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Machinable Materials Guide

Where to Start?

Selecting the right material for your design can be daunting. You could choose the "best" possible material that far exceeds the needs of your design, but doing so will likely turn out to be costly. Alternatively, you could choose a material that is cost effective but cannot handle the requirements of the job, sending you back to the drawing board if your part breaks, bends, corrodes, or otherwise fails. This guide aims to assist in determining the most practical material for your specific design by examining the qualities of commonly available machinable materials.

"Cost. Strength. Weight. Choose Two."

The first step in selecting your material is to choose the two features that are most important to you. For example, if you are selecting material for an airplane part, strength and weight are very important, but it will be unrealistic to think a material that exhibits these qualities, such as titanium, will be inexpensive. Alternatively, such a part could be made out of aluminum, which would maintain the desired property of being lightweight while sacrificing some strength in exchange for cost-effectiveness.

What Attributes to Consider?

Cost

Cost is a major factor to consider in all but the rarest of circumstances. For this reason, it is imperative to understand the different variables contributing to the cost of your part. See our *cost savings guides* for clarification.

Strength

Understand the different types of strength materials can possess. Typically, when people think of strength, they tend to think of tensile strength. However, in addition to tensile strength, there is compressive strength, impact strength, shear strength, and bending/flexural strength.

Stiffness

Consider the stiffness and rigidity of your material. Be aware of the type of stress your part will undergo. Although a part may not snap if stressed, it can still deform enough to become unusable.

Toughness

Toughness encompasses multiple qualities in a material including different measurements of strength, stiffness, corrosion and/or heat resistance as well as its durability over time. Since toughness covers so many types of material attributes, it is often regarded as the most important aspect of a material's performance.

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Machinability

If you've read our *General Cost Saving Machining Tips*, then you already know why machinability contributes to cost. A hard material could be cheaper than a soft material for a given volume, but if it takes longer to machine, it will increase costs. Don't fall into the trap of choosing an inexpensive but hard to machine material.

Conductivity

Conductivity may be important if you need electrical current or heat to pass through a part, or if you are trying to use your part to insulate something from electrical current or heat.

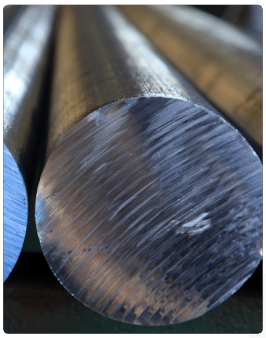
Corrosion Resistance

Consider if your part will be exposed to chemicals, moisture, or the elements for extended periods of time.

Heat Resistance

Metals typically have higher melting points than plastics but are usually more expensive. Knowing how much heat your part will be exposed to is significant to selecting the right material.

Metals



Aluminum

Strong **Flexible** **Tough**

Resistant to: Solvents and most types of corrosion
Susceptible to: Acids and bases

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: 5052, 6061, 7072
Practical Uses: Wheels, rivets, trim on cars, cans, bike frames, ladders, pots, pans, mailboxes, and staples.

Stainless Steel

Strong **Stiff** **Tough**

Resistant to: Extreme cold, abrasion, acids and many forms of corriosion
Susceptible to: High salinity areas and poor air-circulated environments

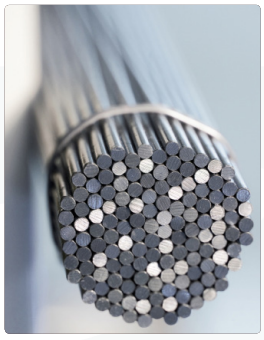
General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: 304, 316
Practical Uses: Tables, tea kettles, pots, pans, sinks, marine equipment, chains, bowls, silverware, and wrenches.

Copper

Soft **Flexible** **Tough**

Resistant to: Moisture
Susceptible to: Corrosion

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: 101, 110
Practical Uses: Roofs, lamps, rain gutters, pipes, tubing, doorknobs domes, spires, jewelry, and kitchenware.



Mild Steel

Strong **Stiff** **Tough**

Resistant to: Wearing down
Susceptible to: Moisture

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: A36, CRCQ, HRCQ
Practical Uses: Aircraft engine mounts, forms, shafts, spindles, chef knives, pins, rods, and springs.

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Metals

Brass

Weak **Stiff** **Soft**

Resistant to: Wearing down
Susceptible to: Moisture

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: 260, 360
Practical Uses: Valves, gears, nuts, locks, pipes, rivets, musical instruments, and hinges.

Titanium

Strong **Flexible** **Tough**

Resistant to: Most types of corrosion and Chloride-containing environments
Susceptible to: Corrosion from hot (>70°C) Chloride, Bromide, Iodide, Fluoride, or Sulfate-solutions

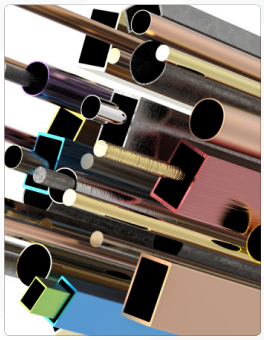
General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: Grade 2, Grade 5, Grade 9
Practical Uses: High-end bicycles, jewelry, toys, tools, knives, fishing rods, armor plating, and golf clubs.

Bronze

Weak **Stiff** **Soft**

Resistant to: Moisture
Susceptible to: Corrosion

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: Aluminum-Bronze, Copper-Nickel, Phosphor-Bronze
Practical Uses: Propellers, bearings, gears, springs, musical instruments, valves and pump parts.



Other Metals

There are other less common machinable metals. These metals include Cast Iron, Nickel, Tungsten, Carbon Steel, Lead, Tin, Zinc, Iridium, Platinum, Gold, Silver, and Magnesium among others.

These metals exhibit unique properties which can be useful in the right type situation.

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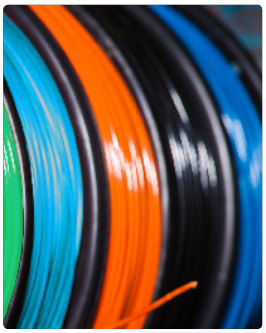
Plastics



ABS

Strong **Flexible** **Tough**

Resistant to: Moisture and heat
Susceptible to: Wearing down and ultra violet degradation

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:

Common Types: General Purpose, High Impact,
Practical Uses: Auto body parts, toys, liquid containers, and outdoor waste receptacles.

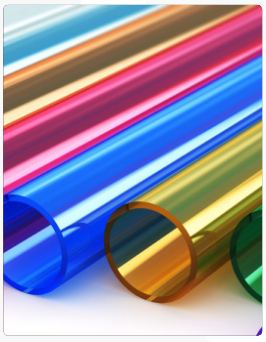
ACETAL

Strong **Stiff** **Tough**

Resistant to: Moisture, chemicals and heat
Susceptible to: Stress

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:

Common Types: Derlin, PTFE blend, Natural
Practical Uses: Ski bindings, bearings, toys, coffee spigots, zippers, safety locks, gears, hobby, R/C, and cams.



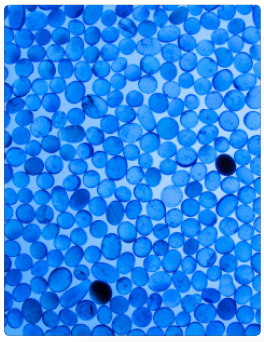
ACRYLIC

Weak **Brittle** **Soft**

Resistant to: Abrasion, ultra violet degradation and shock
Susceptible to: Extreme heat

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:

Common Types: Cast, Extruded, AR2
Practical Uses: Lenses, doors, access panels, jewelry, lighting fixtures, signage, shelving, and prototypes.



NYLON

Strong **Stiff** **Tough**

Resistant to: Moisture, chemicals, heat and abrasion
Susceptible to: Ultra violet degredation and mold

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:

Common Types: Cast, Extruded, 6/66
Practical Uses: Sheaves, wear pads, gears, bushings, handles, caps, beach items, and camping tents.

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Plastics

Polycarbonate

Strong **Brittle** **Tough**

Resistant to: Heat and impact
Susceptible to: Ultra violet degradation

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: Machine Grade, Hygrad, Textured
Practical Uses: Clear tubes for sports equipment, light pipes, bullet-proof windows, and machine guards.

Polystyrene

Weak **Brittle** **Soft**

Resistant to: Moisture, acids and shock
Susceptible to: Solvents

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: GPPS, HIPS
Practical Uses: Office supplies, signs and displays, tv cabinets, refrigerator trim, toys, and building insulation.

Fluoropolymer

Strong **Flexible** **Tough**

Resistant to: Moisture, solvents, chemicals, heat and bases
Susceptible to: Melt-fracture

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: PTFE, FPM, FKM , PFSA
Practical Uses: Manifolds, valve seats, automotive fuel hoses, glides, bearings, wear-strips, and gasketing.

PVC

Strong **Flexible** **Tough**

Resistant to: Moisture, chemicals and heat
Susceptible to: Differential-stress

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: PVC, CPVC
Practical Uses: Tanks, electrical boxes, filters, vinyl siding, car interiors, bushings, window profiles, and pipes.

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Plastics

Polyethylene

Strong **Flexible** **Tough**

Resistant to: Moisture and chemicals
Susceptible to: N/A

General Cost: $ $ $ $ $

Machinability:

Electrical Conductivity:

Thermal Conductivity:

Thermal Resistance:

Common Types: HDPE, LDPE, Polypropylene

Practical Uses: Vapor barriers, cutting boards, cups, vials, caps, furniture, and containers.

Other

Carbon Fiber

Strong **Brittle** **Tough**

Resistant to: Moisture and chemicals
Susceptible to: Ultra violet degradation

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: N/A:
Practical Uses: Sports equipment, car hoods, protective casings, bicycles, hobby, R/C, and avation parts.

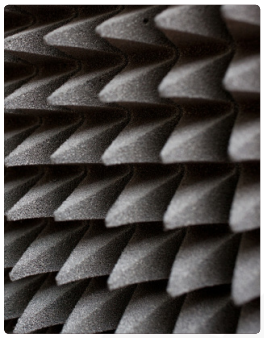
Fiberglass

Strong **Brittle** **Tough**

Resistant to: Moisture, acid and ozone
Susceptible to: Hydrofluoric acid and phosphoric acid

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:
Common Types: G10, Polester
Practical Uses: Housing insulation, outdoor equipement, automotive and avaition applications.

Rubber



Polyurethane

Strong **Flexible** **Soft**

Resistant to: Abrasion and vibration
Susceptible to: Moisture and ozone

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:

Common Types: Sorbothane

Practical Uses: Shoe insoles, compression braces headphone muffs and feet dampeners.

Buna-N

Strong **Flexible** **Tough**

Resistant to: Chemicals, oil, and fuel.
Susceptible to: Corrosion from exposure to ozone

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:

Common Types: Nitrile, NBR, Acrylonitrile Butadiene

Practical Uses: Keypads, footwear, sponges, expanded foams, floor mats, hoses, and seals.

Neoprene

Weak **Flexible** **Tough**

Resistant to: Moisture and heat
Susceptible to: Chemicals

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:

Common Types: Polychloroprene

Practical Uses: Gaskets, hoses, laptop housing, remote controls, mouse pads, face masks and fan belts.

Silicone

Strong **Flexible** **Tough**

Resistant to: Moisture, chemicals and heat
Susceptible to: Corrison from ozone, heat, and ultra violet degradation

General Cost: $ $ $ $ $
Machinability:
Electrical Conductivity:
Thermal Conductivity:
Thermal Resistance:

Common Types: N/A

Practical Uses: O-rings, cake pans, muffin molds, gaskets, and baking mats

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