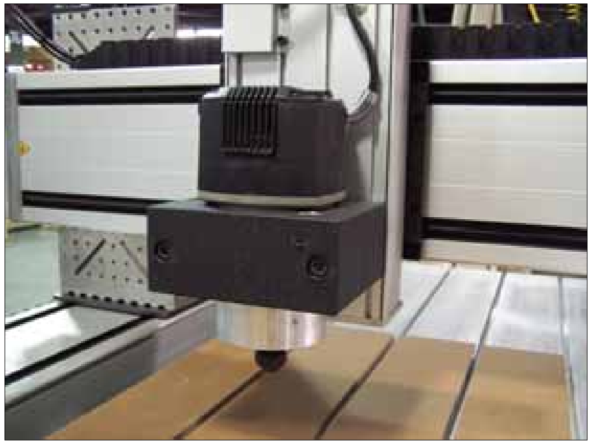
In contrast to steppers, servomotors have constant feedback from the optical encoder. This device sits on the back of the motor and keeps the controller informed of how far the motor has actually moved. This constant feedback is used to correct any discrepancy between a desired and an actual position. This automatic corrective action results in faster cuts (up to three times the throughput), and increased power (up to three times the torque) at high speeds. The closed-loop nature of the servo also ensures that stalling cannot occur unless there is an immovable object in the path. When such an obstacle is encountered, the closed-loop system would communicate to the machine's controller to shut down rather than lose position.

Servomotor resolution depends upon the encoder used. Typical encoders produce positional signals (or pulses) per revolution, and encoders range from 500 to 200,000 pulses per revolution. The more pulses there are, the finer the resolution capability of the motor. Servos can perform high-speed continuous motion much more reliably because of the constant feedback from the encoder, making them much better suited to applications requiring a high-end quality finish.

Spindles

Spindle Types

There are two broad categories of spindles used on CNC machines: brush types and brushless types. The brush type spindles, as the name implies, use commutating brushes to transfer current to the coils that cause the shaft to spin. The brushes tend to wear over time under normal use, and consequently wear out faster under heavier applications. Another drawback to brush type spindles is the noise associated with their commutating brushes. The main advantage, however, is that they are generally much lower in cost. In fact, in some CNC type applications, they are considered disposable.



This low cost also tends to make these spindles less precise. TIR, or Total Indicator Runout, is an industry measure of spindle accuracy. TIR measures how true the rotation of the shaft is. It is typically measured at a fixed distance from the tip of the spindle shaft and, as the measurement name indicates, determines how out-of- round the rotation is. Brush type spindle motors generally have TIR significantly greater than the brushless type spindles. In many applications, such as woodworking, this is not of concern.

The other broad category of CNC spindles are brushless, also known as AC spindles. Brushless AC spindles do not have the maintenance issue of brushes wearing out or the noise associated with brush type spindles. Because AC spindles require less maintenance, have a better TIR rating, they are also a more expensive alternative to brush type spindles. The cost is usually justified when looking at the overall comparison between the two spindle types.

A summary of the comparison of their features is shown in the table on the following page.

In the category of AC spindle motors, there are 3 types: fixed collet spindles, manual quick change spindles, and automatic tool change spindles.

The fixed collet spindle requires the collet to be changed with a manual operation that usually requires a couple of wrenches. This is a fairly simple process but takes a few minutes each time it is required. The manual quick change and automatic tool change spindles have an electro/pneumatic system that releases the current tool and replaces it with another in a matter of seconds. The automatic tool change system, as the name implies, is done without any operator intervention while the manual quick change system usually requires the operator to activate a signal to release the tool and to activate another button to reload the next tool into the spindle.

Features	AC Spindle	Brush Spindle
Brushes	None	Yes
Noise	Relatively Quiet	Noisy due to the brushes
Service Required	None - Bearings are usually sealed and lubricated	Brushes need to be replaced regularly
Speed Control	Usually adjustable from the AC inverter that is needed	Minimal, not precise, usually manual if available
Power Range	Fractional HP to 20HP and above	Typically in the 0-3 HP peak range
Tool Change Option	Manual or Automatic	Manual
Cost	Thousands of $	< $1,000 dollars
TIR Accuracy	Usually < .002”	Usually in the .002” - .004” range
Voltage Required	220-440V AC, single or 3 phase	120V AC typical, 220V AC single phase available
Current Used for 3HP	220V AC single phase – 16A 220V AC 3 phase – 10A	For 3HP peak – 15A circuit required
Maximum Collet size	1.5” and higher	.5” typical

The question of which spindle should be selected depends primarily on the applications and quantities of parts to be made. The benefit of the automatic tool change system is that a great deal of time can be saved for parts that are to be made in large quantities that also require a number of different tools. If the quantities are not so large, the manual quick change might represent an economical compromise. In the case where the quantities of the parts are small or only a small number of tools are required, there is no clear benefit to using either a quick change or automatic tool change system.

Tool Length Offset

The main difficulty with changing tools on spindles is adjusting the length of the new tool to match the previous tool so that the software can continue at the correct height of machining. This task is no longer very time consuming. In the past, the operator would have to either carefully adjust the tool height relative to the workpiece with gauge blocks or adjust the height of the Z-axis relative to the work-piece to re-zero the Z-axis. Although this is not difficult, the task had to be performed carefully or else the second tool would not be at the correct height and the part might have a visible defect. Now, all Techno machines and many other CNC machines come with tool-length sensors and compensation software. This allows for the tool length to not only be measured but automatically compensated for in the G-Code software, with a simple and automatic process.

Spindle Power

The traditional way that the spindle power is “measured” is by the HP rating. This rating has to be carefully considered since the HP rating is generally proportional to the spindle rpm. For example, if a 3HP spindle is rated at 3HP at 18,000 rpm, it would only have 2HP at 12,000 rpm. The speed at which the rating is specified is therefore extremely important.

The other aspect of spindle power that must be considered is the nature of the power rating. The power rating on the brush type spindles is generally specified as a momentary peak rather than a continuous rating. The rating for AC spindle motors is usually considered a continuous rating but even this might be specified as a function of duty cycle. Some spindles are rated for 100% duty cycle – able to maintain the rated power continuously, while others are rated for a 60% or 80% duty cycle. In the latter case, the expectation is that the spindle will be used to its rated power for a few minutes and then allowed to “rest” for a brief period before the next part. This duty cycle rating is associated with the required cooling of the spindle.

Spindle Cooling

Three common methods of spindle cooling include: fan, compressed air or liquid. There are two types of fan-cooled spindles. First is an electric fan which will blow air through the spindle body. The second is a fan blade attached to the spindle arbor. This method of air flow is dependent on spindle rpm. Both methods of cooling have drawbacks.