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Tips and Techniques for Machining Amodel® PPA

Injection molding is one of the most versatile and most widely used manufacturing process for producing plastic parts that range in size from small components, like LED reflector cups, to very large components, such as entire automotive body panels. Machining is a secondary operation used to effectively finish or enhance an injection molded part. Machining is also an economical way to produce prototypes, test samples, or small volume, short-run parts.

Switching from metal to plastic machining often requires new ways of thinking and working since plastics machine differently than metals and differently from one plastic to another. Because of this, molders and OEMs must observe common machining practices in order to produce high-quality parts.

This bulletin provides key recommendations for machining Amodel® polyphthalamide (PPA), a high-temperature polyamide that is stronger, stiffer, and less sensitive to moisture than standard polyamides. Because Amodel® PPA retains its excellent mechanical and electrical properties in high humidity and chemically aggressive environments, it has emerged as a strong metal replacement option, most notably in high-temperature automotive applications.

Tooling Equipment

Amodel® PPA can be machined easily with high-speed steel tools; however, fiber- and/or mineral-reinforced PPA materials that are machined in frequent, heavy-duty jobs typically require carbide or hardened steel tools because of the potential for wear. All cutting tools must be sharp, as unsharpened tools can cause excessive friction and increase heat generation, leading to poor material removal and greater stress.

Cooling

It is good practice to ensure proper cooling while machining Amodel® PPA. The lack of cooling may cause the overheated material to melt or soften, leading to poor material removal. Air cooling is recommended since a machined surface can readily absorb liquid coolant, which in some instances will attack the plastic. Several water-based coolants have been used successfully.

Annealing

It is good practice to both pre- and post-anneal a machined plastic part. Molded-in stresses are normally present in an injection molded part, although they occur less frequently in semi-crystalline materials like Amodel® PPA. Machining a stressed part can lead to breakage, fracture, warpage and dimensional changes, and it is helpful to relieve molded-in stress before machining. Machining itself can create stresses in the part. These stresses should be relieved after machining to lower the chances of part breakage and fracture.

Drilling

Drilling at fast speeds is recommended as it typically results in a better surface finish, especially when using smaller drill bits. Drill feed is the rate that the drill is pushed into the material. Fast feed rates can lead to binding, tearing and delamination of the plastic, resulting in tool breakage. Slow drill feed rates can lead to burning and melting. Slow-to-medium feed rates with a fast drill speed typically result in superior results. Be aware that a fast drill speed can cause the material to soften or melt and result in material sticking to the tool.

Figure 1: Drill bit angles

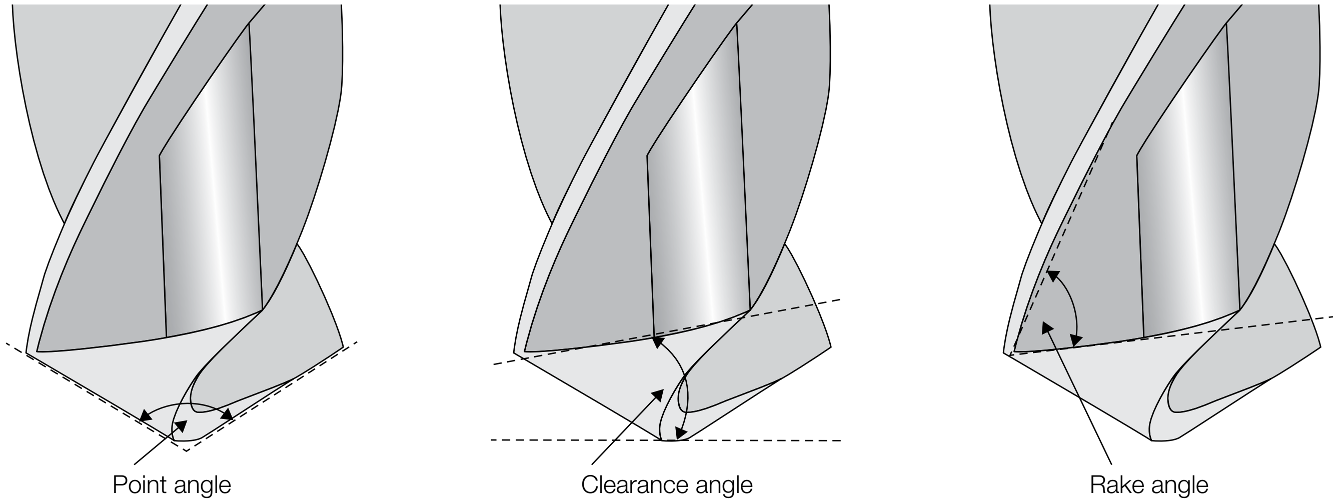
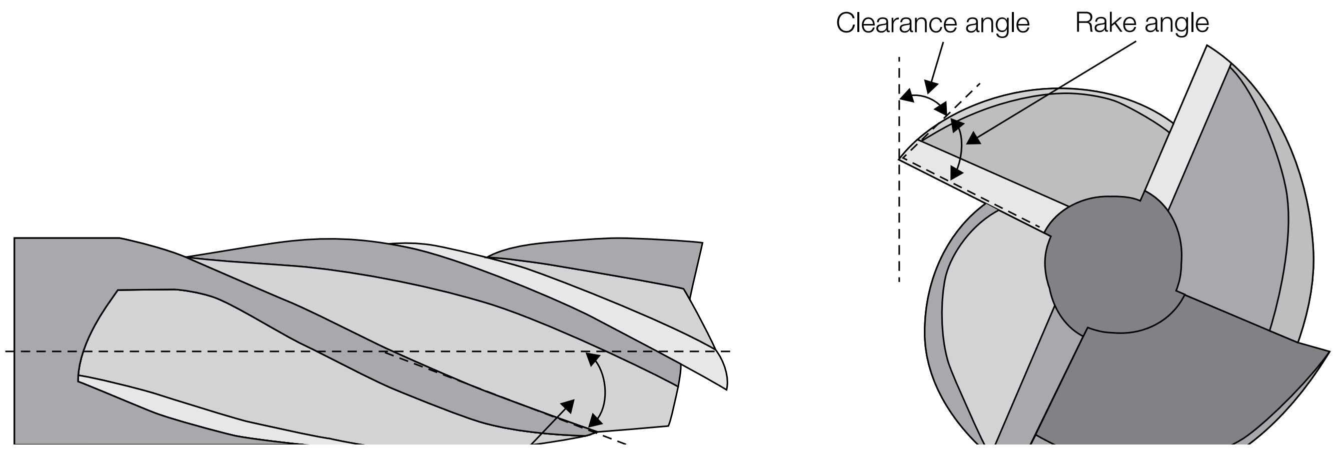


Figure 2: Milling cutter (end mill type)



If the clearance angle of a drill bit (Figure 1) is too small, it will reduce the cutting edges of the drill and cause poor cutting action. Small rake angles are good for an efficient cutting process.

Milling

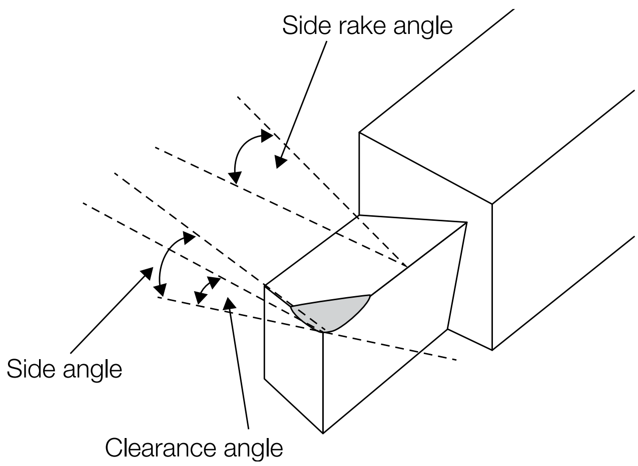
For efficient and optimal cutting of Amodel® PPA, a large helix angle (Figure 2) is recommended. This angle increases the effectiveness of the cutting action and typically reduces the cutting force and the amount of heat generated during cutting. A large helix angle also helps to remove chips more effectively and with less mill vibration. A rake angle that is too large may result in tool vibration.

A cutting speed that is too fast can also lead to vibration (chattering) and cause tool wear. A feed rate that is too fast can lead to tool breakage, misalignment, material clumping at the tool's cutting edge, and a poor surface finish. A slower feed rate provides a smoother finish.

Turning

Although turning an Amodel® PPA part is not difficult, it is important to follow best machining practices. Due to their ductile nature, plastics typically curl or form ribbons at the point of the tool, making it necessary to cool and remove material build-up frequently. A dull tool can also cause excessive heating at the tip and lead to material build up.

Figure 3: Turning tool



Sawing

The difficulty or ease in sawing a fiber- and/or mineral-reinforced PPA part depends on the thickness of the part. Hard blades, like carbide, typically provide the best results as they have good wear resistance and provide a cleaner cut and a better surface finish. Band saws and circular saws can also be used with these materials; a band saw is more versatile.

Excessive heat will be generated if saw teeth are clogged. Note that excessive heat caused by friction in general can also cause clogging of the saw teeth. If this occurs, cooling the blade is necessary. A larger pitch is suggested for more ductile materials, like impact-modified PPA grades. Fewer teeth per inch or a larger pitch are suggested for part thicknesses over 12.7 cm (0.5 in.). Slower speeds are recommended for thicker materials.

Figure 4: Details of band saw

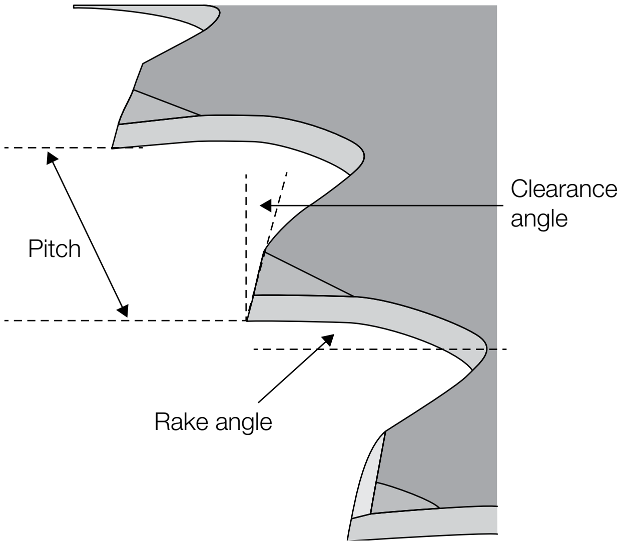


Table 1: Operating parameters

Operations	Cutting Speed [m/min (ft/min)]	Feed [mm/rev (in./rev)]	Clearance Angle [°]	Rake Angle [°]	Side Angle [°]	Pitch [mm (in.)]	Point Angle [°]
Drilling	75–120 (250 –400)	0.10 – 0.25 (0.004 – 0.010)	5 – 12	5 – 20	–	–	90 – 118
Milling	60–90 (200 –300)	0.13 – 0.51 (0.005 – 0.020)	5 – 20	5 – 15	40 – 60	–	–
Turning	150–300 (500 –1,000)	0.05 – 0.13 (0.002 – 0.005)	5 – 10	0 – 5	40 – 60	–	–
Band Saw	150–450 (500 –1,500)	–	20 – 30	5 – 15	–	2.54 – 7.62 (0.1 – 0.3)	–

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SpecialtyPolymers.EMEA@solvay.com | Europe, Middle East and Africa
SpecialtyPolymers.Americas@solvay.com | Americas
SpecialtyPolymers.Asia@solvay.com | Asia Pacific

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