International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 03 | Mar 2020 www.irjet.net p-ISSN: 2395-0072

STUDY ON COMPUTER NUMERICAL CONTROL (CNC) TECHNOLOGY

Nairutya Patel[1]

[1]Student, Mechatronics Engineering Department, G H Patel College of Engineering & Technology, VVNagar- 388120

Abstract - *This paper is proposed to study regarding CNC technology. CNC machine is one of the popular technologies in the field of manufacturing now a days. This paper describes basics of CNC machine. Also elaborate difference between conventional machine and CNC machine. And describes types of CNC machines based on their applications. Mainly this paper conferred a detail of various parts available in CNC machine i.e. drives, motors and controller and working of CNC machine also. At last this paper conclude, why we should use CNC machine over conventional machine and in which cases it is not preferable to use CNC machine.*

Key Words: **CNC machine, Computer Numerical Control, Servo motor, Spindle motor, Drives, CNC working, CNC controller, conventional machines**

1. INTRODUCTION

CNC machine is a typical electromechanical product mainly composed of machine body and the computer numerical control (CNC) system. It is the core equipment of modern manufacturing industry. [1] When we have to do mass production of similar job CNC machine is the most suitable option among conventional machines as on it will give more repeatability and accuracy. The first benefit offered by all forms of CNC machine tools is improved automation. The operator intervention related to producing workpieces can be reduced or eliminated. Many CNC machines can run unattended during their entire machining cycle, freeing the operator to do other tasks. This gives the CNC user several side benefits including reduced operator fatigue, fewer mistakes caused by human error, and consistent and predictable machining time for each workpiece. Since the machine will be running under program control, the skill level required of the CNC operator (related to basic machining practice) is also reduced as compared to a machinist producing workpieces with conventional machine tools. The second major benefit of CNC technology is consistent and accurate workpieces. Today's CNC machines boast almost unbelievable accuracy and repeatability specifications. This means that once a program is verified, two, ten, or one thousand identical workpieces can be easily produced with precision and consistency. A third benefit offered by most forms of CNC machine tools is flexibility. Since these machines are run from programs, running a different workpiece is almost as easy as loading a different program. Once a program has been verified and executed for one production run, it can be easily recalled the next time the workpiece is to be run. This leads to yet another benefit, fast change-overs.[2]

Fig -1: CNC Machine

1.1 CNC machine tool builders

There are number of CNC machine tools builders available now a days in market. FANUC and Siemens are popular manufacturers for CNC controller, drives and motors of CNC machine. Using those, many machine tool builders are manufacturing CNC machines according to requirement. FANUC corporation, Japan also manufacture CNC machine. Apart from that Makino, Mazak, DMG Mori, HAAS, Okuma Hitachi, Jyoti CNC, etc are popular CNC machine makers. They make machines according to customer requirement called special purpose machines. Also make general purpose CNC machines like VMC machines.

Fig -2: Various CNC machine tool builders

2. DIFFERENCE BETWEE CONVENTIONAL MACHINE AND CNC MACHINE

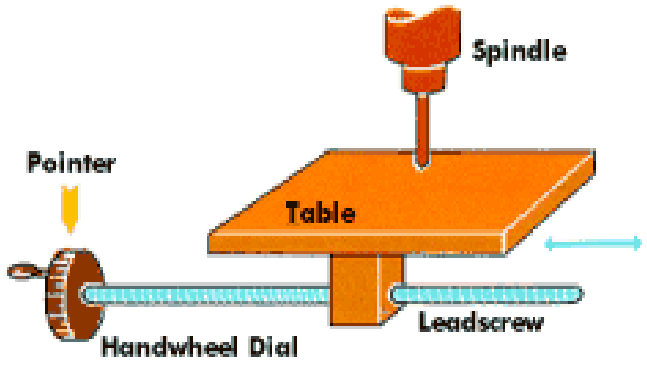

Fig -3: Working of conventional machines [2]

As shown in figure 3, conventional machines using mechanical power given by operator is used for movement of an axis. As operator will operate the handwheel, table will move as on power transmission is carried out with lead screw. We can convert rotary movement into linear movement with proper scale using pitch of lead screw and gear ratio (if gears are used for speed reduction). All axis movement will be like this. So according to our job requirement, operator have to move table for carry out required operation. And if he will make any mistake then job will not have dimensional accuracy. Additionally, repeatability of job also depends on capability of operator. For same operator also human error will interfere. So, conventional machines are not suitable option for mass production or repeated job production.

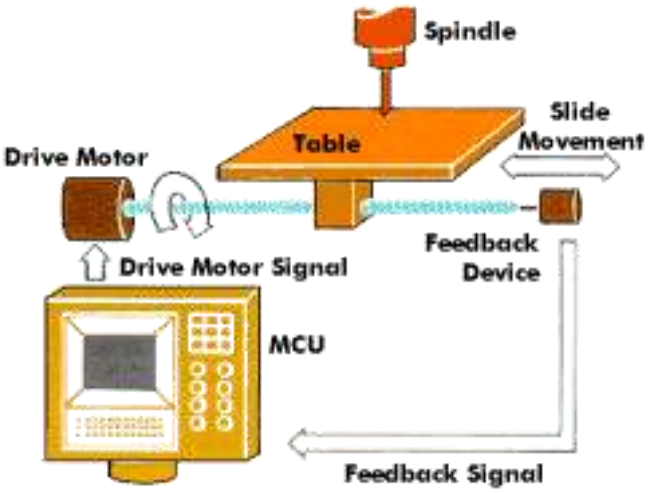

Fig -4: working of CNC machines [2]

The most basic function of any CNC machine is automatic, precise, and consistent motion control. All forms of CNC equipment have two or more directions of motion, called axes. These axes can be precisely and automatically positioned along their lengths of travel. The most common axis types are linear (driven along a straight path) and rotary (driven along a circular path). Instead of causing motion by manually turning cranks and handwheels as is required on conventional machine tools, CNC machines allow motions to be actuated by servomotors under control of the CNC, and guided by the part program. Generally, the motion type (rapid, linear, and circular), the axes to move, the amount of motion and the motion rate (feed rate) are programmable with almost all CNC machine tools. So, we will get high accuracy of job dimensions as axis movement is carried out by servo motor instead of manually by an operator. As well as repeatability will also be more as human errors are not available for axis movement. And this is the main reason that CNC machines are more popular and suitable for mass production.

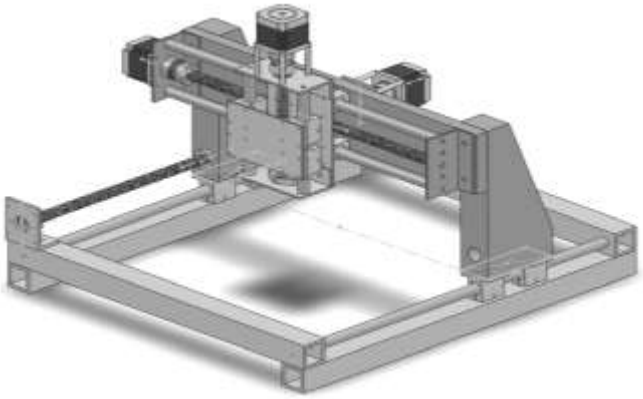

Fig -5: Virtual 3D image of the projected machine [4]

Above figure shows virtual 3D image of CNC machine. We can see servo motors connected with lead screw are used for axis movement. And tool or job (based on machine configuration) will move for particular distance.

3. TYPES OF CNC MACHINES

CNC machines are manly categories in two branches. Conventional machining technologies and novel machining technology.

3.1 Conventional Machining Technologies

Based on conventional machining technologies, CNC machines are basically divided in three machines. CNC Drilling machine, CNC Turning machine and CNC Milling machine. Apart from that CNC Hobbing machine and CNC Grinding machine also includes in conventional technology CNC machines. These are general purpose categories. Apart from these, some customers also have special purpose machines for their specific products.

3.2 Novel Machining Technologies

There are a number of novel technologies that use specialized techniques to cut material. Examples include Electron Beam Machining, Electrochemical machining, Electrical Discharge Machining (EDM), Photochemical machining, and Ultrasonic machining. Most of these technologies are highly specialized and are used in special cases for mass-production involving a particular type of material. There are a number of other novel technologies that use different mediums to cut material. Examples include laser cutting machines, oxy-fuel cutting machines, plasma cutting machines, and water-jet cutting technology.

4. PARTS OF CNC MACHINE

CNC machine consists of various parts. Major parts that makes base model of CNC machine are controller, drive, motor and mechanical structure. CNC machine consists of various mechanical as well as electrical and electronics components. We can consider base, ball screw, gears, bearings etc in mechanical side. In electrical components we can consider servo/stepper motors for axis movement and spindle motor. Apart from that all protection devices like MCC, AC reactors and all. Drives that are used for giving PWM signal to servo/stepper motor or spindle motor are also in electrical part. All sensors can be taken into electronics section. And CNC also consists a software for simulation as well as programming.

4.1 Controller

Controller is the heart of CNC machine. It gives signal to drives for generating particular PWM signal. According to that signal servo motor will move axis and spindle motor will rotate job at particular rpm. Apart from that it will consist PMC ladder regarding I/O signal of CNC. And it will give output signal according to logic. Functions like emergency stop signal, coolant ON/OFF signal, automatic tool changer or automatic pallet changer will be control by PMC and that PMC will be there in memory of controller of CNC machine. It is like CPU of personal computer. All customer data like programmes, parameters, designs, purchased features, etc are stored in memory inside controller. We can see simulation of CNC operation before starting of an operation and we can verify weather our programme will give required out put or not. We can store tools offset data, workpiece origin data in that. Major CNC controller manufacturers are FANUC, Siemens, Mitsubishi, etc.

Fig -6: FANUC CNC controller

4.2 Drives

Drive is used for giving signals to motor. Two main types of drives are available i.e. servo drive and spindle drive. Servo drive will generate PWM signals and that will be given to servo motor. And according to given command, servo drive will generate PWM signal. That signal will switch IGBTs inside drive such that it will generate AC signal that will move servo motor at particular speed for particular distance according to our job requirement. Similarly spindle drive will give signal to spindle motor that will run at particular rpm for and it will carry out required operation on job. Drive of CNC machine is shown in figure 7.

4.3 Motors

In CNC machine, mainly two type of motors are used. One is servo motor and another is spindle motor. Servo motor is used for movement of an axis and spindle motor is used for rotating job or tool at high rpm. They both are having different working and construction according to their application.

4.3.1 Stepper Motors

The name "stepper" comes from the steps made by the motor with every signal pulse. It is simple to operate, inexpensive compared to servo motors and has a high reported accuracy. Its low speed torque enables the use of a pulley reduction and timing belt, allowing several loads to be driven without gearing.

Stepper motors typically have a lower efficiency than servo motors. It is also resonance prone, and smooth movement often requires micro stepping. Loads do not accelerate rapidly due to the low torque to inertia ratio. Despite the loud noise and overheating at high performance, stepper motors have an overall low power output for their weight and size.

4.3.2 Servo Motor

A servo motor is an electrical device which can push or rotate an object with great precision. So, Servo motors are used for axis movement. Servo motor is having permanent magnet rotor, having its own magnetic field. So, it will give constant torque even at no load condition also. Servo motors use closed-loop circuitry to transfer information to the CNC machine. A regular DC or AC motor is connected to an encoder fixed with a sensor. Servo motors have high accuracy and resolution owing to the sensor-fixed encoder. The motor is powered by the servo amp, which also counts the steps made. Its high torque to inertia ratio enables rapid load acceleration. With lighter loads, efficiency may reach up to 90 percent.

Servo motors are generally more costly than stepper motors and more complicated to operate. As peak operating power only develops at high speed, and the ventilation system easily becomes contaminated, servo motors are more susceptible to damage due to overheating and overloading. They also require servicing after the brush reaches its 2,000-hour life span.

4.3.3 Spindle Motors

Spindle motors are used for rotation of spindle. Spindle having job or tool attached with it and rotating at high speed according to machine configuration. Like in CNC turning machine job is fixed on spindle and tool movement is carried out with axis. While in CNC milling machine tool is fixed with spindle and job is fixed on table that moves by axis movement. Generally, 3-phase induction motors are used as spindle motor. Spindle motor are constant power motor. So, it is used where high speed is required, not high precision.

Fig -7: FANUC drives with spindle motors and servo motors used in CNC

4.3.4 Linear Motors

A linear motor is an electric motor that has its stator and rotor "unrolled" thus instead of producing a torque (rotation) it produces a linear force along its length. However, linear motors are not necessarily straight. Characteristically, a linear motor's active section has ends, whereas more conventional motors are arranged as a continuous loop.

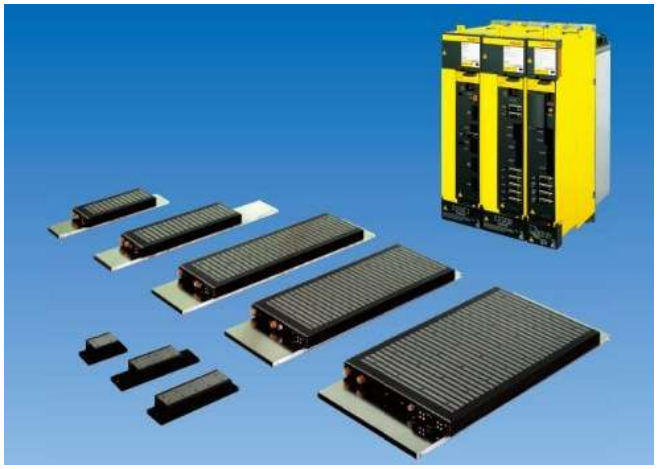

Fig -8: FANUC drives with linear motors used in CNC

5. CONNECTIONS OF DRIVES AND MOTORS

According to FANUC packages connections of drives and motors in CNC machine are shown in figure. Main power supply is 200-240v 3-phase AC supply. Circuit breaker is provided for protection. Then magnetic contactor is there which will allow supply to pass when machine will be in ready condition. MCC will cut the supply in emergency stop condition. So, from protection point of view MCC is very important. Then AC reactor is used for reduce harmonics. Then main supply will be given to CNC drives.

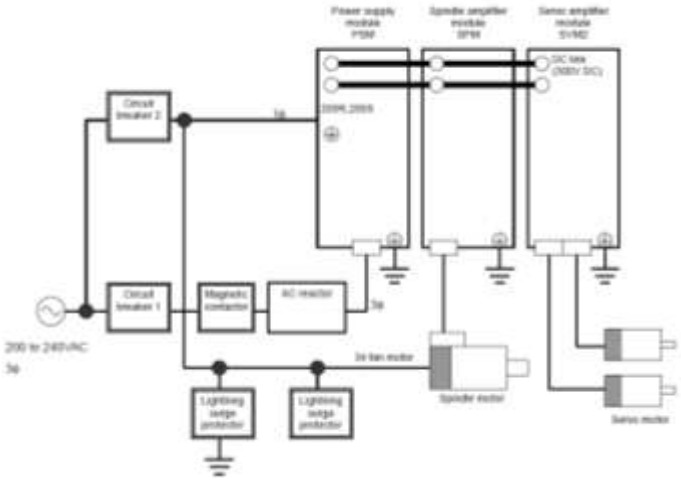

Fig -8: FANUC drives and motors used in CNC [3]

First drive will be power supply module. That will convert 200-240v AC into 300v DC. If supply is HV series i.e. 400-440v AC then it will convert into 600V DC. That DC supply will be further given to servo drive and spindle drive. This drive is having inverter inside it. This IGBT will convert this DC voltage into controlled AC voltage with help of PWM technique. Controller will give signal what AC voltage to be generate according to defined speed and axis movement in CNC programme. That controlled supply will be given to servo motor or spindle motor. And it will carry out operation accordingly.

6. CONCLUSION

CNC machine is having advantages as well as disadvantages at a time. If it is mass production, we should go for CNC machine only instead of conventional machine. As CNC machine is having high initial cost it is reliable for mass production only. For less production and small-scale industries conventional machine is more preferable if cost is limitation. CNC machine is having initial cost high, but once it is installed, it will give continuous production for long time if proper environmental conditions are followed.

Advantages of CNC machines

- Machining is accurate
- Time taken to perform a job is very less
- Safe to operate
- Number of operators required to operate a machine are reduced
- No possibility of human error
- Reliable
- Even very complex designs can also be made
- Low maintenance required
- They are versatile
- Uniformity in designs
- They could run for all 24 hours a day (under certain conditions)
- Simulation can be performed

Disadvantages:

- Initial cost is high
- Trained operator is required to operate the machine
- In case of breakdown a highly skilled professional is required to solve the problem

REFERENCES

[1] Fanmao Liu and Haiping Zhu, "Analysis of operational performance reliability for CNC equipment," 2016 6th International Conference on Instrumentation & Measurement, Computer, Communication and Control

[2] The fundamentals of CNC, Morden machine shop

[3] Alpha i Manual by FANUC Corporation, Japan

[4] Paulo Augusto Sherring da Rocha Junior, Rogério Diogne de Silva e Souza, Maria Emília de Lima Tostes, "Prototype CNC machine design.", 2010 9th IEEE/IAS International Conference on Industry Applications