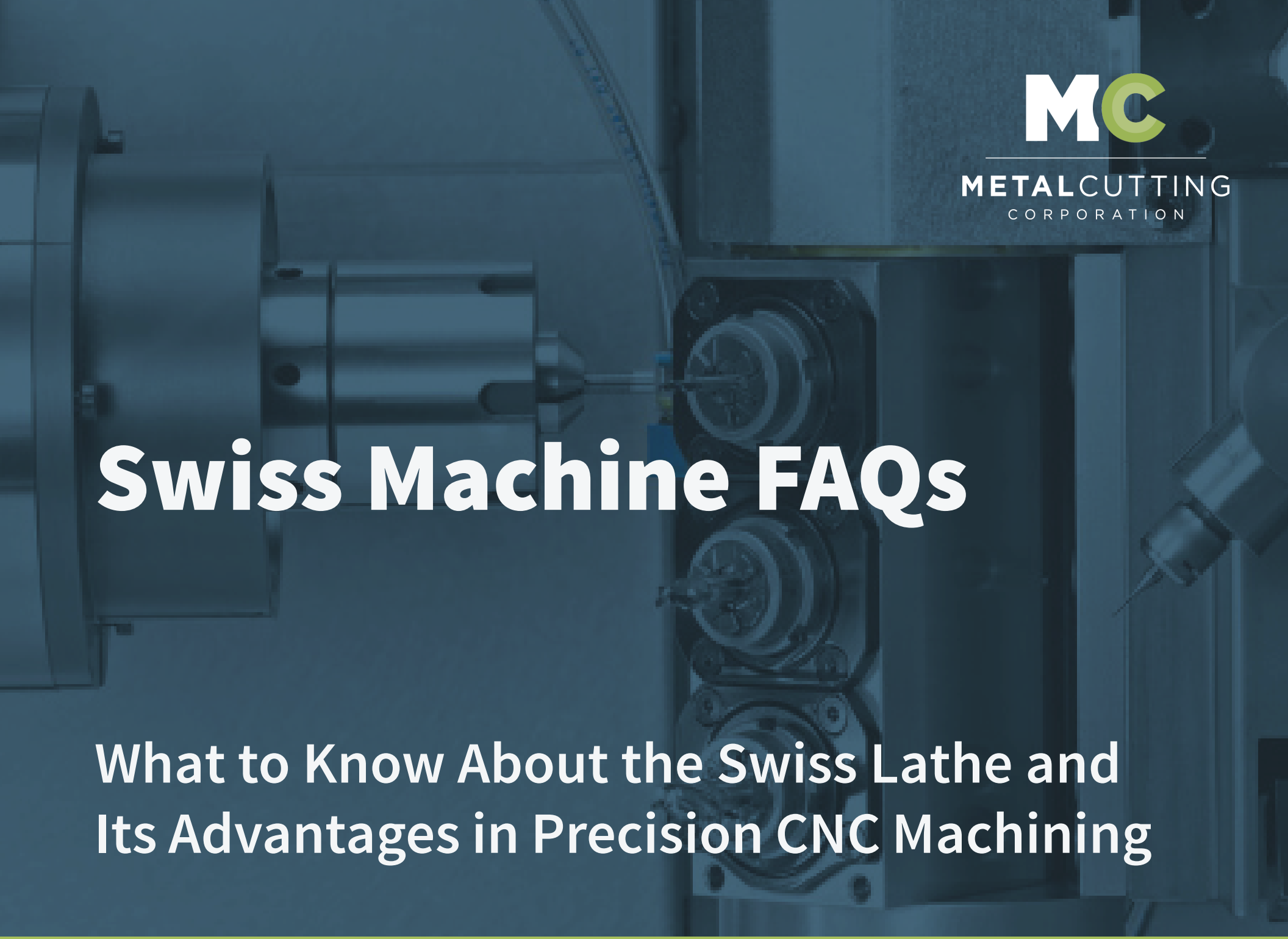

METALCUTTING CORPORATION

Swiss Machine FAQs

What to Know About the Swiss Lathe and Its Advantages in Precision CNC Machining

Like many manufacturers, you may be looking to improve part quality for a difficult geometry, reduce production time and cost, and decrease time to market. In your efforts to achieve these goals, you've probably come across a Swiss machine at some point.

But, have you thought about how having a partner with capabilities in the Swiss screw machine could help you meet your goals? Do you know how it might benefit your process and your bottom line? Or if it could consistently improve part quality?

Here, we'll explore many of the capabilities of the Swiss machine by answering some of the most frequently asked questions:

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Why is it called a “Swiss” machine and what does it have to do with screws?

The Swiss screw machine has its origins in the Swiss watch industry, where the ability to turn tiny, long, thin, intricate parts — mostly watch screws (hence the term “Swiss screw”) — with relative speed and high accuracy was invaluable to production.

At the crest of the Industrial Revolution, a competitive watchmaker had to produce not only exceptional quality, but also a large quantity. So, a certain amount of automation was the key to success.

Although today’s machines may have far surpassed the level that made Swiss watches famous, the same basic concepts continue to be a vital part of the industrial landscape.

How has the Swiss screw machine evolved?

Today, an automatic Swiss machine would be unrecognizable to early nineteenth century watchmakers. Their Swiss lathes used a disc cam to rotate tooling to a workpiece, which was held in place by a collet and supported by a guide bushing. Disc cams moved the tools in a radial motion while simultaneously altering the headstock position.

In recent years, Swiss machines have quickly become a must-have piece of value-added equipment for many component manufacturers. Why? Unlike older lathes, these newer Swiss machines provide manufacturers with an invaluable competitive edge, through:

- An ever-increasing array of tooling capabilities
- Improvements in servo communication, motion, and speed
- The virtual elimination of secondary operations

In the 1970s, Swiss machines were vastly improved by replacing cams with computer numerical control (CNC), allowing for the automated control of machining tools. Precision CNC machining (Swiss or otherwise) uses coded programming instructions to process a workpiece to specifications without intervention by a manual machine operator.

With the addition of CNC, Swiss machine tooling areas began to include turrets, gang slides, and secondary spindles, improving speed and accuracy. When parts are rotating at a speed of up to 15,000 RPM with live tooling up to 10,000 RPM and tolerances anywhere between ±0.0002” (±0.00508 mm) and ±0.0005” (±0.0127 mm), Swiss machines can support high volume requirements with just a single skilled machinist.

That translates to more parts in less time at a competitive price.

Since then, continuing improvements in servo motors and controls, as well as the use of high-pressure coolants, have made Swiss machines a permanent fixture across industries that have high precision, speed, and torque requirements.

In particular, the machines are valuable to the medical device, aerospace, and electronics markets, where exceptional tolerances, difficult geometries, and exotic metals and alloys are common.

What are the advantages of using a CNC Swiss machine?

The Swiss machine was designed to achieve tight tolerances while improving the repeatability and quality of production components. The method leverages attributes such as a bar stock feeder, guide bushing, and second spindle to deliver advantages including:

- Increased productivity, which translates to lower cost per piece and less time to fabricate
- Reduced setup and tool change time, which shortens production time on repeat orders and decreases long-term cost per part
- Improved uptime resulting from improvements in programming and bar feeding, which allow a machine to run unattended — perhaps even on a lights out schedule
- Lower tooling costs, which effectively reduce production costs

What unique characteristics of a Swiss machine contribute to its advantages?

In CNC Swiss machining, bar stock is fed through a chucking collet, where the headstock clamps on to it. The bar is located by a guide bushing and then emerges into the tool zone.

Unlike a conventional lathe, where the headstock remains stationary, the headstock of the Swiss lathe moves along the Z axis. The motion of the bar acts as the feed for material removal.

The brilliance of the Swiss method is this eliminates deflection, because the bar stock is never in a cantilevered position and all the stock removal occurs immediately at the exit of the collet.

This architecture and process, along with a robust set of turning tools, produces many of the advantages of Swiss screw machining. For example:

- Because the Swiss machine fabricates parts by moving the material and tool simultaneously, uptime is increased and tool wear rates are reduced.
- The close geometry of the machine — which allows the tool to work within millimeters of the workpiece — reduces chip-to-chip time to a second or less.

Another significant improvement in the industry has been the design of CNC Swiss machines that can accommodate 20 or more tools in the tool zone, many with live tooling.

This array of tools combined with a sub-spindle and backworking stations can virtually eliminate the need for secondary operations on complex parts — allowing Swiss screw machines to often produce finished, ready-to-ship components.

How does a Swiss machine ensure quality and precision in the final product?

Because a workpiece that is subjected to force will deflect, most cutting machines (such as lathes) must make several slow passes to remove material. Conventional wisdom would suggest that the more passes, the greater the margin of error, particularly over long lengths (generally, diameter ratios greater than 3:1).

This would have been an especially big concern for those old-time Swiss watchmakers, who needed to turn long, thin parts. It isn't surprising, then, that the chucking collet, which provides stability to the workpiece, was patented in the 1870s and is still part of Swiss machines.

Today, the efficiency and accuracy of the modern Swiss screw machine greatly depends on the guide bushing, which provides rigidity to the material by supporting it close to the tool.

This effectively reduces deflection to zero, which means the cutting tool can make one deep pass rather than several shallow ones — reducing tool wear rates and making for more consistency and accuracy.

TYPES OF GUIDE BUSHINGS

There are two types of guide bushings:

- **Rotary Guide Bushings**, which are best used when turning wider parts, with tolerances greater than ±0.0005", rotate simultaneously with the workpiece.
- **Fixed Guide Bushings**, which remain static while bar stock spins, are best if tighter tolerances are required.

Additionally, high precision guide bushings are available for difficult materials or tough tolerances.

Coaxiality, which is a measure of concentricity of multiple diameters along a theoretical axis, is used to indicate guide bushing accuracy. To be able to consistently hold micron tolerances over time, guide bushings should have a coaxiality of 0.0002".

OPTIMIZING THE GUIDE BUSHING

The guide bushing alone is not enough to ensure perfect parts. (In fact, a worn bushing can actually result in inaccuracies.) Ensuring dimensional accuracy also requires proper configuration, adjustment, and monitoring.

However, there is no doubt that the guide bushing is a remarkable development. It solves the age-old lathe collet problem of insufficient land, which is the inside portion of the collet that holds the workpiece.

Typically, the land on lathe machines can be fairly short (less than an inch). The brilliance of Swiss machining — the guide bushing's ability to project and retract the workpiece — maximizes the short land.

Segmentation is one of the key strategies to take full advantage of the benefits of a guide bushing. This strategy is employed when the work being done to the part along its length would prevent the land from holding the part correctly.

The most common example is when the diameter is turned along a section of the part and when retracted, the guide bushing is now the wrong size relative to original bar stock diameter.

Segmentation solves that problem by dividing the part into sectors and programming the correct sequence. This strategy solves the guide bushing inside diameter issue with now-smaller material while ensuring that the land is never used to hold excessive projected length, to prevent deflection from occurring.

How does a Swiss screw machine save time?

Reducing production time on a Swiss machine depends on the machine design, which is driven by part size — particularly diameter — design, and volume, as well as commercial demands.

The vast majority of modern Swiss-style automatic lathes are sold with a maximum diameter as their most important defining specification. In fact, this maximum diameter is almost always embedded in a lathe's model name.

Job shops of all sizes purchase machines with the first consideration being the diameter envelope in which they will be working. Using the right size machine will save the most time once production begins.

VARIANTS FOR SPECIALIZED USES

Before describing the typical machine variables and opportunities for efficiency, it is worth highlighting two variants that, when appropriate, will be true time-savers.

The first is a small subset of machines designed to produce small runs of complex parts. These machines tend to be larger than one might normally consider if driven only by part diameter. However, in certain limited circumstances the larger work envelope permits gang slides and turrets to be outfitted with arrays of tools that, once started, will run several different jobs in succession.

This is not a common scenario, but when it is beneficial, these larger machines consolidate setup and eliminate retooling once the sequence commences.

The other variant is purpose-built, compact custom Swiss machines that are deployed when there is a demand for very small diameter part sizes that are produced in the tens of millions. For these parts, the normal bar stock starting diameter would represent a huge waste of time and money when being turned down to the final diameter in such quantities.

With these specialty machines, changeover is not an issue because their entire production may only be one part design. Although useless for a versatile job shop, these machines do enjoy efficiency advantages such as non-cutting tool travel time, known as rapid, reduced to the barest minimum.

In addition, the live area is typically constructed to be extremely limited, with room only for the tools needed for a repetitive task and no more. These compact machines can outperform their more sophisticated rivals, but only because they are trading away flexibility for the sole purpose of producing certain limited geometries.

TWO TYPES OF BAR FEED SYSTEMS

Another feature of the Swiss-style machine that can save time is the bar feed system. Generally, there are two types of material delivery systems, each engineered to support specific volume requirements and part complexities.

Hydrostatic bar feed systems: Here, the stock sits in a series of plastic channels, which close around the stock and hold it in place. Typically, oil is then pumped into the closed guide channel to provide stability while the independent servo motor-controlled feed mechanism advances the material during the turning operation. Hydrostatic systems generally have a 12' (3.66 m) stock capacity, which is automatically reloaded in a magazine-style system.

Hydrodynamic bar feed systems: These systems hold the bar stock in a feed tube, which is then surrounded by pressurized flowing oil. The oil not only provides a hydrodynamic wedge, centering the bar stock in the tube, but also acts as a noise dampener and the force on the piston that advances the stock. These systems require manual reloading of one bar stock at a time.

HYDROSTATIC VS. HYDRODYNAMIC BAR FEEDING FOR SWISS TURNING

When considering a manufacturing partner with Swiss turning capabilities, be mindful that the partner's feed system can have a significant impact on your bottom line, depending on your volume requirements, part length, and cycle time. However, some general guidelines are as follows:

- For high volume runs (e.g., thousands of parts or more), less complex geometries, or common materials, a hydrostatic bar feed system is best.
- Smaller runs, R&D work, or difficult materials requiring longer cycle times are better suited to a hydrodynamic system, where an operator is present to manage manual reloading.

An additional advantage of a hydrodynamic bar feed system is increased bar stock stability resulting from the tight diameter of the feed tube. This added rigidity is especially beneficial because many single spindle machines run at higher than average RPM, allowing operators to maximize the machines' uptime.

SPECIALIZED TOOLS FOR MICRO APPLICATIONS

In the past, it was difficult to find readily available tools for micro applications. That has now changed, largely in response to the competitive demands of the medical device market and the need to turn smaller, limited run parts.

Today, toolmakers are able to supply multiple-use tools that not only eliminate the need for secondary operations, but sometimes can complete an entire part in a single setup. Main spindles and sub-spindles operating simultaneously, combined with an array of standard tooling and fairly accessible specialized tools, can mean a significant reduction in time to market for many applications.

How does a Swiss machine save money on component fabrication?

The growth of the Swiss screw machine was driven by profitability. Today, it continues to provide innumerable benefits related to time savings and labor reduction for the manufacturer, which ultimately translate to cost savings for the end user.

USE OF AUTOMATION

Automation is an obvious contributor to cost savings, because it reduces setup costs, machine downtime, and labor costs. It also reduces production run times by combining operations into a single setup or leveraging gang slides and turrets to run several limited production parts consecutively.

DECREASE IN LABOR COSTS

With CNC, a single operator can run multiple Swiss lathes at once. Additionally, with the right setup, the machines can often be programmed to run unattended on a lights out schedule.

ELIMINATION OF SECONDARY OPERATIONS

Live tooling on sub-spindles enables multiple machining operations on one machine, which reduces overall machining costs on complex parts. With the ability to mill, drill, thread, polish, and more, Swiss machines are capable of completing and dropping parts that are ready to ship.

HIGH QUALITY

Components that are reliably turned to specifications reduce costs related to returned parts, such as shipment and restocking expenses as well as delayed lead time and retooling costs.

REDUCTION OF SCRAP

Swiss machines typically leave a 6” to 12” (152.4 mm to 304.8 mm) remnant, which can be costly, especially if the material is a precious metal. However, smart manufacturers find ways to reuse the scrap or weld a piece of inexpensive stock to the end of the high-value material, rendering the entire length of the material usable.

Additionally, knowledgeable CNC programming exploits the full range of a machine’s capabilities and leverages its efficiency to reduce waste.

What industries and applications benefit from parts fabricated by a Swiss screw machine?

Accuracy, quick production times, and a reduction in variable costs have made Swiss machining the process of choice for a variety of industries and their applications. Industries that require high precision metal machining include aerospace, defense, electronics, medical devices, and automotive. The following is an overview of these industries and some of their relevant applications.

AEROSPACE

Precision machined components are critical for safe and secure operation of aerospace equipment and engines. Swiss screw machines are utilized in the fabrication of various mechanical parts for airplane and spacecraft motors, wings, and wheels, as well as in the manufacture of electrical components for cockpit controls.

Swiss machining ensures that the products meet the aerospace industry's rigorous demands, which include ultra-tight tolerances and exceptional finishes. Common materials typically include titanium, aluminum, and stainless steel.

DEFENSE

The exceptional accuracy of Swiss machines makes them well suited for the complex geometries required for parts used in defense helicopters, tanks, missiles, ships, and aircraft, where proper end-use functionality is a must. The precision of Mil-Spec parts is easily handled on a Swiss screw machine.

Swiss machining can be applied for a range of materials commonly used in defense manufacturing, including brass, copper, titanium, stainless steel and even some plastics. These materials become tight tolerance parts for applications where there is no room for error.

ELECTRONICS

Consumer electronics products have components that require the exacting tolerances and intricate forming that Swiss machining offers. Here, precise machining is needed for components such as fine threaded screws, lens housings, mounts, and connectors.

In addition, the sophisticated equipment used to manufacture semiconductor-based devices also benefits from Swiss machining methods for critical components used to make electronic panels, printed circuit boards, controls, and interfaces.

As computers, phones, tablets, and other consumer electronics continue to become more compact and intricate, Swiss screw machines will continue to provide tight tolerances, precision, higher quality, and smooth finishes.

MEDICAL DEVICES

A growing demand for more precision, tighter tolerances, and smaller components has made Swiss machining a top-of-mind process for the medical sector.

Precision machining processes are well suited for minimally invasive catheter components such as complex hinges, pull rings, anchors, and electrodes, as well as components for a wide range of medical instruments and devices in the diagnostic, surgical, and drug delivery fields.

AUTOMOTIVE

The automotive industry uses Swiss screw capabilities to produce bushings, fuel-injection components, shafts, housings, pins, suspension components, brake system components, and timing covers. The Swiss machine operation provides automotive OEMs with reliably accurate parts.

What should I look for in a CNC Swiss machining partner?

When considering a contract partner offering Swiss machining for your precision parts manufacturing, look for the characteristics and capabilities like those demonstrated by Metal Cutting Corporation.

YEARS OF EXPERIENCE

Metal Cutting's experience in precision metal fabrication dates back to 1967. Since then, our expert machinists have been providing burr-free abrasive cutoff and manufacturing precision parts for every market segment requiring tight tolerances.

IMPRESSIVE ARRAY OF EQUIPMENT

Metal Cutting's expanding CNC Swiss machining equipment includes Citizen K16E and Citizen L12 with LFV (low frequency vibration) machines. These technologies along with our critical measuring equipment, capabilities, and skills allow us to offer the highest levels of precision machining — representing our determination to provide customers with a solution for exceptionally accurate, specialized components.

FULL RANGE OF CNC MACHINING PROCESSES

Our Swiss screw machines, including Citizen K16E and Citizen L12 with LFV machines, offer turning and milling capabilities including (but not limited to) the following:

- Drilling
- Threading (both internal and external, or ID and OD)
- Slotting
- Boring
- Polygon machining
- Broaching
- Deburring

VERSATILE EQUIPMENT CAPABILITIES

At Metal Cutting, our multi-axis machining offers up to 7-axis capabilities and uses Autodesk Partmaker software, allowing us to create very complicated geometries.

We can provide very close tolerances and achieve turned surface finishes of 16 Ra inch and better. We also achieve secondary polishing capabilities to less than 1 Ra inch measured by our in-house profilometers and optical interferometry machines.

FLEXIBILITY IN MATERIAL SELECTION

Metal Cutting can process both customer-supplied and internally sourced materials. We partner with an extensive network of raw material mills that can provide the right materials for the needs of each project.

PRECISE PART SIZES AND LENGTHS

Metal Cutting is able to produce part sizes from 0.625” (15.875 mm) down to 0.030” (0.762 mm) and part lengths from 0.030” (0.762 mm) and up.

Where can I learn more about Swiss machine capabilities?

Metal Cutting Corporation is committed to providing customers with a vertically integrated solution for Swiss machining and all of their precision CNC machining needs.

For more information, please contact a sales representative at **800.783.6382** or **973.239.1100** — or send your questions to **sales@metalcutting.com**. Or to learn more about Metal Cutting's Swiss machining capabilities or request a quote, visit our website at **www.metalcutting.com**.

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