MISSING THE MARK

How to avoid or camouflage sink marks in injection-molded parts

AUTODESK.

Missing the Mark

Seeing is believing

The value of injection-molded parts—and the products they are ultimately used to create—depend in large part on how they look, regardless of functionality. Unfortunately, aesthetic defects can be caused by even small deviations from guidelines for mold and part design. Predicting when defects will occur can be difficult, and sink marks offer a particularly frustrating challenge.

In this brief report, we look at traditional methods of avoiding sink marks as well as design choices engineers can make to mask sink marks when they are unavoidable.

Sink marks explained

A sink mark is a surface depression that usually occurs in thicker sections of the part or in locations directly above ribs, bosses, and internal fillets. Sink marks are caused by localized shrinkage of the material during cooling whenever there is insufficient compensation. In other words, they are the result of unbalanced heat removal caused by any number of factors, including:

- Low injection and packing pressure
- Short hold time or cooling time
- High melt temperature or mold temperature
- Localized geometric features

After the external material has cooled and solidified, the core material begins to cool. Its shrinkage pulls the surface of the main wall inward, causing the sink mark (see Fig. 1).

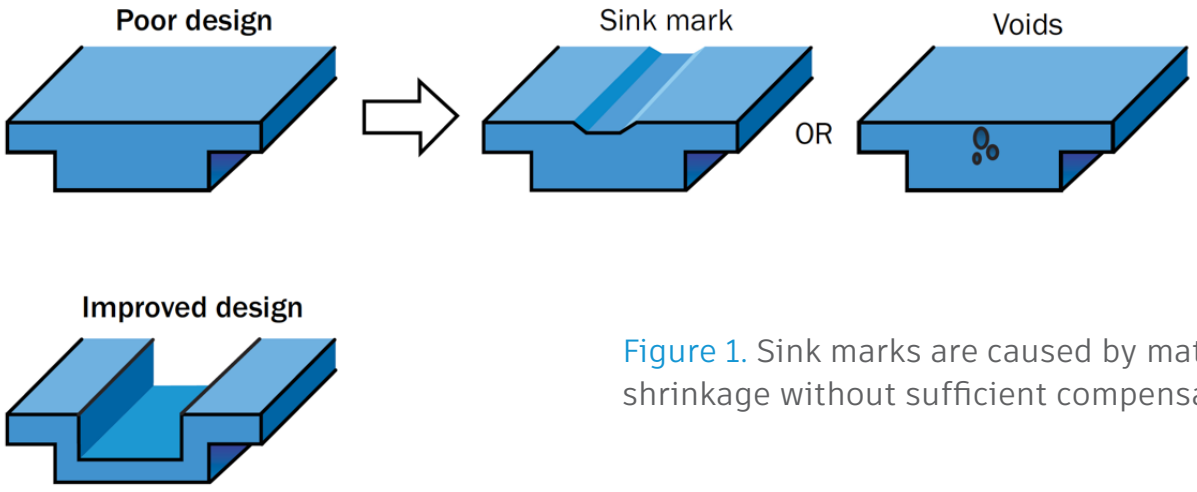

Figure 1. Sink marks are caused by material shrinkage without sufficient compensation.

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Traditional compensation methods

Cooling simulation and finite element analysis (FEA) can be used to predict the severity of sink marks formed in a product. Often, these defects can be alleviated by fine-tuning some combination of the part and mold design as well as the processing conditions:

1. Alter part design
   - Add a design feature, such as a series of serrations, to the affected area
   - Modify the part thickness to minimize variation
   - Make ribs, bosses, and gussets 50 to 80% of the thickness of the attached (base) wall

2. Alter mold design
   - Increase the size of gates and runners to delay gate-freeze
   - Add vents or enlarge existing vents
   - Relocate the gate to a thicker section

3. Adjust processing conditions
   - Maintain a cushion at the end of the injection stroke
   - Increase injection pressure and holding time
   - Increase screw-forward time and decrease the injection rate
   - Decrease melt and mold-wall temperatures
   - Increase cooling time
   - Check the non-return valve for possible material leakage

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Dealing with the inevitable

There will be times when avoiding sink marks will not be feasible using traditional methods. You may not be able to alter the design of the part or the mold without affecting structural integrity or cost per piece. You may not have the time, budget or authority to exert control over processing conditions. Other possible scenarios are numerous.

When this happens, sink marks can still be hidden from view. One study in particular demonstrated that simple changes in texture and color can give mold and part designers another way around the sink mark problem if traditional methods can't be applied.

In the study, individuals were shown a set of two molded plaques with varying levels of sink mark sizes, textures and colors to determine what factors influenced the overall visibility of these defects. Keep in mind, these changes affect only the visual perception of sink marks—not whether sink marks appear in the first place. Given the fact that sink marks are an aesthetic defect, visual camouflage can be an effective design strategy.

Sink mark visibility

The study examined several factors, including the size of the sink mark, its color (or luminescence) and the amount of texture applied to the plaques. Three interesting points emerged:

1. **Width affects visibility more than depth.** Not surprisingly, deeper sink marks are generally more visible than shallower ones. But wider sink marks were more visible than narrow ones. This finding runs counter to the conventional wisdom that wider sink marks are less visible because they feature subtler transitions in topology.

2. **Texture is tricky.** Minimal texture (0.018mm) was no more effective than no texture at disguising wide sink marks. Thicker texture (0.060mm) reduced the visibility of narrow sink marks, but affected wide sink marks only marginally. Complicating these calculations is the fact that texture raised the incidence of "false positives," or people identifying sink marks when none were present.

3. **Color adds camouflage.** In cases where some people identified a sink mark while others did not, gray parts masked the marks more effectively than black parts. Gray also improved the effectiveness of texturing. On black parts, texture of 3X sink mark depth was needed to hide sink marks. For gray parts, texture of only 2X sink mark depth was required.

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Guidelines for design

When conventional design changes can't be applied, following a few basic guidelines can improve the ability to mask sink marks and preserve visual integrity:

- If sink marks can't be avoided, make them narrow rather than wide.
- Choose brighter, more luminous neutral colors to hide sink marks.
- Use texture for additional camouflage, either at 2X or 3X sink mark depth.

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