

Whitepaper:

---

# Plastic Injection Molding and the Challenge of Color Consistency

---

Authors: Ken Adams & Patrick Neikes

## **Abstract:**

Color consistency for injection molded parts poses a challenge. This becomes apparent for mating parts in any assembly where colors usually need to match 100%. Additionally some production batches may require stringent color consistency. This guide explains how to choose the right techniques by making you aware of the challenges that each coloring option poses.



Star Prototype Manufacturing Co., Ltd.,  
15 Huan Mao 1 Road, Zhongshan Torch  
Development Zone, Guangdong  
Province 528437,  
People's Republic of China  
[www.star-prototype.com](http://www.star-prototype.com)

---

## **Citation:**

Adams, K., & Neikes, P. (2014). *Plastic Injection Molding and the Challenge of Color Consistency* (Vol. 1). Zhongshan, Guangdong, China: Star Prototype Manufacturing Co., Ltd.

## 1 The challenge

If you plan to produce your parts in a plastic injection mold and you are going for low volume production, you need to decide between *color consistency* and achieving *custom colors* for your parts.

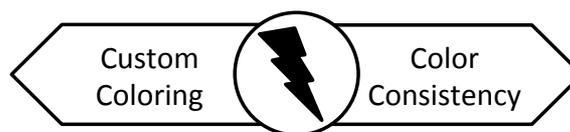


Figure 1: Color Consistency vs. Custom Coloring (for low-volumes)

If you plan to produce higher volumes (above a ton of material) then color consistency for custom colors is not a big issue. Depending on your situation you may then follow the below guidelines.

## 2 Achieving Consistent Colors vs. Custom Colors (for Low-Volumes)



Figure 2:  
Standardized colors:  
Pantone & RAL

If you need to achieve *color consistency* in an assembly where the color matching of mating parts is critical and where low production volumes are required we need to respect these two simple rules:

1. Choose a predefined color

Usually Pantone® or RAL colors are a good place to start

2. Assure raw-material availability

Please keep in mind that not all RAL and Pantone® colors have material available

Given that we can order the right material for your desired Pantone® or RAL color, we can achieve fairly consistent color matching per batch. In between production batches you may face slight color alterations, but they are insignificant.

### 2.1 Achieving 100% Color Matching Within Assembly

There are cases where parts need 100% color matching – for example in an assembly. Two techniques allow you to achieve that: Molding in a *family mold* or *painting*.

*Family Mold:* You can theoretically put two different components into the same mold – this is called a family mold. The components are therefore molded from the same batch of raw material. This gives you the same color for both parts.

This technique may prove difficult when the two components differ in their geometry. For this purpose sequential valve gating is required. The cost of this type of hot runner system is higher. For small batch productions this is not economically viable.

*Painting:* Painting after molding can be considered as another option. Subsequent scratching will have a minimal visual effect, if the part is molded in a color fairly close to the paint.

To sum it up:

- Components with *similar* geometries can be made in a family mold with 100% color matching
- Components with *different* geometries may require sequential valve gating, which is more expensive and economically suited for larger production volumes.
- Painting of parts is the last option and assures color consistency but also adds to the cost.

## 2.2 Achieving Custom Color for Low Volumes:

There are three types of options to achieve customer coloring.

- Using Pigments in the Hopper (Low-Volume)
- Purchasing Compound Custom Material (High-Volume)
- Using a Master Batch Colorant (Very High-Volume)

For low-volumes, only the first option (using pigments in the hopper) makes economic sense but color consistency is virtually impossible. Further explanations for the interested reader is given below. Using compound custom material, or using a master batch colorant, allows color consistency within batches, but these techniques are only suited for larger production volumes. They are described in a separate section below.

### 2.2.1 Using Pigments in the Hopper and the Challenge of Color Consistency

In this method a natural colored granulate is mixed with pigment- powder before the blend is filled into the hopper. But, as mentioned before, color consistency is an issue with this technique. There are four main reasons for that: *Inconsistent mixing of granulate and powder, pigmenting powder sticking to the hopper's walls, pigmenting powder spots in the parts, and humidity.* All four are explained below in greater detail.

#### 2.2.1.1 Inconsistent mixing of granulate and pigments

A colorless granulate is mixed with pigmenting powder in a rotating drum. The only force keeping the two components together is of electrostatic

Pigmenting Powder & Natural Material



Figure 3: Pigmenting Powder & Natural Material

nature. The nature of the process therefore does not allow 100% consistent coloring of the granulate. The material is then filled into the hopper.

#### *2.2.1.2 Pigmenting powder sticks to the hopper's walls*

Within the hopper, the granulate-powder blend can therefore easily detach. A portion of the powder is statically attracted to the walls of the hopper. Hence, some of the granulates in the middle of the hopper are better pigmented than the ones close to the wall. This influences color consistency of the injected parts. Subsequent loads will transfer less pigment to the hopper wall thus causing color variation within the batch.

#### *2.2.1.3 Pigmenting Powder Spots*

Pigmenting powder is very thin in its nature. When heating it up with regular plastic granulate it sometimes causes burning of the particles. The powder then turns into black carbon oxide. When injected, the parts might be sprinkled with tiny black spots.

#### *2.2.1.4 Humidity of material:*

Engineering plastics need to be dried in a desiccant dryer before injected. The pigment must be added after drying. The granulate material absorbs some moisture during this delay, which causes the material properties to change. Furthermore handling problems with a material at elevated temperatures causes complications in the process.

Using Pigmenting for coloring:

- ✓ Advantage:
  - Minimum cost for coloring
  - Low volume custom colors possible
- ⊗ Disadvantage:
  - No color consistency
  - Environmentally problematic

### 3 Achieving Consistent Custom Colors (for High-Volumes)

When you manufacture thousands or up to hundreds of thousand of units, then achieving consistent custom colors becomes less of a problem. There are two different approaches to achieve custom coloring for your parts: pre-fabricated *compound material* and *mixing a master batch with natural material*. Both options are explained below.

#### 3.1.1 Purchasing Compound Custom Material (For high volumes)

Custom colored material can be purchased from a supplier. The material is then injected into the mold.

A minimum tonnage of at least a ton of natural material needs to be purchased on the open market so this process is economically less suitable for low-volume production. Usually color consistency is good but there are slight variations from batch to batch.

- ✓ Advantage:
  - Custom color can be achieved
  - Fair color consistency
- ⊗ Disadvantage:
  - Only suitable for high volume
  - Minimum tonnage of 1.02t required
  - Higher cost for compounding per kg



Figure 4: Pre-Fabricated Compound Material

#### 3.1.2 Mixing a Master Batch Colorant With Natural Material (for very high volumes)

Custom colors can also be mixed on the injection-molding machine. Two materials need to be mixed in order to create the final material: The *master batch* colorant and a *natural material*.

The *master batch* is a pre-fabricated colorant. The *natural material* are colorless granulates. The master batch and the natural material are simultaneously injected into the machine. The mix ultimately creates the final custom color.

The reason that this approach only suits for high volume production is the mixing ratio of natural material and master-batch colorant. For 96 units of natural material, only 4 units of master-batch colorant is needed. The minimum order quantity of master-batch colorant is two tons. Ultimately this results in a minimum of 50 tons of final material for manufacturing. Figure 5 graphically explains this calculation.

The process is similar to the one described in 3.1.1 but now the blending is taking place on the machine. This process allows much higher volumes at a lower compounding cost per kilogram. Color

variations within the batch are fairly stable, but as in the previous case, there will be deviations from batch to batch.

- ✓ Advantage:
  - Less cost for compounding per kg
  - Good color consistency within batch
- ⊗ Disadvantage:
  - Only suitable for very high volumes
  - Minimum tonnage: 50t
  - Slight color variations between batches

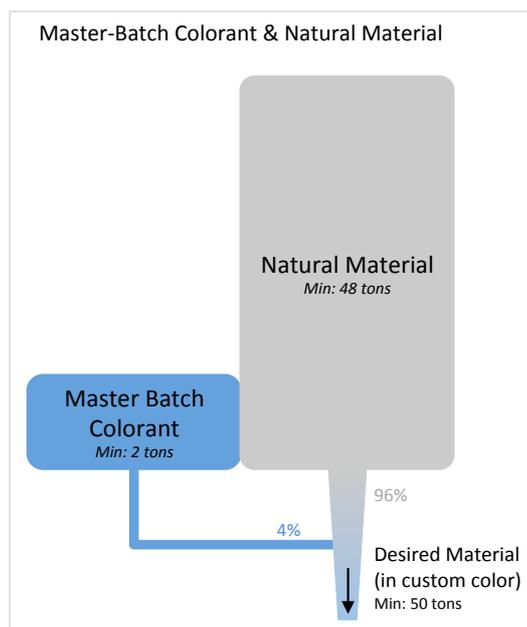


Figure 5: Master-Batch & Natural Material

#### 4 Summary:

Regardless of the coloring method used; if 100% color matching is required the parts **must** be molded at the same time in the same mold (family mold). Variations will be apparent from batch to batch but as the parts are molded in the same mold they will match in each individual assembly.

If you plan to produce **low volumes** in plastic injection molding you need to decide between *color consistency* and choosing a *custom color*.

- Color consistency is achieved by choosing a standardized color and purchasing it on the open market
- Custom color can be achieved but the parts will have slight color variations within the batch due to the procedure of mixing pigmenting powder and granulates.

If you plan to produce **high volumes** in plastic injection molding you do not need to decide between *color consistency* and choosing a *custom color*. You can achieve fairly consistent coloring within a batch. Furthermore you can save costs when choosing the right color mixing strategy:

- Using *compound material* from supplier
  - For high volume production of at least 1.02 tons
  - Higher cost per kg
- Mixing *master-batch* and *natural material*
  - For very high volumes of at least 50 tons
  - Lower cost per kg