



Making the Power Mac G4 Cube



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Introduction

Building on its tradition of bringing innovative design to the computer industry, Apple introduced the revolutionary Power Mac G4 Cube in the summer of 2000. A supercomputer miniaturized into an eight-inch cube, the G4 Cube features a stunning, crystal-clear enclosure that houses the computer's core. This paper provides background information about the manufacturing process for the G4 Cube's enclosure, whose beauty is an object of desire.

The Industry-Standard Injection Molding Process

The G4 Cube's crystal-clear enclosure is created via an industry-standard manufacturing process called "injection molding."

During the injection molding process, raw plastic pellets are fed into a molding machine, which heats the pellets until they become fluid-like with a consistency similar to caulking compound.

The melted plastic is then pumped under very high pressure through an extremely small tunnel, or "gate," that leads into a steel mold, which gives the plastic its shape. As soon as the plastic passes through the gate, it begins to spread out and fill the steel mold. Once the steel mold is completely filled, the plastic is allowed to cool and solidify into the desired form, much the same way that water freezes to take the shape of an ice-cube tray. The mold is then opened and the solid part removed. The process is then repeated.

Steel molds often contain holes or "cut-outs" to accommodate features (like DVD drives) or objects (screws) that later will be inserted into the final plastic piece. During the injection molding process, melted plastic must flow around these holes or cut-outs in the steel mold and rejoin, or "weld," on the other side. When the two flows of melted plastic meld together, a thin line called a "weld line" or "mold line"—may form at the joint.

Close examination of any injection molded plastic part may reveal mold lines around any hole or cut-out, provided that the part has not been painted over to hide the lines. If the plastic part is a solid color and has a rough surface, then the mold line may look like a dull streak. If the part is a solid color and has a shiny surface, it may look like a scratch. If the part is clear and has a shiny surface, then it may look like a scratch or hairline crack because one can see into the clear material beyond the top surface.



Since the Power Mac G4 Cube's enclosure is made from one of the clearest plastic materials available, light passes through it easily. In fact, the material is so efficient at transmitting light that light reflects off of the inside surfaces of the DVD slot and Apple logo, making fine mold lines even easier to see.

It is important to note that a mold line is not a crack. The mold line will not lengthen over time and it does not represent a defect in the plastic.

Minimizing Mold Lines

Considerable engineering care was taken to minimize the appearance of mold lines. During the development of the G4 Cube's injection molding process, engineers changed the location of the gate in order to shift the mold lines into less noticeable areas of the G4 Cube's enclosure. Since the top of the enclosure has five openings, it took several changes to the design of the mold (moving the location of the gate) to position mold lines where they are today. Given the physical limitations of the manufacturing process, such as having to locate the gate somewhere on the top surface where the plastic is the thickest, it is impossible to create the enclosure with absolutely no lines visible from the front of the G4 Cube.

Once the position was determined, the next step was to make the mold lines as small as possible by using extremely high pressure (20,000psi) to force the flows of melted plastic together as tightly as possible and to hold that pressure until the material solidified. The extra pressure was needed, since the enclosure is more than three times as thick as conventional plastic parts, and thus takes longer to cool and solidify.

An additional engineering consideration centered on the fact that the G4 Cube's enclosure is made up of two pieces: the clear housing and the white, ribbed top vent panel. Since the one-piece clear housing can be viewed from every angle, there is only one place to hide the gate (in the area where the vent panel gets assembled) and no place to hide the mold lines. Other commonly used plastic parts exhibit mold lines, but they usually have a place to hide.

During development, great effort went into selecting a material for the Cube that exhibited the highest mechanical and environmental performance. None of the acrylic samples that underwent extensive research and testing exhibited mechanical issues. As a result, acrylic was selected as the material for the G4 Cube's enclosure due to its superior environmental performance along with its excellent visual clarity.

Conclusion

In summary, the G4 Cube's enclosure was one of the most demanding plastic part and tooling designs ever undertaken. Apple engineers invested a minimum of 12 months of mold development, material investigation and process engineering before a single part was made for mass production. The result is a product that meets the most stringent engineering and structural requirements in conjunction with the highest aesthetics possible.