DENSITY OF PLASTICS

Density is an important physical property of plastic. It turns out to be useful in multiple ways in the plastics industry. This article will discuss applications of density with some interesting examples.

Density Definitions

The fundamental definition of Density is the Mass Density, the mass per unit volume of the material:

Density = Mass/Volume

Examples: 5 g/in^3, 2 kg/m^3, 4 slugs/ft^3.

Weight Density, also called Specific Weight, is the weight per unit volume of the material:

Weight Density = Weight/Volume

Examples: 1.2 gf/cm^3, 5 lbs/ft^3

Here gf is gram force, a unit of weight, used to differentiate it from g , a unit of mass. 453.59gf = 1 lb. I will follow the engineering convention of using g as a weight for gf in what follows.

Mass density is an intrinsic property of matter: an object will have the same Mass Density on the Moon as it does on Earth, but it would not have the same Weight Density. Weight density plays a major role in Engineering and is the density used in the plastics industry. It is the subject of the remainder of this discussion.

Types of Weight Density and their applications

Three different weight densities are commonly used in the plastics industry:

I. Bulk density

II. Solid density

III. Melt density

I. Bulk Density

Bulk density is the weight per unit volume of the raw plastic material as it is purchased from the material supplier, usually in the form of small pellets or beads. Bulk density is useful as an incoming quality check on material. Careful measurement can reveal lot to lot variations. A significant change in bulk density would indicate that there is variation in
pellet weight and/or size.

II. Solid Density

Solid density is the density of the plastic in its as-molded final state. It is usually expressed as a Relative Density, the Specific Gravity (SG) of the material. Specific Gravity is the ratio of the density of the material to the density of water and is therefore dimensionless. But since the density of water is very close to 1 when expressed in units of g/cm^3, SG can be considered to be the solid density of the material in g/cm^3. SG is the parameter commonly given in the manufacturer's material data sheets.

Specific Gravity has 3 important uses in plastics:

1.) Estimating parts weights.

The weight of a part that has not yet been molded can be calculated from an estimate of the part volume:

Part Weight = Part Volume x SG x conversion factor

Example: 5.4 cubic inches x 1.20 g/cm^3 x (2.54 cm)^3/in^3

5.4 x 1.2 x 16.39 = 106.21 g.

2.) Comparing the costs of materials

To compare the cost impact of molding a part in different materials, it is necessary to take into account the density of the materials considered. The price per pound of the material cannot be used as the sole criteria: the material price per unit volume is the key factor:

$Material/Volume = $Material/lb x SG x conversion factors

$/lb x lb/453.59g x SG g/cm^3 x (2.54 cm)^3/in^3

2.50 x 1.2 x 0.0361 = $0.1083/in^3

The cost of a part in a given material is:

Vol./part x $Material/Volume = $Material/part

Example 1: Part Volume 5.4 in^3, material $2.50/lb and density 1.20 g/cm^3

5.4 in^3/part x $2.50/lb x 1.20g/cm^3 x 0.0361

Or 5.4 x 2.50 x 1.20 x 0.0361 = $0.585/part (1)

Example 2: Same part volume, material price \$2.75/lb, density 1.04 g/cm^3

5.4 in^3/part x \$2.75/lb x 1.04g/cm^3 x 0.0361

Or 5.4 x 2.75 x 1.04 x 0.0361 = \$0.558/part (2)

Note that the higher priced material is more economical!

Continuing: divide Example equation (1) by Example equation (2) to give:

\$2.50 x 1.20/(\$2.75 x 1.04)

which is equal to the ratio of the material costs. Therefore, to compare the cost of two materials, just compare the \$/lb. x SG products. The material with the smaller product would be less expensive.

This concludes the 1st part of my discussion on Plastic Density. A future article will discuss the 3rd use of Solid Density which will segue into the discussion of the 3rd type of density used in plastics: Melt Density.