



Machining

The Ultimate Accuracy: Manufacturing With High-Performance Machine Tools

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Higher productivity keeps shops profitable, but higher accuracy has made humanity richer. Since the *first all-metal lathe* was developed in the 1750s, increasing levels of accuracy have enabled incredible technological advancements, from the Industrial Revolution to the Information Age. The modern metalcutting shop routinely deals with tolerances well below a thousandth of an inch, and in the most demanding industries, the acceptable deviation can be measured in microns.

High-end machine tools now come packed full of features that allow them to remain accurate and precise, even during jobs that take dozens of hours to complete. Here are some of the factors that make these machines so accurate – as well as steps you can take to ensure you're achieving the highest accuracy possible with your equipment.

Thermal Stability

Friction creates heat, and heat is the enemy of accuracy. Effective metalcutting usually requires managing heat at the tool tip, but with 5-axis movement, multiple spindles and other features common in modern machine tools, the increased numbers of linear and rotational axes mean more opportunities for heat generation. Most manufacturers used to manage this with climate-controlled facilities, but today's high-end machine tools usually feature ball screw core cooling and other active internal coolant methods to keep processes thermally stable. Even older machines can often be retrofitted with coolant chillers, a simple but effective way to better manage heat.

Vibration Damping

Temperature is not the only factor that must be kept stable for truly outstanding accuracy. Even slight vibrations can cause chattering and inaccurate positioning, which means effective damping is critical. Vibration damping isn't a new concept, of course – cast-iron machine bases and solid constructions have been the norm for years. But machine tool OEMs have taken it much further in recent years. Advanced synthetic materials for bases and more symmetrical machine designs are only the beginning; the latest machines use machine learning algorithms to adjust performance in real time to compensate for vibrations.

Positioning and Metrology

All of these advanced systems are dedicated to a single factor: making sure the tool tip is exactly where it needs to be to make chips. In the past, confirming accurate tool positioning required exhaustive measurements of both the machine and the workpiece. Touch probes, optical sensors and other metrology innovations have simplified that process considerably, and modern controls often automate most of this process for even greater ease of use. However, the potential for human error remains – unless shops opt for robotic part loaders/unloaders or palletized systems, which makes perfect repeatability far easier to achieve.

Installation & Maintenance

None of these factors matter if the machine wasn't installed correctly in the first place – and it won't be accurate for very long if it's not effectively maintained. Naturally, partnering with your machine tool OEM is the best way to ensure a machine is correctly installed, but keeping up with scheduled maintenance is often on the end user. This process has gotten much easier with the advent of machine connectivity and monitoring technology, which can often provide real-time feedback on machine performance so that potential problems can be fixed before they cause unexpected downtime.

Tools & Toolholding

Naturally, a high-performance machine tool with all the bells and whistles will still fail to provide good results if the tooling can't keep up. Many shops can thrive with more universal tooling, but for the highest level of accuracy, inserts, mills, drills and other tools should be optimized for each given application and material. And naturally, the connection between the tool and the spindle is key – which is why many manufacturers choose powRgrip, a hydraulic toolholding system that delivers $<0.0001\text{E}$ ($\leq 3\text{ }\mu\text{m}$) TIR for a guaranteed 20,000 cycles.

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