What to Look For Before You Leap

How to spec the hardware for your new CNC system.

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Question:

We are interested in purchasing our first gear hobbing machine. What questions should we ask the manufacturer, and what do we need to know in order to correctly specify the CNC hardware and software system requirements?

Answer:

Buying a gear cutting machine is no small investment. You can't afford to make mistakes, and key to a successful purchase is being clear ahead of time about just what you need. In this issue we will discuss the considerations that go into speccing CNC hardware. Next issue, we'll talk about the software requirements.

It is a good idea to have some basic understanding of the capabilities of modern CNC-equipped machines. Not all machine manufacturers offer identical capabilities, and asking the correct questions will ensure that you are not surprised or disappointed when your new machine arrives at your plant.

New users of CNC gear machinery are especially vulnerable to disappointment. A number of firms who have never produced gears before are considering purchasing their first machine. These typically are shops that have been turning blanks and sending their blanks out for cutting and are now considering buying a machine to do this work in-house. Many shops that already manufacture gears are also unsure of what to specify when it comes to machine controls and electrical systems and leave this important decision up to the vendor. Finally, users who are considering updating their machine control systems should arm themselves with some basic knowledge in order to effectively communicate their needs to the machinery or retrofit provider and to more accurately compare competitive quotations.

Although the following guidelines are specific to gear hobbers, most of the suggestions are also valid if you are specifying a shaping, grinding or other gear finishing machine.

Which Axes Will Be Controlled by the CNC?

A "full" CNC machine will *generally* direct all six axes normally found in a gear hobber. (See Fig. 1.) Not all CNCs control all six axes. Make sure you understand which axes are controlled by the CNC and which ones are manual. At a minimum, a CNC machine should control the three most important axes, the axial, radial and tangential slides. Depending on your needs, you can also automate the hob spindle, hobhead swivel and worktable.

In general, the more axes controlled by the CNC, the more expensive the machine. The trade-off of expense vs. changeover time depends on the type of gear products you are generating. The more changeovers you do and the more intricate the parts you manufacture, the more axes

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manufacture, the more axes you will want automated.

You should clearly explain to your vendor what type of parts you are manufacturing so that he can suggest the number of axes to control. For example, if you are using flexible manufacturing or cutting multiple gears on a long shaft, and you are concerned with long setup times, you will require a full six-axis CNC machine. On the other hand, a machine for automotive use may not have the hobhead swivel controlled by the CNC, since it is usually cutting only one part, and the position of the hobhead may *not change for years.*

Before you decide that a particular axis can remain manual for your application, keep in mind that it is not only the time it takes for an operator to change over the machine that you should consider. A gear engineer will need to specify the machinery settings and calculate the correct input. In a full CNC machine, the control automatically calculates many of the more complicated settings. CNC machines require fewer inputs (making for fewer input errors), since some of the inputs are calculated for you. You will need simpler setup sheets, fewer tools and specialized operator skills and less changeover time.

CNC machines have numerous other automated features. For example, the CNC today can calculate from the menu entry the usable hob length, how many parts can be cut on the loaded hob and automatically reposition the hob to recut a workpiece.

Digital Versus Analog Drives and Motors

Digital drive and motor systems should be specified whenever possible. The older analog drives require periodic maintenance that far outweighs the higher up-front cost of a digital system.

Analog drives (like analog radio tuners) will over time "drift" out of tune. The

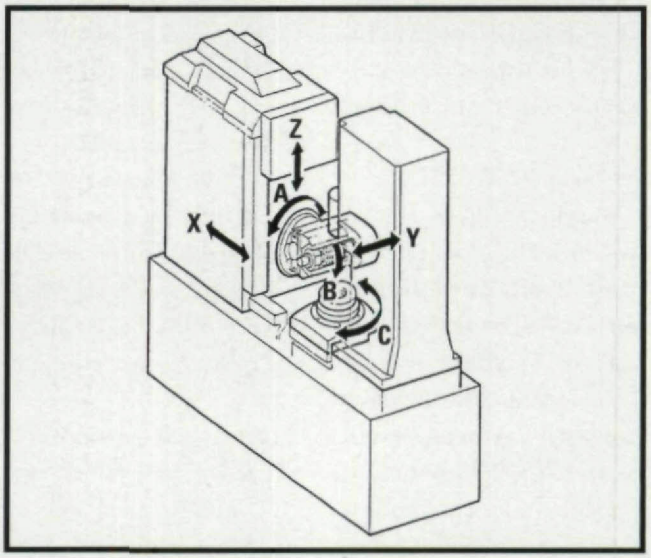

Fig. 1 — Typical 6-axis machine. X = radial; Y = tangential; Z = axial; A = hobhead swivel; B = hob spindle; C = worktable. (Courtesy of NUM Corporation. Used with permission.)

result is that the machine may not be able to make quality parts or run at full speed. Retuning the drives requires a skilled technician and is not normally attempted by the maintenance department. Digital drives do not require periodic tuning and run maintenance-free.

DC or Brushless DC Motors

DC motors run on direct current. They have a "commutator" that changes the direction of electric current in order to make a rotary magnetic field, which in turn moves the motor. The commutator is nothing more than copper contacts with brushes. These brushes will eventually wear out, especially if the motor develops a leak or is not sealed properly.

A brushless DC motor has an electronic commutator that changes the direction of the electric current using transistors (no brush contact). These motors require little or no maintenance. (Some engineers argue that a brushless DC motor is really an AC motor because the transistors emulate the alternating current.)

You should weigh the advantage of a maintenance-free brushless DC motor against the lower cost of a traditional DC motor when specifying your machine tool.

Drives

If you have a CNC system, you have a drive. It is an intermediary device that helps the CNC system communicate with the electric motors of the machine itself. CNC systems are very low power devices; on the other hand, the electric motors attached to the machines require high voltage, current and frequency. The CNC therefore needs to send the appropriate data to the "drive" hardware to interpret, amplify, filter and "drive" the motor.

Absolute Scales

Modern CNC machines are equipped with absolute scales (optical, magnetic, etc.), which give the machine a reference point for positioning on the slide. Without these scales, a machine will need to be taught the home position whenever it is turned on. "Homing" is the term for sending the machine slides to a known reference position. Most modern machines are equipped with absolute scales that will remember the exact position of the machine, even if the machine is turned off. In addition to eliminating the need for homing, absolute scales also increase the accuracy of the machine. The cost of absolute scales is negligible, and in general they should be specified whenever possible.

Keep in mind that the leading cause of machine crashes is the incorrect manual homing by the operator. Operators must be trained to manually home a machine correctly if absolute scales are not purchased. Tool or fixture interference can sometimes make this task difficult.

Rotary Encoders

Many modern machines come with built-in rotary encoders. One difference between scales and rotary encoders is that rotary en-

coders are more rigid and dependable. Scales still require some maintenance (occasional cleaning), although new technologies are being introduced to make scales as maintenance-free as rotary encoders. An absolute scale will give you more accuracy on the machine because the measurement of the slide is direct. The rotary encoder measures the slide position indirectly as a factor of the turning of the ballscrews. Modern rotary encoders and CNCs can even correct the inherent errors in the ballscrews. During the manufacturing process, the machine tool builder can "teach" the CNC where the errors are in the ballscrew and compensate for these errors. The only problem with this correction is that it is not consistent over the lifetime of the machine. As the ballscrew mounting brackets loosen or the screws get out of position, the machine's error correction will come out of alignment. The error compensation can be corrected in the field, but again, this is out of the area of expertise of most gear shops.

Screen Type and Size

This is not a minor issue and should be discussed with your supplier. As you might guess, the bigger the better as far as screen size is concerned. Larger screens generally result in reduced eye strain and fewer screens to flip between because more information is displayed per screen. Do not assume that the screen size can be increased later if necessary. If you later decide to increase the screen size, the software may not display properly without a costly rewrite.

Color screens are generally easier to use than monochrome screens. Make sure that the software you purchase uses the color capability wisely. Warnings, data input screens, help screens, etc., should use color intuitively to convey important information and reduce the number of input errors.

All major CNC manufacturers are offering a color matrix flat screen option to the more traditional cathode ray tube. These screens are limited in size for now and are quite expensive. Machine vendors may use this type of screen when they mount screens on machinery with space limitations or in an effort to make the machine more ergonomic.

The mounting of the screen should also be discussed with your vendor. Depending on the type of machine, you may wish to have the screen mounted on the machine or electrical cabinet or on a pendent. You should also consider the possibility of the vendor providing some type of hand wheel device for data input and machine setup. Give some weight to ergonomics when analyzing your total system costs. Ask the vendor for a layout of how the finished product will look.

Data Input

If you plan to input large amounts of data (say you are a job shop making many parts), you should discuss with your vendor what data input options are available.

Some manufacturers offer a full "QWERTY" keyboard option. These typewriter-style keyboards are much less cryptic and easier to use than the multipurpose keypads that are usually part of a standard CNC. A pointing device or mouse may also be helpful on some systems.

If you are interested in loading part, process and tooling data from a central computer, ask for a quote on a DNC (direct numerical control) option. Additional hardware and software may be required.

You should also ask your vendor how the CNC system is to be backed up. Some vendors use diskettes; others may use PCMCIA cards or back up the systems using the RS232 or DNC port. The media is not really that important, but the method you use to back up the system should be straightforward.

Limit Switches

Be certain the machine you are buying has emergency stop limit switches. Some manufacturers omit these safety devices in an effort to lower the cost of the machinery. Even machines equipped with absolute encoders can sometimes lose their memory if the backup battery fails. In this case the machine will need to be rehomed. If this is not done properly, you can damage the machine. Limit switches on key slides will save you money. The cost is low, about $100 per axis. Over the life of the machine, these low-cost limit switches will save you money even if you have only one crash. Not specifying limit switches is akin to buying an expensive electrical device and not protecting it with a low-cost fuse.

Mechanical Variable Speed Drives

If you are purchasing an older machine and retrofitting it with a modern control, one problem you may need to address is whether to have the variable speed drives replaced with a CNC-controlled motor.

A mechanical variable speed drive is generally used to mechanically control the main spindle speed (from pre-CNC days), and in the past was also used for the feed drives. Variable speed drives are high-maintenance items and should be replaced with a direct drive motor whenever possible. Depending on how you size the motor, a retrofitted machine may have reduced cutting torque and horsepower at low speeds compared to a mechanical variable speed drive.

A simple alternative to a variable speed spindle is a lower cost, fixed-speed main spindle. This is an acceptable alternative for some simple applications, but for multiple cutting cycles or complex cutting cycles, you will need to change the spindle speed. ○

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