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COMPUTER NUMERICAL CONTROL MACHINING AN ESSENTIAL TOOL FOR DEVELOPMENT

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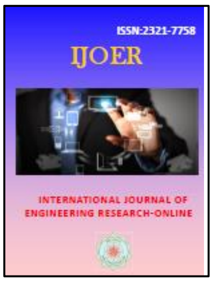

ABSTRACT
This paper tends to bring to limelight the modern processes of well-known conventional machining processes being accomplished with the aid of the Computer known as CNC (Computer Numerical Control). It describes what CNC means and explains how the process works in relation to conventional machining taking Drilling as an example. The paper then went ahead to describe the elements of CNC machines and stated their types. The applications of the CNC technology in numerous facets of the Manufacturing Industries were outlined. Two drawings and a table were used to explain how to carry out Ordinate Drawing and Calculation while the programming process was briefly described. Finally the advantages of using CNC machines over the well known conventional machines were enumerated and conclusions were drawn on the whole write up indicating its relevance to development.
Keywords: CNC, machining, conventional, manufacturing.

1. INTRODUCTION

Computer Numerical Control (CNC) is a system in which a control computer is an integral part of a machine or a piece of equipment (onboard computer).

CNC stands for Computer Numerical Control and has been around since the early 1970's. Prior to this, it was called NC, for Numerical Control. In the early 1970's computers were introduced to these controls, hence the name changed.

CNC has touched almost every form of manufacturing process in one way or another. If you'll be working in manufacturing, it's likely that you'll be dealing with CNC on a regular basis.

CNC machines typically replace (or work in conjunction with) some existing manufacturing process/es. Take one of the simplest manufacturing processes, drilling holes, for example.

A drill press can of course be used to machine holes. (It's likely that almost everyone has seen some form of drill press, even if you don't work in manufacturing). A person can place a drill in the drill chuck that is secured in the spindle of the drill press. They can then (manually) select the desired speed for rotation (commonly by switching belt pulleys), and activate the spindle. Then they manually pull on the quill lever to drive the drill into the workpiece being machined.

As you can easily see, there is a lot of manual intervention required to use a drill press to drill holes. A person is required to do something almost every step along the way! While this manual intervention may be acceptable for manufacturing companies if but a small number of holes or workpieces must be machined, as quantities grow, so does the likelihood for fatigue due to the tediousness of the operation. And do note that we've used one of the simplest machining operations (drilling) for our example. There are more complicated machining operations that would require a much higher skill level (and increase the potential for mistakes resulting in scrap workpieces) of the person running the conventional machine tool.

By comparison, the CNC equivalent for a drill press (possibly a CNC machining center or CNC drilling & tapping center) can be programmed to perform this operation in a much more automatic fashion. Everything that the drill press operator was doing manually will now be done by the CNC machine, including: placing the drill in the spindle, activating the spindle, positioning the workpiece under the drill, machining the hole, and turning off the spindle.

Because of the availability of small computers having a large memory, microprocessor(s) and program-editing capabilities, CNC systems are widely used today [1].

Fig. 1: CNC machining

2. MOTION CONTROL

There are nine standard axes universally used in CNC machining processes. Three are the familiar 'Primary linear axes' straight line movements (X, Y, and Z). Three 'Primary rotary axes' (A, B, and C), are used to identify arc or circular movements such as a programmable turntable, lathe spindle, or an articulating wrist action milling head (rotary motion).

Finally, we have three Secondary, straight-line, motions called the Auxiliary linear axes' (U, V, and W). They are added to the system for multi-axis production on CNC machines, sometimes called multitasking [2].

3. MACHINING CENTERS

The term "machining center" describes almost any CNC milling and drilling machine that includes an automatic toolchanger and a table that clamps the workpiece in place. On a machining center, the tool rotates, but the work does not. The orientation of the spindle is the most fundamental defining characteristic of a machining center [3].

Fig. 2; Five-axis machining center with rotating table and computer interface [4]

3.1 AUTOMATIC TOOL CHANGER

Most machining centers can hold many tools in a tool magazine. When required, the required tool can be automatically placed in the spindle for machining.

3.2 SPINDLE SPEED AND ACTIVATION

The spindle speed (in revolutions per minute) can be easily specified and the spindle can be turned on in a forward or reverse direction. It can also, of course, be turned off.

3.3 COOLANT

Many machining operations require coolant for lubrication and cooling purposes. Coolant can be turned on and off from within the machine cycle.

4. THE CNC CONTROL

The CNC control will interpret a CNC program and activate the series of commands in sequential order. As it reads the program, the CNC control will activate the appropriate machine functions, cause axis motion, and in general, follow the instructions given in the program.

Along with interpreting the CNC program, the CNC control has several other purposes. All current model CNC controls allow programs to be modified (edited) if mistakes are found. The CNC control allows special verification functions (like dry run) to confirm the correctness of the CNC program. The CNC control allows certain important operator inputs to be specified separate from the program, like tool length values. In general, the CNC control allows all functions of the machine to be manipulated [5].

5. CAM SYSTEM

For simple applications (like drilling holes), the CNC program can be developed manually. That is, a programmer will sit down to write the program armed only with pencil, paper, and calculator. Again, for simple applications, this may be the very best way to develop CNC programs.

As applications get more complicated, and especially when new programs are required on a regular basis, writing programs manually becomes much more difficult. To simplify the programming process, a computer aided manufacturing (CAM) system can be used. A CAM system is a software program that runs on a computer (commonly a PC) that helps the CNC programmer with the programming process. Generally speaking, a CAM system will take the tediousness and drudgery out of programming.

In many companies the CAM system will work with the computer aided design (CAD) drawing developed by the company's design engineering department. This eliminates the need for redefining the workpiece configuration to the CAM system. The CNC programmer will simply specify the machining operations to be performed and the CAM system will create the CNC program (much like the manual programmer would have written) automatically [6].

6. DNC SYSTEM

Once the program is developed (either manually or with a CAM system), it must be loaded into the CNC control. Though the setup person could type the program right into the control, this would be like using the CNC machine as a very expensive typewriter. If the CNC program is developed with the help of a CAM system, then it is already in the form of a text file. If the program is written manually, it can be typed into any computer using a common word processor (though most companies use a special CNC text editor for this purpose). Either way, the program is in the form of a text file that can be transferred right into the CNC machine. A Distributive Numerical Control (DNC) system is used for this purpose.

A DNC system is nothing more than a computer that is networked with one or more CNC machines. Until only recently, rather crude serial communications protocol (RS-232c) had to be used for transferring programs. Newer controls have more current communications capabilities and can be networked in more conventional ways. Regardless of methods, the CNC program must of course be loaded into the CNC machine before it can be run.

7. TYPES AND APPLICATIONS OF CNC MACHINES

As stated, CNC has touched almost every facet of manufacturing. Many machining processes have been improved and enhanced through the use of CNC. Let's look at some of the specific fields and place the emphasis on the manufacturing processes enhanced by CNC machine usage.

7.1 IN THE METAL REMOVAL INDUSTRY

Machining processes that have traditionally been done on conventional machine tools that are possible (and in some cases improved) with CNC machining centers include all kinds of milling (face milling, contour milling, slot milling, etc.), drilling, tapping, reaming, boring, and counter boring.

In similar fashion, all kinds of turning operations like facing, boring, turning, grooving, knurling, and threading are done on CNC turning centers.

There are all kinds of special "off-shoots" of these two machine types including CNC milling machines, CNC drill and tap centers, and CNC lathes.

Grinding operations of all kinds like outside diameter (OD) grinding and internal diameter (ID) grinding are also being done on CNC grinders. CNC has even opened up a new technology when it comes to grinding. Contour grinding (grinding a contour in a similar fashion to turning), which was previously infeasible due to technology constraints is now possible (almost commonplace) with CNC grinders.

7.2 IN THE METAL FABRICATION INDUSTRY

In manufacturing terms, fabrication commonly refers to operations that are performed on relatively thin plates. Think of a metal filing cabinet. All of the primary components are made of steel sheets. These sheets are sheared to size, holes are punched in appropriate places, and the sheets are bent (formed) to their final shapes. Again, operations commonly described as fabrication operations include shearing, flame or plasma cutting, punching, laser cutting, forming, and welding. Truly, CNC is heavily involved in almost every facet of fabrication.

CNC back gauges are commonly used with shearing machines to control the length of the plate being sheared. CNC lasers and CNC plasma cutters are also used to bring plates to their final shapes. CNC turret punch presses can hold a variety of punch-and-die combinations and punch holes in all shapes and sizes through plates. CNC press brakes are used to bend the plates into their final shapes.

7.3 IN THE ELECTRICAL DISCHARGE MACHINING INDUSTRY

Electrical discharge machining (EDM) is the process of removing metal through the use of electrical sparks which burn away the metal. CNC EDM comes in two forms, vertical EDM and Wire EDM. Vertical EDM requires the use of an electrode (commonly machined on a CNC machining center) that is of the shape of the cavity to be machined into the workpiece. Picture the shape of a plastic bottle that must be machined into a mold. Wire EDM is commonly used to make punch and die combinations for dies sets used in the fabrication industry. EDM is one of the lesser known CNC operations because it is so closely related to making tooling used with other manufacturing processes.

7.4 IN THE WOODWORKING INDUSTRY

As in the metal removal industry, CNC machines are heavily used in woodworking shops. Operations include routing (similar to milling) and drilling. Many woodworking machining centers are available that can hold several tools and perform several operations on the workpiece being machined.

7.5 OTHER TYPES OF CNC MACHINES

Many forms of lettering and engraving systems use CNC technology. Waterjet machining uses a high pressure water jet stream to cut through plates of material. CNC is even used in the manufacturing of many electrical components. For example, there are CNC coil winders, and CNC soldering machines [7].

8. POINT TO POINT POSITIONING CONTROL

The objective of this numerical control system is to move a machine tool table (and hence the work) through rectangular co-ordinates according to a program, in order that machine operations can be carried out at the programmed points where the table stops. The machining operation may be drilling, tapping, boring, etc. Once set up, the system will enable any number of components to be produced with the maximum amount of consistency of dimensional accuracy.

9. PROGRAMMING

A CNC program is nothing more than another kind of instruction set. It's written in sentence-like format and the control will execute it in sequential order, step by step.

A special series of CNC words are used to communicate what the machine is intended to do. CNC words begin with letter addresses (like F for feedrate, S for spindle speed, and X, Y & Z for axis motion). When placed together in a logical method, a group of CNC words make up a command that resemble a sentence.

For any given CNC machine type, there will only be about 40-50 words used on a regular basis. So if you compare learning to write CNC programs to learning a foreign language having only 50 words, it shouldn't seem overly difficult to learn CNC programming.

Some controllers may include other words in their vocabulary to carry out certain function and the format of the values varies among the many different types from different vendors. G and M codes are very widely used. Not all codes are available on all controls, and some controls have other codes [8].

10. ORDINATE CALCULATING AND PLANNING

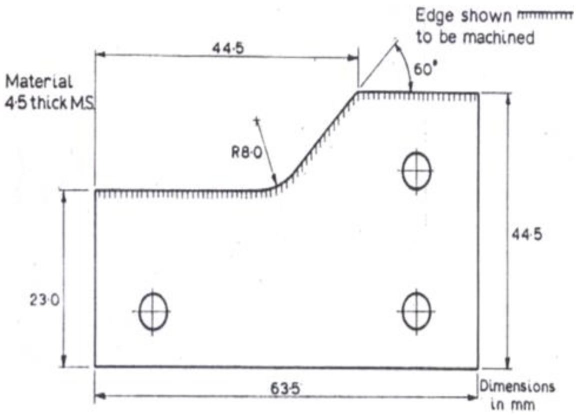

Fig. 3: Component Drawing

The initial component drawing produced will be of the orthodox type, suitably dimensioned.

The three previously drilled holes could be used for location. In general, fixtures for numerical control machining are simpler than for other forms of machining.

An ordinate drawing must now be prepared on which all the dimensions are shown as rectangular co-ordinates from datum point to which the cutter is set before commencing machining.

In practice, it is also necessary to indicate the points where the profile changes (change point) with an identifying number. The change points are then written on to a table with the calculated ordinate dimensions shown alongside.

The direction of cutter movement is important, and the accepted convention shown in Fig. 3 is adhered to, i.e. leftward along the x- axis is negative, and downward along y- axis is negative and vice versa. Finally, the ordinate shown below are calculated from the datum to the work profile. Fig. 3 shows the ordinate drawing for a component with the accompanying table of ordinates shown underneath the drawing.

There are two points worth 'noting'; first, the cutter diameter does not have to match the component profile. This is because the cutter is going to track around the profile, and as long as the cutter does not 'foul' (cutter interference) the work, any sensible diameter will suffice.

After the cutter has over run the profile it is returned to the datum point by the shortest route.

11 ADVANTAGES OF CNC MACHINES OVER CONVENTIONAL MACHINES

1. FLEXIBILITY IN DESIGN & PRODUCTION: CNC machine can switch over to different types of jobs more easily for sudden requirement. The CNC machine also gives designers freedom to design various conventional machines.

2. OPERATORS SKILL: The accuracy of components produced by CNC machine depends upon accuracy and ability of the machine and not the skill of the individual operator.

3. LESS INSPECTION TIME: High position accuracy and repeat ability are the inherent features of CNC machines, so it reduces the inspection time considerably.

4. MINIMUM SPACE: One CNC machine can replace five, six or more conventional machines, so manufacturing activities of a company is expanded without the floor area.

5. PRODUCTIVITY: In CNC machine the cutting is brought to its machining position much faster and efficiently than it can be done manually in conventional machine, so the time for removal of metal increases considerably for a specific cycle time, compared with any conventional machine.

6. REDUCTION OF SCRAP: Because of inherent accuracy and repeat ability of a CNC machine, scrap materials are drastically reduced compared with conventional machines, which reduce the production cost of the component.

7. FIXED CYCLE TIME: Time required to produce a component in a CNC machine is fixed and does not depend on operator's skill and efficiency.

8. TIME REDUCTION: In conventional method if a component requires 10 to 12 setups, in CNC machining center it may requires only 2 to 3 setups, which reduces the total product flow time [9].

12.0 CONCLUSION: It is clear that CNC Machining is not Rocket Science but a combination of already known and employed basic machining processes incorporated with the use of the Computer.

CNC Technology is quite expensive in short term but the benefits in terms of productivity far outweigh the cost implication of its initial investment if compared to conventional machining processes.

The limitations which are inherent in the machining of intricate and or delicate profiles which sometimes leads to the use of Non-conventional or other Manufacturing processes have been surmounted with the advent of CNC machining.

The use of CNC machining Technology in developing Nations like Nigeria will surely accelerate and consequently propel the rate of Industrialization which is one of the major yard sticks for rating the state of development of a country.

With the wealth of vast local knowledge of machining processes in Nigeria and the high rate of growth in Computer literacy, we should always be thinking and doing CNC TECHNOLOGY, because 'If they can do it, then we can do it'.

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