

Acrylic CNC Machining Guide

Dedicated engineering reference guide for buyers, engineers, and sourcing teams

Based on article:

<https://nylonplastic.com/acrylic-cnc-machining-complete-guide/>

Quick Overview

Acrylic (PMMA) occupies a unique position in CNC machining: it delivers optical clarity approaching glass, machines with clean chip formation, and costs a fraction of polycarbonate or PEEK. But it is also brittle, heat-sensitive, and prone to stress cracking if machined with incorrect feeds and speeds. The line between a diamond-polished edge and a shattered corner often comes down to 0.05 mm chip load and 500 RPM.

This guide covers the specific tooling, feed rates, coolant strategies, and fixturing techniques that produce glass-like surface finishes on acrylic parts without cracking, chipping, or heat damage. Whether you are machining optical lenses, medical manifolds, or retail display components, the parameters below come from our production floor.

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Engineering Notes

Cast vs Extruded Acrylic: Which to Machine

Cast acrylic is the first choice for CNC machining. Its higher molecular weight provides better chip formation and reduced melting during cutting. The stress-relieved manufacturing process produces lower internal stress — critical for parts that will not crack on the fixture. Cast acrylic also polishes to a higher clarity after machining and tolerates flame polishing without crazing. Extruded acrylic costs 30-40% less but contains higher residual stress and softens at lower temperatures (glass transition ~105°C vs ~115°C for cast). It is usable for simple 2D profile cutting and low-tolerance parts, but fine details, threads, and deep pockets will show stress whitening or cracking. At Nylon Plastic, we default to cast acrylic for all precision-machined parts and only use extruded when the customer specifies it for cost reasons on simple geometries.

Design Rules for CNC Machining Acrylic

Minimum wall thickness 1.5 mm: Thinner walls vibrate under cutting forces and crack. For unsupported walls over 10 mm tall, increase minimum to 2.5 mm. Use ribs and gussets rather than thicker walls for stiffness. Internal corner radius ≥ 0.5 mm: Sharp internal corners concentrate stress and initiate cracks during machining. Even a 0.5 mm radius distributes load and allows the tool to transition smoothly. For optical parts, specify 1.0 mm minimum to avoid visible stress marks. Tool engagement below 30% diameter: Keep radial engagement below 30% of tool diameter for finishing passes. Full slotting generates excessive heat in acrylic, causing melting and chip welding. Use trochoidal toolpaths for deep slots instead of straight plunging. Fixturing without point stress: Use vacuum chucks for flat parts or soft jaw vises with full-contact pads. Never clamp acrylic with steel jaws directly — even with soft metal shims. Point loading creates micro-cracks that propagate during machining. Double-sided tape works for thin sheets but limits DOC.

Industry Application Matrix

Light pipes, prisms, sensor windows <0.05 µm haze, no internal haze Microfluidic chips, cuvettes, manifolds
Chemical resistance, autoclavable (limited cycles) Point-of-sale stands, signage, trophy components Cast or extruded (non-critical)
Flame-polished edges, 3D engraving clarity Sight glasses, flow indicators, filter housings Cast acrylic, UV-stabilized
Pressure rating, solvent-bond compatible edges

Cost Decision Framework

Material cost: Cast acrylic sheet is \$12-18/kg (6-12 mm thickness); extruded is \$8-12/kg. The price difference narrows for thicker sheets (>20 mm) where cast is the only option. Machining cost drivers: Acrylic machines 30-50% slower than aluminum due to lower feed rates and depth of cut limits. Complex 3D contours add 40-60% to machining time versus 2.5D prismatic features. Flame polishing adds \$2-5 per visible edge for manual work. Decision rule: For production volumes above 500 pcs, injection molding acrylic (PMMA) beats CNC on per-part cost at \$1.50-4.00 vs \$8-25 for machined. But CNC wins for 1-200 pcs, prototypes, and parts requiring optical-grade surface quality that molding cannot consistently deliver.

Common Defects and Solutions

Fracture at edges or corners during cut Tool runout >0.01mm; excessive DOC; extruded acrylic stress Use cast acrylic; verify tool runout <0.005mm; reduce DOC 50% Chips weld to tool or workpiece surface Insufficient cooling; RPM too high for feed rate Add mist coolant; reduce RPM 20% or increase feed to clear chips Cloudy, hazy, or frosted machined surface Dull tool; wrong tool coating (TiN sticks to acrylic) Use sharp polished carbide (uncoated or DLC only); fresh tool for finish pass Part measures out of tolerance after unclamping Part deformed under clamping pressure; thermal expansion Use vacuum fixturing; allow part to cool 5-10 min before measurement

Why Choose Nylon Plastic for Your Project

30+ CNC & injection molding cells under one roof Certified quality system, full inspection reports Fast turnaround with expedited options available Air & sea freight to North America, Europe, Asia Free PDF reference guide with technical data, design rules, and supplier checklists.

Frequently Asked Questions

Cast acrylic is superior for CNC machining in nearly all cases. It has lower internal stress, higher molecular weight, better chip formation, and a higher softening temperature (~115°C vs ~105°C). Extruded acrylic can work for simple 2D profiling on thick sheets (>10 mm) where stress is less of an issue, but expect more scrap and lower surface quality on fine features. Five key factors: (1) Always use cast acrylic, not extruded. (2) Use sharp carbide tools with less than 0.01 mm runout. (3) Keep depth of cut conservative — 1-2 mm for roughing, 0.2-0.5 mm for finishing. (4) Avoid point-load clamping; use vacuum chucks or soft jaws. (5) Pre-anneal at 80°C for stress-critical parts. Cracking usually traces back to tool condition or fixturing, not the material itself. A light mist of water-soluble coolant provides the best balance of cooling, chip evacuation, and surface finish. Avoid flood coolant — acrylic absorbs water and swells slightly, affecting dimensional accuracy. For engraving and light cuts, compressed air blast alone is sufficient. Never machine acrylic dry at production speeds — the heat buildup causes melting within seconds.

RFQ Checklist

- Application environment: temperature, moisture, UV, chemicals, sterilization, or outdoor exposure.
- Mechanical requirements: load, stiffness, impact, wear, friction, creep, and fatigue life.
- Drawing requirements: tolerance class, critical dimensions, surface finish, threads, inserts, and inspection method.
- Production needs: prototype or production quantity, expected annual volume, target unit cost, and lead-time window.
- Material notes: preferred grade, color, reinforcement, flame rating, certification, and substitute-material flexibility.

Need manufacturing support?

Share your drawing, target material, working environment, tolerance requirements, and quantity. Nylon Plastic can help evaluate manufacturability, material alternatives, and production quotation details.

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