06;  
S2000 M03;  
G00 G54 G90 X-7.0 Y-7.0;  
G43 H01 Z50.0;  
G01 Z1.0 F500;  
M08;  
G150 G40 P00001 Z-0.3 Q0.2 X-7.0 Y-7.0 I6.0 D01 F500;  
G00 Z100;  
G28 G90 X0.0 Y0.0;  
M05;  
M09;  
M30;
```

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Drilling Operation

G83 (normal peck drilling canned cycle)



All dimensions are in mm

Main- Program

```
O0003;  
T1 M06;  
S590 M03;  
G00 G54 G90 X45.0 Y40.0;  
G43 H01 Z50.0;  
G01 Z1.0 F500;  
M08;  
G83 G98 Z-30.0 Q0.2 R1.0 F500;  
X45.0 Y120.0;  
X135.0 Y40.0;  
X135.0 Y120.0  
G00 G80 Z100.0;  
G28 X0.0 Y0.0;  
M05,  
M09;  
M30;
```

4. PARTS OF CNC MILLING MACHINE

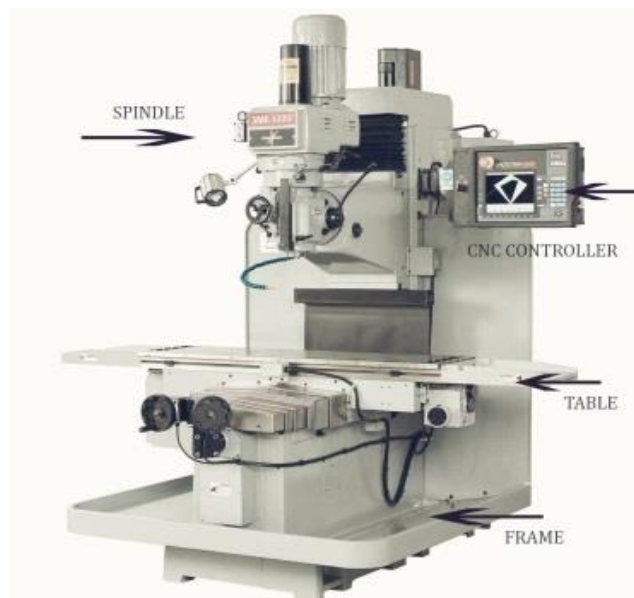


Fig-4.1: CNC milling machine

FRAME: Frame is lies above ground or foundation of CNC milling machine. Function of frame is that support the machine weight and also damper for machine vibrations.

AXES: Axes provides the motion to predetermine directions as the machine is computer controlled it is done by the program. It is also done by manually. Simple CNC milling machine has 3-axes and moves in respective 3 directions. Apart from these 4-axes, 5-axes, 7-axes, 9-axes with functional axes, the part can be turn and multiaxial milled in a singular set up. Benefit of this multiaxial machine is that eliminate the manual load and unloading and secondary fixtures, they can make fully finished product at a single run.

TABLE: It is place on top of saddle, working of table is to hold the job and also job holding devices. jigs and fixture are also mounted on table for different types of job holding purpose.

SPINDLE: Spindle is a rotating tool holder, usually z-axis represent the spindle axis.

AUTOMATIC TOOL CHANGER (ATC): ATC also called as tool magazine. It is use in CNC machine tool. ATC carrying a multiple number of tool carrying capacity that's why, it improves production. Benefit of ATC is that tool changes very quickly, reducing non production time, improve capacity of machine to work with number of tools.

CNC CONTROLLER: It is a brain of CNC machine, electrical and electronics equipment's executes the code given as in input.

Name of some CNC controller:

- **FANUC:** Fuji Automatic NUmERIC Control. It has market share 21.5% which is largest selling controller.
- **Siemens:** It has market share 11.0%
- **Haas:** It has market share 9.0%
- **Mazak:** It has market share 6.5%
- **Heidenhain:** It has market share 6.0%
- **Mitsubishi:** It has market share 5.0%
- **Okuma:** It has market share 4.5%

4.1 Advantages of CAM

- Repetitive task can be carried out quickly.
- Faster error elimination and assists product development.
- The application of CAM in the production offers advantages to the company to improvement capabilities by combining traditional economies of scale with economies of scope resulting in the desired flexibility and efficiency.
- Faster response to changes in market demand.
- Improved consumer service, quality of product, less time to make a new product, reduce inventory levels, greater flexibility and responsibility.

4.2 Advantages of CNC machine

The computer can design best tool path, spinning and cutting speed of tool according to data of product. This can help decrease the time and cost of manufacturers.

- CNC machine usually have ATC (Automatic Tool Changer) function.
- CNC machine consist a feedback system, and it can keep its high quality and reliability, this can help to reduce the number of rejected products and the cost of inspection.
- CNC machine is s programming base therefore, accuracy and precise of product is more.
- CNC machine control the tool movement in any axes, so it can work on complicated geometry efficiently.
- Safer, higher productivity, better quality.
- Produce complex shape with good dimensions accuracy, repeatability, reduce scrap loss, and high production rates.

4.3 Disadvantages of CNC

- Cost of machine is so high therefore, small company can able to afford.
- Skilled worker need to control or operate the machine.
- Control system is complicated and sophisticated; therefore maintenance cost is very high.

4.4 Applications of CNC machine

- Metal removal industries.
- Industries for fabricating metals.
- Machine tool application: facing, drilling, cutting, milling, boring bending, spinning etc.

3. CONCLUSION

In the study on the process of Computer-Aided Manufacturing (CAM) and Computer Numerical Control (CNC) machine. By using a CAM, Product design and development made easily as compare to old technique. Editing and improvement done at any stage that increment the quality of product.

The CNC programming is way to operate at CNC machine. CNC milling machine uses giving many advantages for increment accuracy and production cycle, as well as improved consumer service, quality of product, less time to make new product, reduce inventory level, greater flexibility.

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