What to look for in an Aerospace CNC Job Shop

PROTOMATIC

Life-saving precision.

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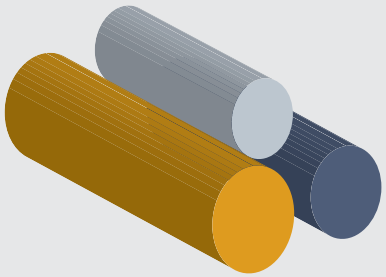
The changing demands in the aerospace industry have prompted CNC machine shops to quickly evolve their processes and equipment, while maintaining flight-critical performance in the components they produce. No longer can a shop be content to simply machine and ship components. They must now concern themselves with the lifetime performance of the component if they are serious about aerospace work.

Due to extreme market pressure on pricing, batch sizes have been cut in the transition to JIT production; some firms have gone so far as to adapt a "design and integration" model in which they rely on suppliers to engineer the process to produce the parts. The expectations put on CNC job shops continue to grow, and it is more vital than ever that the shop you work with is up to the task.

In this eBook, you will get some examples and some questions to ask when selecting a CNC shop for your next project. So, let's get started.



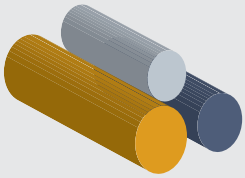
Is the job shop familiar with a range of materials?

It is important that the shop is experienced with the machining and properties of a variety of engineered materials. Machining of elemental materials like refractory alloys such as Tungsten and Niobium, and super alloys such as Inconel and Monel requires different approaches to machining, tools and equipment compared to softer materials.

Beyond those more exotic materials, look for expertise in aluminum (A356, 2024, 6061, 7075), stainless steels (17-4PH, 15-5PH, 13-8MO), titanium and titanium alloy grades like Ti 6AL-4V.

Plastics create other challenges, where techniques and equipment are equally demanding. Plastics do not transfer energy into cutting chip the same as metals, so experience with Ultem™, PEEK, Noryl™, Teflon™, Delrin™, Rulon™, Torlon™ and of course, foams, rubbers and composites is important. Processing and finishing requirements are also more stringent on many of these materials.

Is the job shop familiar with a range of materials? *Cont'd*



Process operations like heat treat, Type III hard coat anodize, Type II anodization, passivation, plating, and paint can change finish dimensions or create problems like hydrogen embrittlement if not understood.

If the shop doesn't have experience engineering a variety of materials, you may want to consider another source. Protomatic has the ability to confirm material alloys with an X-Ray Florescence (XRF) instrument upon receipt or helping in reverse engineering tasks.

Materials and parts that require more testing are welcome and common. That includes third-party testing for: ultrasonic metal, coefficient of thermal expansion, chemicals and physical strength.

Does the shop depend on intuition or technology?

New alloys call for a different kind of expertise than what has worked historically. Previously, when machinists undertook a new machining operation, they could actually listen to it. Audio feedback came from carefully listening to the excitation frequency — the rpm of the cutting tool and how it responded.

What was being heard and interpreted were the various harmonics of the cutting tool, part vibration, machine vibration, and tool vibration. The cutting sound told machinists when they were at the correct or incorrect cutting speed. They would then adjust their speeds or feeds to remove the harmonic until it was running smoothly.

The problem moving forward is that the horsepower and RPMs of machine tools are increasing. Machines have moved from 4,000 RPM in the 1980s to 12,000-120,000 RPM currently. This means that the relevant sounds may be outside the sound spectrum of human hearing.

Does the shop depend on intuition or technology? *Cont'd*

That's why progressive shops are now using a frequency-analyzer system that determines and analyzes where the harmonics are occurring. This type of software performs Fourier transform and produces Bode Plots of the audio spectrum to recommend safe machining rates for optimal machine performance and material removal.

Technology is indeed making decisions that the machinist used to make, and doing it much faster and more accurately. Check to see that your shop is using the latest technologies to optimize material removal performance.

Are the best cutting tools being used?

Cutting tools have improved dramatically in the last two decades. To ensure precision in consistent production of parts requires improved technology. Look for suppliers that understand cutting tools and the importance of improved cutting tool geometry.

Tough substrates (carbide), durable coatings, and superior grinding and edge prep are critical to providing smooth machining finishes.

For Class-A surface parts, smooth finishes provide better looking parts; require less finishing work; provide more consistent parts due to less tool wear; and lower the cost of parts due to increased tool life. (Although the cost of the perishable tools may be higher initially, the overall cost is typically lower.)

For demanding materials such as Inconel 718, a tough nickel-chrome-iron-niobium alloy used in aerospace high strength, high temperature applications, we recommend 5+-flute carbide, helical-style cutting geometry with special tool holders.

Are the best cutting tools being used? *Cont'd*

Not only is the geometry of the tool's cutting edge important, but also the tool holder behind it. When machining deep pockets, the tool needs to be kept as short as possible for rigidity and to minimize vibration. It is typically better to machine part of the way down with a shorter tool, and then switch to a longer tool to complete the pocket. This increases tool life, which ultimately affects the part cost to the customer.

Bottom line? Make sure your CNC machine shop is using the best tools and applying the best practices for the available tools.

Are the tools taking the best path?

Along with the best tools, your shop also needs to be using the best toolpath software. Protomatic uses Computer Aided Machining (CAM) toolpath-generating and optimizing software programs such as Volumill™ from Celeritive Technologies, and Truemill™ or MTM™ from Vero/Hexagon.

These programs keep the tool engaged with the material at all times, so there's no wasted motion. Many tool paths "machine air" for a significant percentage of time, slowing the overall run time, unnecessarily increasing product cost.

It is equally important that a carbide tool is engaged continuously, because carbide is brittle and doesn't like to be shocked. If the carbide tool is shocked, the vibration may create tool fracture or tool chipping, resulting in a broken tool and manufacturing an unusable part.

Although there are many tool paths for a machinist to choose from, experience of what path works the best is most beneficial. Sometimes, the fastest removal can add heat or stress and warp parts, adding more work, so experience and CAM simulation time studies are most beneficial.

Does the shop use diamond or ceramic tool coatings?

Advanced aerospace CNC machine shops are using ceramic tools to cut the hard and high-temperature nickel-based superalloys that allow aerospace engine components to run at high temperatures. Ceramic tools offer an advantage to job shops that are tasked with cutting them.

Amorphous diamond-coated tools are brittle and cannot take the shock of superalloys. But they are successfully used to cut softer materials like aluminum and plastics. They work best for abrasive materials like glass-filled plastics that require a consistent cutting edge.

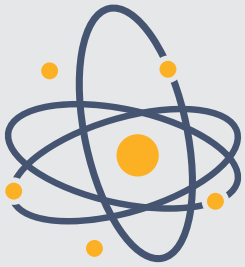
Uncoated tools are still used and have applications where sharp cutters are required, typically for aluminum and virgin plastics.

What techniques are used to keep the cutting edge cool?

When machining at the tool performance limits with high-temperature alloys (Ti, Nickel, Tungsten, etc.), tool wear is critical.

When tools become dull, the localized cutting area can create heat buildup and result in work-hardening the machined area. This super hard area can become difficult to re-machine. The conventional solution is to check coolant concentration, change the coolant, or add a coolant lubricity additive. These techniques should always be done first, but other solutions are possible.

One solution is the use of a free-cutting tool. The one chosen by Protomatic exerts less pressure on the part being cut and puts more of the heat into the chip instead of the tool or material, significantly increasing tool life.



Can the job shop adjust to changing material requirements?

Moving from relatively easy-to-machine grades of aluminum and steel to high-strength, high-temperature alloys is a major adjustment that many aerospace CNC machine shops have had to make. An equally big move has been from metals to composites.

Military projects, such as the F-35 Lightning™, and commercial ones, such as the Boeing 787™, are known for their use of carbon composites.

In their wake, more components than ever are being made for a variety of aero platforms — and leading CNC machine shops have stepped up and adapted to a new way of processing parts. These new materials require different methods and tools to machine parts.

Can it handle aerospace component prototype development?

Some shops, such as Protomatic, go beyond the machining process with design and prototype development services.

For instance, Protomatic's highly advanced CAD and CAM software allows for the creation of custom aerospace components. Each part of the proposed project is researched and investigated, tested and inspected. As the device is developed, it is checked against aerospace standards, and the most efficient production process (PFEMA) will be utilized in machining the prototype.

Not every CNC machine shop is fully capable of prototyping and manufacture for production, so be sure to check experience and resources before trusting them to bring your idea to life.

Is it registered?

It's one thing to talk about leadership and expertise in aerospace prototyping and machining, and another to prove it. Protomatic is proud to have earned the following certifications and awards:

- AS9100D:2016
- ISO-9001:2015
- ISO-13485:2016
- Michigan Manufacturing Center — Certificate of Recognition

This is where ideas take flight.

Protomatic is the CNC contract manufacturer with the people, equipment and technology it takes to develop precision aerospace components that can save lives. We know that our aerospace CNC machining results in parts that are mission critical. We take personal ownership in every project.

Turning ideas into reality has always been our cornerstone. Whether we are manufacturing a component or going from a concept to electronic design, to CAD and CAM files that lead to manufacture, you'll get the same standard of quality of "Life-Saving Precision."

For an introductory discussion, please contact our Vice President and Managing Director, Doug Wetzel.

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