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Full 4th Axis vs. Programmable Indexer?

Many companies face this question when deciding to purchase a servo driven Rotary Table/Indexer for their VMC. First of all we need to examine the distinct differences between the two.

Programmable Indexer

A little history.....

The term "Indexer" is typically used to describe a device which rotates to a desired radial position. Until 1981 this was achieved by the use of manual indexers commonly known as "Super-Spacers" or "dividing Heads" In 1981 the first programmable Indexer was introduced which incorporated a programmable controller and a 5C Index head using an "open-loop" stepping motor drive system. This was a real break-through in technology because up to this point; the NC machines that were available on the market either did not have the capability for a full additional integrated "4th Axis" or offered a very large DIA Rotary Table at a very expensive price. The 5C Programmable Indexer was very reasonably priced (around \$ 2,000.00 which included the controller and 5C Head with stepping motor) vs. the 4th Axis which had a total cost of more than \$ 20,000.00. The Open Loop system however did have its drawbacks; 1st the stepping motor did not include an encoder, so that radial position could not be verified. Basically the motor would move a certain amount of pulses as given from the Stepping motor driver (the PC card device inside the controller which sends the electronic pulses to the stepping motor as directed from the Motion Control Card (the main CPU card also inside the controller). The problem was that without position feedback to the Driver and CPU, it was possible for the Indexer not to reach the desired position due to spindle interference (such as coming into contact with a fixture) or any host of motor or brake problems; in any case after the Driver sent the total amount of pulses to the motor; the CPU would automatically send a "Step-Finish" signal back to the CNC Machine control; satisfying the M-CODE sent from the CNC Machine control; thereby allowing the CNC machine program to move to the next block in the program. This meant that it was possible for the CNC Machine spindle to for example drill a hole in a part chucked in the Indexer at the wrong position; without the knowledge of the machine operator. Un-Checked as you can imagine this could cause a full run of bad parts. In addition to this main flaw, the stepping motor did not provide much motor torque and was motor drive package (motor and driver) could only achieve a very slow RPM speed (1,000 RPM div. by 90:1 gear ratio = 9RPM indexer spindle speed)

Today, the Stepping motors are gone, and most companies providing programmable rotary systems provide an AC Servo drive system or at the very least a brush type DC servo drive package. The AC is much preferred as the motors are "brushless" and provide a very smooth fast relatively constant torque range throughout the entire RPM spectrum. The controllers also are much advanced, supporting the AC servo system, along with



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the latest in servo loop technology, M and G Code programming, PC software and output ports such as RS232C, Ethernet, and USB for communication directly with either a PC or CNC Machine control. In 1981, the available method for interface with the CNC Machine control was by connecting an M-Code interface cable (see illustration below) to the CNC Machine. The way it worked was you would program a series of position moves into the programmable controller; and then each move would be executed on by one by use of an M-Code sent from the CNC. Typically the M-Code signal is nothing more than a "circuit to ground" which would then complete the circuit of the 24VDC or 100VAC relay (either added or supplied with the M-Code board from the CNC builder) This circuit would be maintained while the Indexer is in motion (essentially putting the CNC into a "motion-hold state" . Once all the pulses were sent from the Prog. Controller driver, then the controller CPU would send a "STEP-FIN" or finish signal back to the CNC satisfying the M-Code and allowing the CNC to move to the next block. Later stepping motor systems included an encoder (as do all current servo systems), which confirm radial position of the motor; and send the Step-FIN signal, only after the position has been confirmed and if the unit has a brake system, that the bake is also engaged. This is done normally by a pressure switch inside the rotary indexer body.

Advantages of a programmable Indexer.....

Flexibility; the programmable Indexer is portable and can be used on any CNC Machine tool with an available M-CODE. Many customers also use these units for rotating parts for certain free standing measuring devises, along a variety of manual or automatic milling and drilling machines. Many customers actually put pin type connectors on the bulkhead of their CNC's so that it becomes a simple plug-in of the M Code cable in order to begin using the Programmable Indexer on another machine. Cost; a typical Prog Indexer system is between \$ 5,000.00~\$ 10,000.00 less money than a full 4th axis; see cost comparison chart below. The main reasons for this cost difference is that with the programmable Indexer, you only need to have the CNC supplied with a spare M Code, and the installation fee is very nominal (normally \$ 500.00~\$ 1,500.00); whereas a 4th Axis system includes an expensive servo drive package and costly installation.

	Drive package	controller	Install fee	
Indexer				
4 th axis				

Disadvantages of a programmable Indexer.....

Many customers do not like the idea of having a separate controller box (4th axis does not require a separate controller). Programming is done directly from the CNC control for the 4th Axis rotational movements; whereas on a prog. Indexer, the index movements need to be programmed into the separate controller box (with the exception if you use the "DPRNT MACRO method, described below). But the main reason for customers deciding on a full 4th Axis is due to the fact that since the rotary table position feedback is sent directly to the CNC control, coordinated movements between the CNC and the rotary table are possible. These include all helical cutting where the X and or Z Axis needs to move at the same time the Rotary table is moving. Since the



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4th Axis provides “DIRECT” feedback to the CNC; the CNC control always knows the radial position and therefore can compensate for any variations in movements. In addition, complex simultaneous movements of machine axis moves with Rotational movements requiring CAM profile generation are much easier to generate with a 4th Axis.

Helical Cutting with a programmable indexer.....

Yuasa INTL (Elk Grove IL) has developed a method of generating a helical cutting operation with simultaneous movements with the CNC Axes, as shown below. It must be understood however that this method while providing for the helical cutting capability, does not directly feedback position data to the CNC control and as such will not provide for any servo torque or velocity changes “on the fly” from the CNC control. The Yuasa Controller firmware however does permit the CNC machine axes to start simultaneous with the Prog indexer rotational moves. This advanced controller firmware also features “continuous prog line data” whereby if the helical moves require changes in RPM and feed-rate; the Yuasa controller can execute each line with ZERO dwell between lines flowing from line to line enabling a continuous servo speed and feed-rate changes for radius movements on round shaped parts.

Yuasa Controller programming moves

M40
G91
A23.456 F0.023
A23.564 F0.025
A24.678 F0.029
A25.076 F0.035
A25.092 F0.037
M41
G90B0
M30

CNC Controller Prog moves

M21;
G04P500;
G01X3.07F125

The term “Rotary Table”, or servo Rotary Table is understood in our industry as a “full 4th axis”. On most CNC machines the letter designation is either a “B-Axis” or “A-Axis” The machine builders never seem to get together on if the A Axis is “Radial” and the B Axis is tilting.

Before the introduction of the NC machine; the way to rotate a part on a Milling Machine was to use a “Rotary Table” (see photo below) this was done (as is still done today) by turning the handle on a manually operated worm screw engaging a worm gear, thereby rotating a round table which your work-piece would be fixtured to. With the introduction of NC machines some manufactures began to introduce the ability to rotate your



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work-piece by use of a servo driven (in some cases stepping motor driven) Rotary Table. As described earlier these Rotary tables were very expensive and normally offered only on larger NC Milling machines. In addition, the rotational speed was very slow, (less than 5 RPM in many cases). During this period, most customers decided not to purchase the 4th Axis option and use their current manual rotary tables, dividing heads or super-spacers. They would put in a "program stop" into the NC control; then manually turn the Rotary table; then re-start the NC machine.

As time moved forward, with the introduction of CNC machines; many customers started to OPT for 4th Axis Rotary tables as an addition to their VMC (Vertical Machining Center). More models began to be offered along with faster indexing speeds. The 4th Axis offers some distinct advantages over the programmable Indexer (as shown above) whereby cost, flexibility and portability remain as the disadvantages.