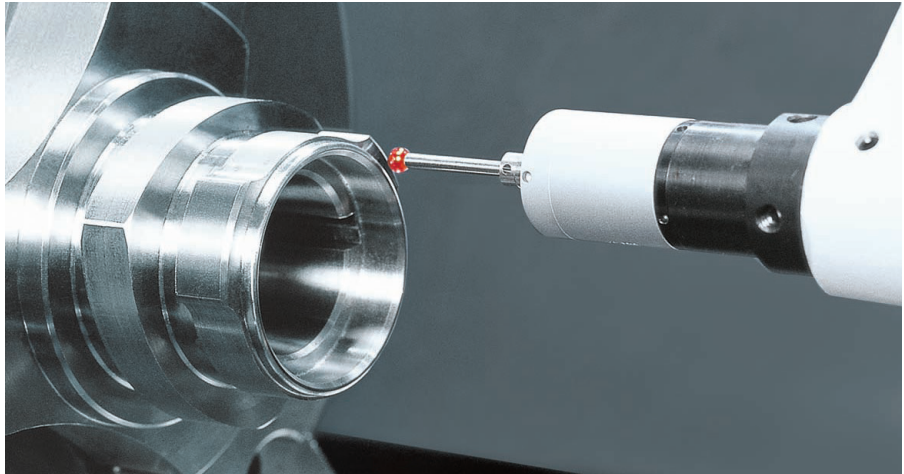


Weighing the Importance of Scales in Machine-Tool Accuracy

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Repeatable machine-tool performance demands consistently accurate results to avoid rework and scrap. Linear scales can make straight-line motion more accurate but can't compensate for machine alignment or structural flaws. However, the inherent accuracy of today's high-quality machines diminishes the value of linear scales. Scales can compensate for many deficiencies, but initial quality, structure, squareness, perpendicularity and parallelism are even more important. Left ignored, other aspects of the machining environment can compromise a modern machine's excellent accuracy. For most shops, the scales-or-no-scales decision isn't as simple as it looks.

ACCURACY AND LONGEVITY

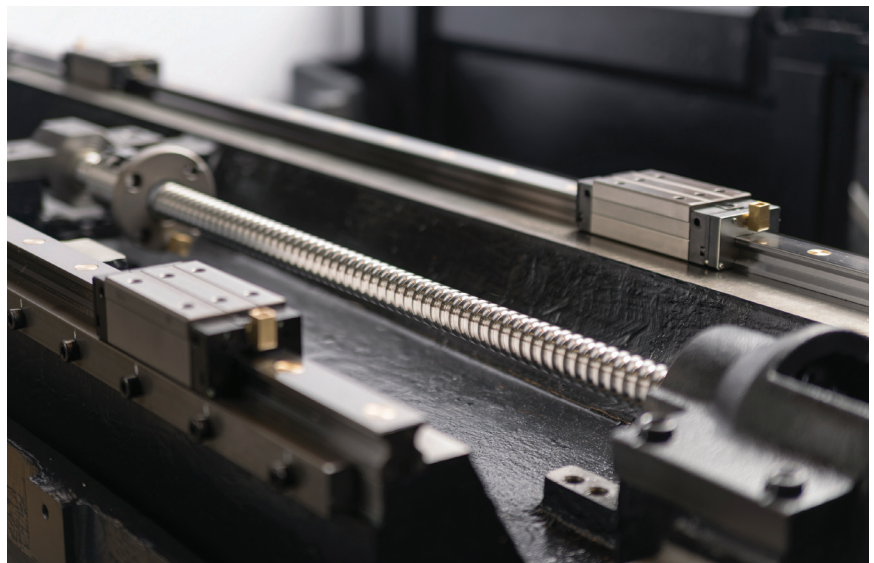
Scales alone do not make a machine more accurate. Historically, shops have rationalized the use of scales to maintain accuracy as a machine ages and its components wear. Scales may not increase accuracy in a new machine, but if a shop intends to keep it

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for 10 or 15 years and work it hard, scales may help sustain accurate output. To produce precise parts, however, nothing substitutes for a fundamentally sound, modern machine that takes advantage of the latest developments in machine design and build quality.

MODERN DESIGNS ACHIEVE PRECISION

Improved construction methods have enhanced machining accuracy. Finite element analysis (FEA), computational fluid dynamics (CFD) and thermal analysis boost rigidity, increase resistance to cutting forces and damp vibration. Ball screw materials and design limit thermal growth. On many machines, linear guides have replaced box ways. Today's machine servos operate at 4 million pulses per revolution, a far cry from past designs with revolutions of 25,000 or 50,000 pulses. Machine builders previously discussed accuracy in terms of thousandths of an inch while today it is in millionths. Compared to the old machines, modern equipment is extremely accurate.



Mazak's MX Hybrid Roller Guide System incorporates a special X-design that efficiently distributes load in four directions — allowing for better force/load distribution across a larger contact area.

POSITIONAL FEEDBACK

In the early days of CNC, a scale/encoder/servo system often compensated for machine-tool variability. Today, many OEMs fit their machines with an active positional feedback system that communicates with the CNC and adjusts machine movement to prevent errors from inconsistent positioning. Adding scales to a machine can improve repeatability specifications, but scales do not improve geometry, control squareness or boost the ability to handle a load.

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For example, machine-tool OEM Mazak offers a machine with 160" of x-axis travel and positioning accuracy of 60 millionths – without scales – and greater accuracy may be elusive or illusory. In fact, Mazak specifications quote equal accuracy for machines with and without scales. The company's high-accuracy package that includes scales also includes other components, such as high-precision linear guides, hand-scraped ways, and thermal cooling in the bed and in the column.

ON THE SHOP FLOOR

Rather than focus entirely on the effect of scales, shops must consider the overall machining system and its environment. Temperature control on the shop floor may have a bigger impact on accuracy than whether a machine uses scales. Exposure to sunlight from a shop window can raise machine temperature by three degrees and cause thermal expansion that compromises accuracy. At the same time, a rigid machine structure, solid shop floor, and the precision of tooling and workholding systems affect the quality of results, as small deviations from tolerances stack up.

Linear scales may improve the performance of a machine that lacks a fundamentally sound structure. Application of rotary scales is more difficult than linear positioning because errors increase with diameter. Measure rotary positioning with a small device, and error increases farther away from the center when part diameter reaches 20", 40", or 100". Five arc seconds of positioning error at one inch from the center may translate to 0.00002", but at 42", it may equal or exceed 0.001".

In the bigger picture, even in a thermally controlled room, scales must be installed properly and insulated from the machine structure to avoid the effects of thermal distortion. Thermal control of other machine components, such as the spindle, also is essential to precision. Spindle growth of 0.0001" will affect part accuracy, even with scales on board.

THE RIGHT INVESTMENT

Cost considerations form part of the decision to purchase or add scales for long-term precision. Shops may find it more cost effective to replace an aging machine's worn ball screws than to equip every new machine with sensors and scales.

As shops evaluate equipment purchases, they must decide whether scales are necessary to meet the needs of their specific applications. Decisionmakers must determine which elements best maximize the machine's accuracy in a shop's workflow and on its specific jobs. They may discover that air conditioning the shop floor makes a better investment than buying scales – or that a rebuilt floor may provide greater stability and more benefit.

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In the long run, shops need modern accuracy and top-quality performance built on a rigid, stable base. Although scales can be beneficial in some instances, shops must consider whether their effects are worth the price. Rather than assume that part precision depends on scales, shops would do better to acquire high-quality machine tools and install them in the right environment. A very small proportion of Mazak sales – perhaps less than one percent – includes scales. This is one OEM that concentrates on building fundamental precision into its machine tools rather than relying on scales to improve performance.

About Mazak

Mazak Corporation is a leader in the design and manufacture of productive machine tool solutions. Committed to being a partner to customers with innovative technology, its world-class facility in Florence, Kentucky, produces over 100 models of turning centers, Multi-Tasking machines and vertical machining centers, including 5-axis models. Continuously investing in manufacturing technology allows the Mazak iSMART™ Factory in Kentucky to be the most advanced and efficient in the industry, providing high-quality and reliable products. Mazak maintains eight Technology Centers across North America to provide local hands-on applications, service and sales support to customers.