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ABOUT MODERN STRATEGY ON TOOL CHANGERS DESIGN

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ABSTRACT
An important strategy for tool changers, especially larger-capacity ones, is to minimize stroke between tools. The two common methods for implementing that strategy are the migrating and assigned-tool approaches. With the assigned-tool approach each tool returns to the same location after each use. The migrating approach on the other hand puts the old tool in new tool's spot. Because the magazine moves once not twice, the migrating scheme is often faster then the assigned approach.
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1. THE SEARCH FOR SIMPLICITY
Machine tool builders offer a myriad of tool-change options on their machining centers. Some can be cumber-some gib cranes, but much sleeker version offer subsecond tool-change time for smaller tools, read-write chips embedded in the toolholder, and 200-tool storage matrices. The trend is toward ever faster tool changes and simpler mechanisms.
Tool-change speeds start at less than a second for small tools and go to 30 sec for huge 110-kg. Most tool changers for typical machining centers, however, are in the 5-10-sec range. Some even have dual speeds to accommodate both heavy and light tools.
The firm for horizontal machining centers, Cincinnati Milacron (Cincinnati), breaks out average speed by taper size, for the 40-taper class, the average is probably 2 sec. tool-to-tool and 5 sec. metal-to-metal. For the 50 taper, it's about 3 and 6 sec.
When evaluating those tool changer speeds , you need to know whether the time given is tool-to-tool or chip-to-chip (or metal-to-metal).The first value is the time the mechanism takes to exchange tools ; the second adds to that the time to stop and restart the spindle and to move from and to the work. The first is a constant, and the second varies with each tool and cutting operation.
Tool-to-tool is a meaningless speed, you are really interested in reducing parasitic time [time not in the cut] -so you can ship more parts at the end of the day. What good is changing the tool rapidly only to wait for the spindle to stop and start or for the B axis to finish rotating He thinks chip-to-chip time is the better measure because it accounts for parasitic factors.
Of the four categories - drum, double-arm, pivoting-arm, and multiaxis - that most automatic tool-changers fall into today, the drum and double-arm styles vie for the distinction of being the simplest. They, however, are not always best.
The double-arm style engages the tools in the spindle and storage magazine simultaneously and rotates 180° to swap tools. As the arm rotates, it puts the new tool in the spindle and the old one in the magazine.

The pivoting-arm style differs in that the arm pivots on its base in addition to rotating I80o. The arm removes the new tool from the magazine, pivots to the front of the machine, removes the old tool from the spindle, rotates 180°, inserts the new tool, and then pivots to put the old tool in the correct storage slot in the magazine.
The double arm style is simpler, requires less motion, and changes the tool faster. The downside is that the tools must be stored in a plane parallel to the spindle, a position that may be inconvenient and that could allow chips and coolant to contaminate the toolholders. Most builders keep the double arm and the tool magazine outside the work envelope to prevent contamination. There are exceptions, but it's a serious design flaw.
Tool changes with the doable arm can be very fast if the arm need not watt for the matrix to index. Matrices can be very extensive, holding up to 200 tools. The next tool can be a long way away. A way around that wait is a ready position, a separate mechanism that removes a tool from the matrix and holds it until it is time to change the working tool. As the tool waits in the ready position, the matrix can index to the working tool's location. In fact a built-in ready position is how Klabunde explains why pivoting arms are more popular than the simpler double arm. The tool sits in the pivoting arm at 45° until the machine finishes its operation; then the arm pivots another 45° for the 180° rotation. The machine resumes its work white the arm deposits the tool in the matrix. Even though the pivot motion adds complexity, it can cot overall tool-change time because the arm moves only a half cycle from the ready position during the actual change.
A few pivoting arms come without the ready position. They are more typical on boring mills and large machines because they swing around the side of the column. A simple double arm doesn't have a clear way to get close to the spindle.
Multiaxis toolchangers typically use a robotics wrist to remove the tool in the spindle, return it to the magazine, grab the new tool, and swing back to the spindle again to install it. The design tends itself well to vertical machining centers, and it works with either side or back-mounted tool magazines. Unfortunately, it requires too mach tool handling and motion. It was used it for some complex jobs that had long reaches, but it's usually cost prohibitive and slow. The trend now is simple and fast.
Drum-type toolchangers differ from the others in that the magazine, a circular wheel often called a carousel moves directly to the machine spindle. During tool changes, the carousel index to the required tool slot and removes the old tool. The carousel then indexes to the new tool and inserts the tool into the spindle. Afterward, the carousel moves away from the spindle.
On some large vertical machines, the spindle goes to the carousel rather than the carousel moving to the spindle. Tool and carousels on these large machines are often too big and heavy to manipulate easily.
The drum type is one of the simplest designs and, therefore, one of the most reliable. Its drawbacks, though, are it holds a limited number of tools and has a problem accommodating migrating tools. Users must load the tools in the order the machine uses them. Otherwise, the machine can spend a long time putting the old tool away and retrieving a new one from the other side of the drum.

2. MAGAZINES MATTER

Carousels can mount on the sides or backs of machines and work well with drum-type toolchangers on vertical machining centers. They also can sit on carts for transportation from toolrooms to machines. Carousels tend to be more popular on turning centers than on machining centers because turning centers tend to need fewer tools.
Although toolchangers other than the drum type can store tools in a carousel, most use matrices of long, conveyor-like chains of 200 or more pockets that hold tools. When the machine needs a new tool, the chain rotates to present the correct tool pocket to the exchange arm. The technique can add a great deal of flexibility. The practical limit, however, seems to be around 200 tools because, beyond that, the toolchanger would use too much floor space. The average capacity is probably a little more than 100.
The chief advantage of chain matrices is that they are not limited to a circular shape. Oval and serpentine configurations can store a large number of tools in limited space. A disadvantage is cost. A chain and the associated parts are usually more costly and may be less reliable than a carousel which is basically a simple plate with some pockets.
Builders are combating cost and reliability problems by making the tool pockets from injection-

modeled, glass-reinforced composite materials. The pockets are simpler with fewer moving parts to fail. Many of the features that damp the tool in the pocket are now moulded into one piece, rather than assembled with bolted and glued-on parts. The pockets went from 28 parts to 4 parts. If you multiply that rimes 80 tools in a chain the benefits add up fast.
Another drawback can be the indexing time when matrices are long serpentine configurations. If it is necessary to wait for a 180-tool chain to present the right tool, it is possible to wait 30 or 45 sec. That is why he advocates modular 40-tool matrices. The exchange arm picks tools from one or more of them so that it is never more than 20 tools away from any tool.
Vibration from a big matrix sitting on top of a machine can be significant.
Without an isolator between the machine and matrix, vibration can create flaws in the work if the matrix-rotates while the machine is cutting. Another technique is to run the matrix only as fast as you must. Besides isolating the matrix and monitoring its speed, the only other option left for controlling vibration is a stand-alone magazine. Some large machines pick tools from unattached, dedicated, inanimate racks. This technique is also useful when matrices cannot handle large and heavy tools.

3. CONCLUSIONS

When a machine needs new tools, there are many ways to replenish storage magazines- that is, add and subtract tools- while the machine is operating. Techniques include loading them manually to the storage magazine, using an automatic loader, and adding them using the spindle.
To decide which style of tool changer is best of your jobs, the advice is to look at the economics and to choose the simplest mechanism that offers the necessary toolchange time, tool storage, weight capacity and reliability.

6. REFERENCES

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