REPRINTED FROM CUTTING TOOL ENGINEERING AUGUST 2000/VOLUME 52/NUMBER 8

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A look at the different options for upgrading an old machine tool.

The 3 R's: Retrofit, Rebuild and Remanufacture

Anyone considering the purchase of a new machine tool at IMTS will probably wonder if his current machine could be upgraded. This article explores the three primary types of machine tool upgrades available from builders and third-party specialists: retrofit, rebuild and remanufacture.

Going Retro

The term "retrofit" usually means an upgrade to just the CNC. However, a control upgrade should also include new servomotors, drives, magnetics (motor starters, breakers, solid-state relays, etc.) and a complete rewiring of the machine.

A retrofit costs about 30 percent of the price of a new machine, so the retro candidate must be mechanically sound to justify the investment. The OEM, or reputable third-party rebuilder, can provide a complete mechanical assessment of your machine tool.

Don't be afraid to pay for a second opinion. It often proves to be money well spent.

An older CNC machine tool undergoing a retrofit probably will have a control installed that incorporates features not available at the time the machine was purchased. Faster data-processing speed means a faster acceleration/deceleration rate and axis motion, and greater positioning accuracy.

These capabilities are what make it wise to upgrade a machine's servomotors, drives and magnetics during a retrofit. Failing to upgrade the entire system means the user won't realize the full benefits of his new CNC.

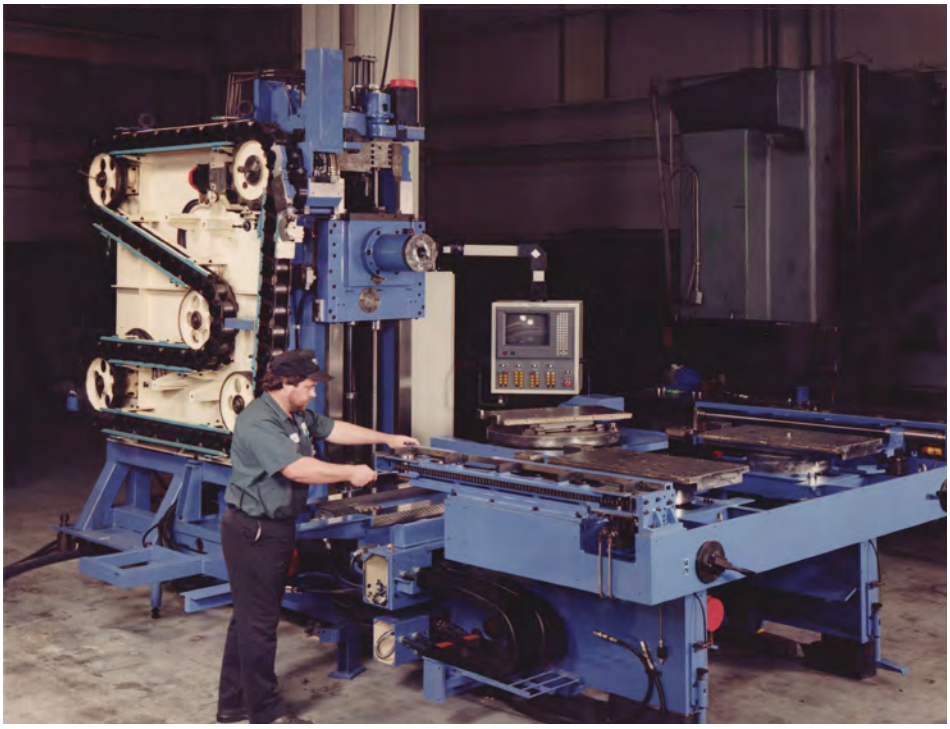
Many older controls have no host-computer communication capabilities, while new CNCs provide a variety of communication options. Today's controls also have built-in computer diagnostics to assist the operator, programmer and maintenance person when troubleshooting a tooling problem, programming error or machine fault.

A dedicated control just runs the machine tool, while a PC-based CNC can run the machine program and other software simultaneously. Both types have advantages. Familiarize yourself with what each offers in terms of speed, programming features and memory before selecting your new control.

Servos, Drives, Wiring

The predominant servomotor installed on new and upgraded machine tools is the brushless AC motor. It has an excellent power-to-size ratio and requires little or no maintenance. Some dedicated controls mandate the use of both digital servomotors and drives—an excellent combination—in order to upgrade the control.

The drive tuning on a digital system is done via the control screen, with soft parameters; no manual tuning is required. The connections between the



drive and CNC are usually serial or fiber optic, a faster and more reliable method than analog connections. Some control and drive manufacturers have joined forces in an effort to develop digital interfaces that can be used with PC-based systems.

Although many successful retrofits are done without replacing the original magnetics system (motor starter, fuses, disconnect, relays, etc.), it's not recommended. One of the advantages of having a new control, servomotors and drives is that they are significantly smaller than their earlier-generation counterparts. Similarly, the newer magnetics panels are smaller, so they occupy less floor space while meeting modern electrical codes.

Completely replacing the machine wiring also is a highly recommended. Rewiring also ensures that the machine meets modern electrical codes.

Today's demand for higher spindle speeds raises the issue of whether to replace the spindle motor and drive. The limiting factor for increasing spindle speed is mechanical. You simply cannot put a 6,000-rpm motor in place of an 1,800-rpm motor without causing irreparable damage to the transmission.

But unlike servomotors, there are certain instances where it makes sense (as in dollars and cents) to rebuild the original DC motor and match it to a new digital DC drive. Generally, you should keep a DC system that's above 30 hp and replace one that's below 30 hp with a brushless AC system.

Make sure, though, that you consider the base motor speed. Older DC spindle motors have base speeds that range from 500 to 850 rpm, with top speeds of 2,500 to 3,000 rpm. The base speed of a brushless AC motor is usually 1,500 rpm, with maximum speeds as high as 10,000 rpm. If the base speed of the AC motor is three times the old DC motor, then at the original base speed, an AC motor will only generate one-third of the old DC motor's rated horsepower.

One way around this problem is to change the gear or pulley ratio. But if the motor is directly coupled to the spindle, some engineering work will be needed to make the brushless AC system generate the same low-speed horsepower.

A Rebuilding Season

When the machine tool industry refers to a rebuild, it generally means that all of the mechanical components of the machine are cleaned, inspected and then reassembled using new or remachined components. As with a retrofit, a rebuilt CNC machine costs about one-third the price of a new unit.

Good candidates for a rebuild are machines less than 12 years old that have a reliable CNC, and servomotors, a spindle motor and drives that do not need upgrading. Also, make sure that any unreplaced components are readily available and will continue to be supported for the expected life of the rebuild. Few things are more frustrating than to spend money on a rebuild only to discover later that the spindle-drive manufacturer, for example, no longer produces your machine's drive.

Any major mechanical upgrade to a machine tool should always include the replacement of all bearings and seals, to OEM specifications.

In addition, the spindle assembly (or cartridge) and/or headstock should be completely disassembled and inspected. All internal bearings should be replaced, including the precision-class spindle bearings. All gears should be checked for wear and cracks. The shafts should be checked for straightness and all of the bearing journals should be repaired as needed. The spindle itself should be reground.

On a milling machine, the spindle taper and face must be reground to OEM specifications. The drawbar should be rebuilt, which includes replacing all of the clamping springs. Lathe spindles should be checked for straightness. The taper must be carefully inspected and, if necessary, reground. The final reassembly should follow the OEM specification for proper runout and endplay.

It's possible that damage to the spindle/headstock will be too severe to repair, but that cannot be known until it is taken apart and inspected. Fortunately, many of today's OEMs manufacture and stock replacement spindle assemblies and cartridges.

Another mechanical area to be rebuilt is the way system. The work done here is critical to returning the machine to its original accuracy. The two primary systems used in the machine tool industry are box ways and linear guides.

If your machine has box ways, they should be visually inspected for scoring and checked for hardness. Most new ways have an average hardness of Rc 50 to 63 at a depth of 0.090" to 0.125". They should be reground flat, perpendicular and parallel, within 0.0002" TIR and a 32µin. finish. This level of accuracy is obtained by grinding the ways on a precision bed grinder. The ways should have no less than a 0.050" depth of hardness after grinding to ensure longevity. If a way has scoring below that depth of hardness, it may have to be scrapped. If the way is integral to the casting, it can sometimes be repaired, but this is not prudent.

Some OEMs make their ways removable. While removable ways can be finish-ground off the machine, they should be reinstalled and then ground in place to ensure the highest possible accuracy.

Hardened-steel box ways incorporate one of three common slide techniques. The first, and most economical, involves the use of a low-friction material like Turcite or Multifil. The existing material is removed from the slide. Then new material is glued in place and the slide is hand-scraped and fitted to the ways.

An alternate technique is to machine the base of the slide to accept a "wear strip." Then Turcite or Multifil is glued to a piece of spring steel so that it can be removed for fitting. Future replacement of the wear strip is easier because the slide does not need to be removed.

The second type of slide system incorporates linear roller bearings. The roller bearings are placed side by side in a cage that resembles a tank track. The cage is held together with a rubber banding and rides in pockets milled in the slides. The rebuilder should replace these bearings.

If the box ways are made of cast iron rather than steel, they can be reworked by two common methods. One is hand scraping and mating the way to the slide until it reaches the accuracy of the OEM specification. But there are at least three potential downsides to this approach.

One is the machine tool's feed rate. This metal-to-metal slide method cannot be driven at rapid feed rates much over 200 ipm. Second, this way system is prone to damage from contamination, usually in the form of metal chips that get between the slide and way, causing scoring that severely reduces machine accuracy. Third, the hand scraping of ways is a rapidly disappearing art. If a company offers this service, check customer references for machines that are at least a year beyond their warranty period. You need to be absolutely sure that the company you contract to rebuild your machine knows what it's doing with respect to scraping ways.

The second method of reworking cast iron box ways is to grind the way to allow Turcite or Multifil to be fitted to the slide. Today's precision grinders produce highly reliable results and attain excellent surface finishes that meet the OEM specification.

A third type of slide, which is found on larger machines, is the hydrostatic system. With this design, the slide rides on a film of oil at all times. When rebuilding a hydrostatic system, all of the pressure-compensating valves must be replaced. The slide should be checked for a proper fit to the way system and scraped as necessary.

The majority of modern CNC machine tools use linear guides. A linear guide system consists of a pair of rails. On each rail rides two or more bearing packs that are called "trucks," which attach to the table or column. If they are still in good condition, they can be reused after basic maintenance is performed.

Unlike box ways, linear guides cannot be reground. Linear guide rails and trucks wear as a system. If replacement is needed, insist that both the rails and trucks are replaced.

Ballscrews are the heart of your axis accuracy and can be expensive to replace. But fortunately, most ballscrews can be rebuilt once—sometimes even twice—depending on the amount of wear or damage that must be corrected. This service is generally outsourced by rebuilders to shops that specialize in the manufacture and remanufacture of ballscrews.

The process requires the screw and nut to be disassembled and inspected for hardness, rust and wear. It then can be determined if a repair is possible. A reground ballscrew will be returned with a new nut, while the bearing journals are checked and repaired as necessary. The ballscrew is then reinstalled with new thrust bearings and checked for accuracy to ensure proper height, parallelism and runout.

If a repair is impossible, be aware that new ballscrews can have a lead time of eight to 10 weeks. Remanufactured screws are usually out and back in less than a month.

Checking Fluids

A machine's hydraulic fluid reservoir should be thoroughly cleaned during any rebuild. The pump and motor should either be rebuilt or replaced, along with any filters or strainers. The flexible hydraulic hoses must also be replaced.

The solenoid valves of a hydraulic system normally do not fail mechanically; a burned-out coil is the usual culprit. Therefore, the decision to replace them during a rebuild is usually made by assessing the risk of obsolescence and whether the valves have been prone to frequent failure in the past.

The central lubrication system is the single most important system on any CNC machine. All of the flexible lube lines must be replaced and all of the metal lines flushed and tested for leaks. The pump should always be replaced.

There are types two of central lube systems on a CNC machine. The one-line resistance system consists of a low-pressure pump that sends a single line of lubricant directly into a manifold. The multiple lines that exit the manifold are routed to individual lubrication points throughout the machine tool. A "metering unit" in each line serves to regulate the rate of oil flow.

A small orifice in the metering unit supplies the proper amount of oil for a given lubrication point. The units come in various sizes, based on the amount of oil that is needed. All metering units must be replaced.

The second lube system is the progressive type, which uses a high-pressure (up to 3,000 psi), air-over-oil pump with individual feeder blocks that contain "spools." Each time the pump piston fires, these spools are shifted in the blocks, precisely controlling the amount of oil that reaches each lubrication point. A block can sense if a spool has not shifted, sending a lubrication alarm to the CNC.

A progressive system can be completely flushed, inspected and reused. If your machine tool cuts cast iron or other abrasive materials and is equipped with a one-line system, consider converting to a progressive-type system.

Final Approach

Reassembly of a machine being rebuilt begins at the base, with proper leveling. A weight shift occurs as each major component (table, spindle, column, etc.) is added to the base. The risk of accuracy error is significantly reduced when the level is rechecked after each major component is added to the machine base. Geometric alignments should be made using OEM procedures and tolerances.

Proper alignment includes a static check performed with a granite square and electronic levels. By today's standards, proper alignment also includes a dynamic check with a system that provides a computer-generated analysis of the accuracy of the machine tool in motion. A "ballbar" test ensures that the individual axes are aligned correctly and that the relationships between the axes in motion are also accurate.

Rebirth

The most comprehensive type of machine upgrade is remanufacturing. It combines everything involved in a retrofit and rebuild. Plus, a remanufacture job includes design changes that improve the machine's performance beyond its original specifications.

These changes could include an increase in the rapid and cutting feed rates, extended axis travels and a higher spindle speed.

At half the cost of a comparably equipped new machine, remanufacturing is only practical when a new replacement machine would cost $400,000 or more.

A typical retrofit that includes a control, servomotors and drives will take four to eight weeks. Most control manufacturers have delivery schedules in the four-to-six-week range, so a control-only retrofit is slightly faster.

The delivery for a complete rebuild should range between 12 and 16 weeks, depending on the extent of the damage and wear to the machine tool. A remanufacture will take five to seven months from the time the machine leaves and returns to your shop floor.

Get It In Writing

Machine tool documentation is a critical element of any machine tool upgrade. The lack of accurate and complete documentation can turn an otherwise good retrofit, rebuild or remanufacture into a disaster when the first problem crops up.

At a minimum, documentation should include high-voltage schematics, all of the input and output diagrams, a complete servo/spindle wiring schematic (including all pin-outs on the plugs), physical machine-view drawings and an operator's manual.

The last piece of documentation may be controversial, so spell it out in the contract. No machine upgrade is complete without a fully cross-referenced ladder or soft-logic diagram. Some OEMs and third-party specialists believe that this is their proprietary information. But you cannot effectively troubleshoot a CNC machine without it.

All of the documentation should be provided in several formats. Insist on a hard copy with a digital backup written in a commonly available format that can be stored, duplicated or reprinted in-house.

Interview the operators and maintenance mechanics to expose any known problems with machine performance before any work is contracted. In the written agreement, spell out the specific performance problems you expect to be eliminated by whatever upgrade is selected.

Competent firms will give you a list of references and offer to show you machines they have upgraded.

And, lastly, be wary of one "R" that seems to get thrown around a lot these days—refurbishment. Many "refurbished" machines have received little more than a bath and a paint job.

About the Author

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