Density Determination

Easy Density Determination

for Consistent Plastics Quality

Archimedes' principle states that a body immersed in fluid indicates an apparent loss in weight equal to the weight of the fluid it displaces. This ancient principle, from around 200 BC, is precisely what is used in today's modern world to test molded plastic parts to ensure product quality and monitor manufacturing processes.

This application note describes how the density of solid plastic parts can be easily determined using the integrated application on a METTLER TOLEDO MX, MR or MA analytical balance with a Density Kit.

Density determination of solids on the MX304 analytical balance is a straightforward and convenient quality control test.

METTLER TOLEDO

Introduction

This application note will illustrate how using a METTLER TOLEDO MX, MR or MA analytical balance and Density Kit is an easy and cost-effective way to determine consistent parts quality and monitor production processes over time.

Background

Our world relies on plastics. For everything from automotive parts to mayonnaise tube lids, the density of the molded plastic is a key indicator of how well such parts perform. Key performance requirements such as flexibility, strength and crack resistance are all related to density. Consideration of such properties is important during product development, and, in particular, density is useful for calculating the strength to weight ratio. Following manufacture, density can be used to confirm product quality as a measure of the consistency of the individual parts and this can also provide additional information on the performance of the manufacturing equipment itself.

Density for quality control

To ascertain parts consistency as a quality control test, the density of an individual part is calculated and compared with its expected value. Density determination involves weighing the object in air and then in a liquid of known density (usually water or ethanol). Whilst visual inspection can confirm the part is okay externally, the density measurement confirms its internal uniformity and the consistency of its manufacture in terms of the raw materials as well as the production process itself. For example, an internal air bubble could ultimately cause a part to fail when placed under stress or a variation in the raw material will be indicated by a change in the density which may have a detrimental effect the functioning of the part. Such occurrences can damage a manufacturer's reputation, cause recalls and even pose a threat to consumer safety. Random sampling of mass produced parts is a simple and cost-effective way to monitor ongoing quality and provide assurance that parts will perform as expected.

Application example

One major European plastics manufacturer tests the density of its plastic parts in accordance with ISO 11831[1]. Density measurements are made as part of production control as well as during product development in their R&D department. In production, samples are tested regularly throughout the 3 x 8-hour shifts. Such production control measures ensure parts meet the company's defined specifications. Should a part be found to be out of tolerance, it is the production manager's responsibility to determine the cause. It may be a spurious result but incorrect raw material may be indicated or the production process may need fine-tuning.

An easy guided process

A METTLER TOLEDO MX analytical balance with a density kit provides the company with the accuracy they require as well as the ease-of-use necessary to ensure reliable results with different operators across the various production shifts. Operators are prompted to enter the water temperature at the start of the process and step-by-step instructions on the balance touchscreen guide them through the in-air and in-water measurements. The density calculation is performed automatically and all the results are printed out to fulfill documentation requirements.[1]

Figure 1: Density Kit MX, MR, MA analytical balances

[1)] ISO 1183-1:2012 Plastics – Methods for determining the density of non-cellular plastics – Part 1: Immersion method, liquid pyknometer method and titration method

Method

It is important to develop a density determination method tailored specifically for each component that needs to be tested. Factors to be considered are: shape, surface charac- teristics, immersion liquid and temperature. The addition of a surfactant to the immersion liquid breaks down the surface tension of the water to help ensure that no air bubbles adhere to the sample surface. Density measurements carried out on a balance with readability less than 1 mg may require a protected environment and a longer settling period.

Equipment:
MX analytical balance e.g. readability 1 mg or 0.1 mg (shown) Density Kit

1. Install the Density Kit

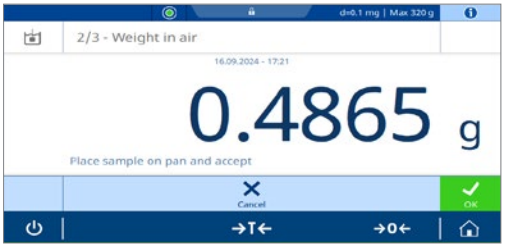
- The Density Kit is easily mounted on your balance in a few simple steps

2. Open the application and input initial parameters

- Type of immersion liquid
- Temperature

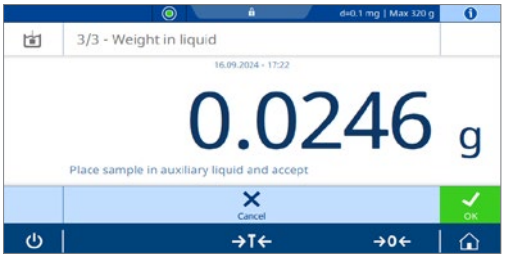
3. Weigh the sample in air

- Press 'Start' to begin the density measurement
- Place sample on side-mounted weighing pan or the platform above the basket
- Accept the weight result



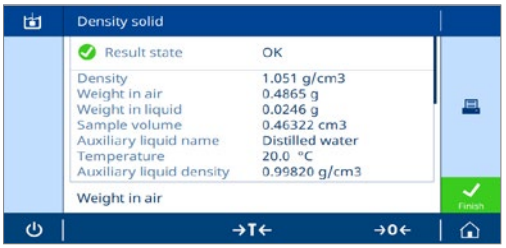
4. Weigh the sample in liquid

- If required, use a wetting agent (coat the sample or add to the immersion liquid)
- Place the sample in the basket (invert the basket for parts that float)
- Accept the weight result



5. Density Result

- Calculation is performed automatically
- Results and process parameters can be printed out in a convenient short report, saved to a USB memory stick or transferred to your PC (file server)



Results

The density of a solid is determined with the aid of a liquid whose density ρ_O is known (usually water or ethanol). The solid is weighed in air (A) and then again in the liquid (B). The density of the solid ρ can be calculated as follows:

$$\rho = \frac{A}{A\text{-}B}(\rho_o - \rho_A) + \rho_A$$

ρ = Density of the sample
A = Weight of the sample in air
B = Weight of the sample in liquid
ρ_o = Density of the liquid
ρ_A = Density of air (0.0012 g/cm$_3$)

The temperature of the liquid must be taken into account as this can cause density changes of the order of magnitude 0.001 to 0.1 per °C, the effect of which can be seen in the third decimal place of the result.

The balance automatically calculates the final density result which can then be compared to pre-set tolerances to ensure the part meets the defined quality standards. Density measurements compared over time highlight any subtle trends in raw materials or injection molding processes. These trends can be used to decrease the number of rejects and improve productivity for bottom-line savings.

Conclusion

Density determination of molded plastic parts, and other solid materials, is a straightforward process which can be effectively used to ensure product quality and monitor manufacturing processes. Density determination using a balance is an easy and convenient process that delivers highly reliable results when compared to other methods in which the volume of the part is determined independently of the weight. By converting a standard laboratory balance with the addition of a Density Kit, you avoid the necessity to purchase a dedicated piece of equipment to carry out this straightforward procedure. This makes the purchase of the Density Kit accessory a very cost-effective investment.

The density application built-in to all MX, MR and MA balances provides step-by-step instructions making it easy for even untrained operators to use. Fewer mistakes occur and production managers can be confident in the results. The application offers a high level of flexibility to accommodate individual process needs: the statistics option enables you to quickly examine trends when several samples are measured one after another and the results report can be tailored to your needs with a variety of customization options available for the sample and header/footer information. The report can be printed, saved to a USB stick or transferred to your computer for convenient and error-free documentation.

METTLER TOLEDO Group
Laboratory Weighing
Local contact: www.mt.com/contacts

www.mt.com/MX-balances
For more information

30327308B
Group MarCom RITM1253788 NM