

From 6061 to 7075: How to Select Aluminum Alloys for CNC Machining

By GEMS-MFG Team

I. Introduction

Aluminum is one of the most widely used materials in CNC machining — and for good reason. It's lightweight, strong, corrosion-resistant, and highly machinable, making it ideal for everything from aerospace components to consumer electronics and medical housings.

But not all aluminum is created equal. With a wide range of aluminum alloys available, each with its own strengths, weaknesses, and ideal applications, selecting the right grade can be the difference between a successful product and costly redesigns. Two of the most recognized alloys in CNC machining — 6061 and 7075 — serve as perfect examples of how varied aluminum performance can be, especially when precision, strength, or surface quality is at stake.

In this article, we'll guide you through the key aluminum alloys used in CNC machining, how to evaluate their properties, and what factors to consider when choosing the best alloy for your project. Whether you're prototyping or scaling into production, understanding aluminum alloys is critical to achieving optimal results.



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II. Why Aluminum Is Ideal for CNC Machining

Aluminum is a go-to material in the CNC machining world, offering a rare combination of performance, efficiency, and versatility. Its material characteristics are highly compatible with precision machining processes, making it suitable for prototyping, functional components, and mass production.

Here's why aluminum stands out:

Excellent Machinability

Aluminum cuts quickly and cleanly, reducing tool wear and shortening cycle times. Its chips evacuate easily, and it responds well to high-speed machining, making it one of the most efficient materials for CNC milling and turning.

✓ High Strength-to-Weight Ratio

Aluminum offers impressive mechanical strength without the bulk. Alloys like 7075 can rival steel in tensile strength while weighing significantly less, making them ideal for aerospace and performance-critical components.

Corrosion Resistance

Many aluminum alloys form a natural oxide layer that resists corrosion. This makes aluminum a reliable choice for outdoor or marine applications, especially when paired with surface treatments like anodizing.

Thermal and Electrical Conductivity

Aluminum alloys conduct heat and electricity better than most metals, which is essential for heat sinks, housings, and electronic enclosures. CNC machining allows tight control over thermal-critical dimensions in these parts.

Good Surface Finish Options

Aluminum machines to a clean, bright finish. It can be easily anodized, painted, polished, or chemically treated to improve appearance, wear resistance, or performance.

Recyclability and Sustainability

Aluminum is 100% recyclable without degradation. This supports sustainability initiatives while also helping companies reduce material costs in large production runs.

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III. The Most Common Aluminum Alloys in CNC Machining

Aluminum alloys vary widely in strength, corrosion resistance, and machinability. Selecting the right grade depends on your part's function, structural demands, and finish requirements. Below is a comparative overview of the most commonly used aluminum alloys in CNC machining:

Alloy	Strength	Corrosion Resistance	Machinability	Heat Treatable	Typical Applications
2007	High	Fair	Excellent	Yes	Automotive parts, precision fasteners, mechanical components
2024	High	Low	Fair	Yes	Aircraft structures, fatigue-loaded components
5052	Medium	Excellent	Fair	No	Marine hardware, fuel tanks, enclosures
5083	High	Excellent	Poor	No	Shipbuilding, structural panels, cryogenic tanks
5754	Medium	Excellent	Good	No	Automotive parts, food processing equipment, welded assemblies
6060	Medium	Good	Good	Yes	Architectural components, piping, lightweight structures
6061	Medium	Good	Excellent	Yes	General-purpose parts, enclosures, jigs, brackets
6063	Medium- Low	Good	Good	Yes	Extruded parts, frames, window profiles
6082	Medium- High	Good	Good	Yes	Structural components, transportation equipment
7075	Very High	Fair	Good	Yes	Aerospace fittings, performance parts, high- stress parts



Special Highlights:

- **2007** is a free-machining alloy with **very high strength** and **excellent surface finish**, ideal for intricate turned parts.
- 2024 offers great fatigue resistance, but requires protective coatings for corrosion-sensitive applications.
- **5052, 5083, and 5754** are **non-heat-treatable**, corrosion-resistant alloys excellent choices for marine, chemical, or food-contact environments.
- 6060, 6061, 6063, and 6082 are part of the 6xxx series, offering a good mix of strength, corrosion resistance, and machinability often selected for structural and general-purpose parts.
- **7075** delivers **exceptional strength-to-weight ratio**, making it ideal for aerospace and high-performance engineering.

IV. Key Selection Criteria for Aluminum Alloys in CNC Machining

Choosing the right aluminum alloy for your CNC machining project involves balancing performance, cost, and application-specific requirements. Below are the most important criteria to guide material selection:

🗱 1. Mechanical Strength

- When strength is critical, such as in structural components or aerospace applications, 7075, 2024, or
 5083 are top choices.
- For general-purpose applications where moderate strength is acceptable, **6061**, **6082**, and **5754** are more than sufficient.

2. Corrosion Resistance

- Alloys like **5052**, **5083**, and **5754** provide **excellent corrosion resistance**, ideal for **marine**, **chemical**, **or food-grade environments**.
- 7075 and 2024 offer less corrosion resistance and typically require protective finishes such as anodizing or painting.

3. Machinability



- 2007 and 6061 are among the **best for CNC machining**, delivering smooth surface finishes and reduced tool wear.
- Alloys like **5083** and **2024** are harder to machine and may require specialized tools or slower feed rates.

👌 4. Heat Treatability

- If post-machining heat treatment is required to enhance mechanical properties, focus on heat-treatable alloys like 6061, 6082, 2024, and 7075.
- Alloys such as **5052** and **5754** are **non-heat-treatable** and depend solely on cold working for strength.

🮯 5. Weldability

- Alloys such as 5052, 5083, 5754, and 6061 are highly weldable.
- 2024 and 7075 are not suitable for welding due to cracking risk and poor joint strength.

5 6. Cost and Availability

- **6061** and **5052** are **widely available and cost-effective**, making them go-to options for prototyping and mass production.
- 7075 and 2007 are more expensive but justified for high-performance needs.

7. Surface Finish Requirements

- Alloys in the 6xxx series (6060, 6061, 6063) offer excellent surface finishes and are ideal for anodizing.
- **2007** provides an outstanding surface finish directly off the machine, useful for tight-tolerance and cosmetic parts.

V. Surface Finish and Anodizing Behavior by Alloy

Surface finishing is a critical step in CNC aluminum part production, especially when aesthetics, corrosion resistance, or wear protection are important. Among the many finishing options available—such as polishing, brushing, bead blasting, or powder coating—**anodizing** is by far the most popular for aluminum alloys. However, not all aluminum alloys respond the same way to anodizing, and selecting the right alloy can significantly affect the final surface quality.

Anodizing Basics

Anodizing is an electrochemical process that converts the metal surface into a durable, corrosion-resistant oxide layer. This oxide layer can be clear or dyed in various colors. The quality of this finish depends heavily on the alloy's composition—particularly the amount of copper, silicon, and zinc.

Alloy Behavior in Anodizing

Alloy	Anodizing Response	Color Quality	Notes	
6061	Excellent	Clear, uniform	Ideal for both decorative and hard anodizing.	
6063	Excellent	Bright, smooth	Often used for architectural finishes.	
6082	Good	Acceptable	Slightly coarser than 6061.	
5083	Moderate	Dull grey	High magnesium content reduces visual quality.	
5754	Moderate	Grainy, dull	Best for corrosion resistance, less ideal for aesthetics.	
7075	Poor to Moderate	Blotchy, dark	High zinc content causes uneven color and pitting.	
2007	Poor	Very dark	High copper content makes it reactive and less suitable for anodizing.	

Choosing the Right Alloy for Anodizing

- Best for Decorative Finishes: 6061, 6063.
- Best for Marine or Corrosive Environments: 5083, 5754 (despite less aesthetic anodizing).
- Avoid for Cosmetic Anodizing: 7075, 2007 unless hard anodizing is required for functional wear resistance.

Additional Finishing Tips

- **Pre-treatment matters**: Polishing or bead blasting before anodizing can enhance or smooth the surface appearance.
- **Color matching**: Even good alloys can produce slight variations in color when dyed, so batch consistency matters.
- Hard anodizing: Alloys like 7075 and 2007 are better suited to Type III hard anodizing for wear protection rather than aesthetics.

VI. Machining Challenges and Best Practices by Alloy

CNC machining performance varies significantly across aluminum alloys due to differences in hardness, chip formation, thermal conductivity, and alloying elements like silicon, copper, and zinc. Understanding the unique behaviors of each alloy can help optimize tool life, surface finish, and part accuracy—especially in high-precision applications.

Key Machinability Factors

- Hardness: Harder alloys require more robust tooling and slower feeds/speeds.
- Chip Formation: Alloys with poor chip breakability may cause chip re-cutting and tool wear.
- Thermal Conductivity: High conductivity helps with heat dissipation but may soften tools quickly.
- Abrasiveness: Alloys with high silicon content are abrasive and reduce tool life.

Alloy	Machinability	Challenges	Best Practices
6061	Excellent	Minimal	Use standard carbide tools, dry or mist cooling.
6063	Good	Slightly gummy	Use sharp tools; reduce built-up edge with high RPMs.
6082	Good	Stronger than 6061	Requires more rigid setups and higher torque.
5083	Fair	Gummy and work-hardens	Use aggressive cuts; minimize tool rubbing.
5754	Fair	Similar to 5083	Sharp cutters, frequent tool changes recommended.
7075	Very Good	Risk of surface tearing	Optimal for precision cuts with coolant.
2007	Excellent	Short tool life from abrasiveness	Use coated carbide tools, control heat buildup.

Alloy-Specific Machining Notes

VII. Cost Factors and Supply Chain Availability

When selecting the right aluminum alloy for CNC machining, cost and availability are just as critical as performance. The overall price of a machined part is influenced not only by the base material cost but also by



machining time, scrap rates, tool wear, and lead times. Let's examine these aspects by alloy to help you make informed, cost-effective decisions.

Breakdown of Key Cost Drivers

- Raw Material Cost: Influenced by alloy composition, global aluminum pricing, and supplier markup.
- **Machinability Impact**: Poorer machinability leads to longer machining times, higher tool consumption, and more frequent maintenance.
- Scrap & Yield: Alloys prone to distortion or poor anodizing results can reduce yield and increase overall part cost.
- **Post-Processing Compatibility**: Alloys that require additional steps (e.g., polishing, heat treatment, anodizing correction) incur additional labor and cost.

Alloy	Relative Material Cost	Availability	Cost Notes
6061	Low to Moderate	Widely available worldwide	Very cost-effective; standard for many industries.
6063	Low	Common for extrusions	Low cost but limited to structural or aesthetic use.
6082	Moderate	Good in EU/Asia, less in US	Slightly higher cost due to strength and availability.
5083	Moderate to High	Readily available	Higher cost due to marine-grade corrosion resistance.
5754	Moderate	Good availability in Europe	Preferred for forming and corrosion applications.
7075	High	Widely available in aerospace-grade	Excellent performance, but expensive and sensitive to anodizing waste.
2007	Moderate	Moderate availability	Lower-cost alternative to 7075, but tooling costs are higher.

♦ Alloy-Specific Cost and Supply Insights

Supply Chain Considerations

• **Global Sourcing**: Alloys like 6061, 7075, and 5083 are available globally, while 5754 and 6082 are more region-specific.

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- **Stock Shapes**: 6061 and 7075 are commonly stocked in round bars, plates, and blocks, allowing for quick procurement and low scrap.
- Extrusion Compatibility: 6063 and 6060 are often only available as extrusions, which limits their use in solid block CNC machining.

Optimization Tips

- For general prototyping or cost-sensitive projects, **6061** is usually the most economical.
- For premium strength with weight savings, **7075** is worth the higher cost.
- When corrosion resistance and formability are critical, **5083** or **5754** offer long-term value despite higher machining effort.

VIII. Alloy-Specific Applications and Use Cases

Understanding how each aluminum alloy aligns with real-world applications can help you select the right material for both performance and cost-efficiency. Below is a breakdown of **common use cases** tied to specific aluminum alloys in CNC machining:

🗄 2007 – Precision Parts with High Machinability

- Applications: Fasteners, valve components, pins, bushings, and turned parts.
- Why choose it: Excellent machinability and surface finish make it ideal for high-speed machining and mass production of intricate parts.

🔀 2024 – Aerospace and Structural Components

- **Applications**: Aircraft skins, fuselage structures, wing tension members, and automotive parts subject to fatigue.
- Why choose it: High strength and fatigue resistance, especially in aerospace-grade designs; however, requires protective surface treatment due to poor corrosion resistance.

🚔 5052 – Marine and Chemical Equipment

- Applications: Boat hulls, fuel tanks, electrical enclosures, and pressure vessels.
- Why choose it: Outstanding corrosion resistance, excellent formability, and weldability—especially in saltwater or acidic environments.

Sold - Heavy-Duty Marine and Cryogenic Use

- Applications: Shipbuilding, offshore structures, cryogenic tanks, and industrial pressure vessels.
- Why choose it: High strength, toughness, and exceptional corrosion resistance in extreme environments.

riangletic states and Welded Assemblies

- Applications: Car bodies, truck trailers, welded frames, and food processing equipment.
- Why choose it: Excellent corrosion resistance and moderate strength; especially suited for applications requiring good formability and welding.

🚹 6060 – Architectural and Lightweight Structures

- **Applications**: Piping, railings, lightweight structural elements, and extrusion profiles.
- Why choose it: Good strength-to-weight ratio, corrosion resistance, and surface finish; often chosen for anodized decorative applications.

6061 – All-Purpose Engineering and Fixtures

- **Applications**: Jigs, brackets, enclosures, structural parts, and machinery components.
- Why choose it: Balanced mechanical performance, weldability, and machinability make it a popular "default" alloy for prototypes and production runs alike.

2 6063 – Extruded Shapes and Finishing

- Applications: Window frames, doors, decorative trims, and piping systems.
- Why choose it: Excellent finish quality and anodizing response; best used when aesthetics and extrusion compatibility matter.

🚐 6082 – Load-Bearing and Structural Parts

- Applications: Truck bodies, rail components, bridges, and frames.
- Why choose it: High strength and good corrosion resistance; a structural-grade alternative to 6061, especially in Europe.

7075 – Aerospace and Performance Engineering

• **Applications**: Aircraft fittings, sports equipment, drones, racing bike frames, and tooling.

• Why choose it: Among the strongest aluminum alloys available; perfect for high-performance, weightsensitive, and fatigue-critical parts.

IX. Tips for Making the Right Aluminum Alloy Choice

Selecting the optimal aluminum alloy for your CNC machining project can have a significant impact on performance, cost, and manufacturability. Use the following tips to make an informed and strategic choice:

1. Define the Application First

- Is the part structural, cosmetic, or functional?
- Will it be exposed to harsh environments, mechanical stress, or friction?

Start with the end use—it will narrow down your alloy options based on key properties like strength, corrosion resistance, or appearance.

% 2. Match Mechanical Properties to Performance Needs

- High-strength demands? Consider 7075, 2024, or 6082.
- General-purpose or moderate-load parts? 6061 or 5754 are often ideal.
- High corrosion environments? Choose 5083, 5052, or 5754.

Always match the alloy's mechanical profile to the stress, fatigue, and durability required in the final product.

3. Consider Post-Processing and Surface Finishes

- If anodizing is needed, go with 6060, 6061, or 6063.
- If surface finish quality is critical, 2007 and 6063 provide superior cosmetic appeal.
- For heat-treated parts, ensure the alloy is **heat-treatable** (e.g., **6061**, **6082**, **7075**).

The alloy's compatibility with finishing methods should match the product's appearance or durability goals.

4. Optimize for Machinability and Cost

- For complex geometries or large-volume runs, use **machinable alloys** like **6061**, **2007**, or **6082** to save time and reduce tooling wear.
- Need cost efficiency without sacrificing too much strength? **5052**, **5754**, and **6061** are affordable and versatile.



← Choosing a more machinable and cost-effective alloy can improve production efficiency and lead time.

🖉 5. Don't Over-Specify

- Avoid selecting a premium alloy (like 7075 or 2024) unless the application absolutely demands it.
- Over-specifying can result in unnecessary machining difficulty, increased costs, or poor weldability.

Strive for fit-for-purpose, not "overbuilt."

💛 6. Consult Your CNC Machining Partner

- Experienced CNC service providers can offer alloy recommendations based on your design, tolerances, and volume needs.
- They may also suggest material substitutions to reduce cost or lead time.

Collaboration early in the design phase can lead to better material decisions and project outcomes.

X. Conclusion

Selecting the right aluminum alloy for CNC machining is more than just choosing a material—it's a strategic decision that influences the part's performance, appearance, manufacturability, and overall project cost. Alloys like 6061 continue to be the go-to choice for general applications thanks to their excellent balance of strength, machinability, and cost-effectiveness. For high-stress environments, 7075 offers superior mechanical properties and weight savings, albeit with higher cost and certain limitations in anodizing consistency. In contrast, 5083 and 5754 stand out for their corrosion resistance, making them ideal for marine and outdoor applications.

Beyond material properties, understanding how each alloy behaves during surface finishing, especially anodizing, is critical. Alloys such as 6061 and 6082 typically produce clean, consistent finishes, while copper-rich alloys like 7075 and 2007 may result in darker or uneven appearances. Machinability also varies significantly—some alloys are more abrasive or produce poor chip control, which impacts tool wear, surface finish, and production efficiency. Therefore, applying best practices in tooling and feed rate optimization is essential for maintaining quality across different alloys.

Cost and availability complete the picture. While 6061 is globally available and competitively priced, higherperformance alloys like 7075 or marine-grade options such as 5083 often come with longer lead times and increased machining costs. Region-specific availability can also influence supply chain decisions, especially for large-scale production or repeat orders.

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Therefore, choosing the right aluminum alloy for CNC machining requires balancing mechanical needs, surface finish expectations, manufacturing ease, and supply economics. A well-informed selection not only ensures optimal part performance but also minimizes waste, lowers total cost, and streamlines your path from design to final production. Working closely with your manufacturing partner to evaluate these factors early in the project will help you make the most out of aluminum's versatile capabilities.

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