Analytical Testing for Product Development Whitepaper

Dan Clark
Lab Manager—Teel Plastics, Inc.
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Background

This paper provides information on the advantages of a comprehensive testing program for engineers and fellow industry professionals that take part in the manufacturing development process. Analytical testing creates an environment that facilitates proper measurement and documentation of the product throughout the entirety of the development cycle. When a company decides to test their products, they are guaranteeing a better understanding of every aspect involved before, during, and after development and into production. Not only is there understanding, but testing creates a large database of information captured from the tests. Access to this essential information will speed development and troubleshooting and save money in the long run. This paper will focus on the first three stages of a Product Life Cycle.

Introduction to Stages of Product Life Cycle

Stage 1: Prototype

This is the trial stage, as there is uncertainty on what exactly the final product will look like and what attributes it will have. There may be some certainty, as the possibility of knowing of similar products and their characteristics is quite likely. This stage is where the initial concept or idea comes to life.

To begin the product life cycle effectively, prototype testing possibilities must be considered. Determining what the material in a competitive product is by reverse engineering is frequently done using Fourier Transform Infrared (FT-IR) spectroscopy. Further testing using Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis (TGA) determines if other desired characteristics are quantifiable, such as: volatiles, inorganics, and thermal events. Reverse engineering uses microscopy imaging and measurements of shapes, thin walls, OD, ID, and intricate designs to aid in defining form and function.

Benefits of Testing

When deciding whether or not to do prototype testing, it is important to consider the benefits involved. By investing in this process, it saves time and money. The process reduces the amount of research and development needed and will likely lead to reduced effort needed in the next stage. Another benefit is the established library of

characteristics introduced once testing commences. This library categorizes the information taken from all tests completed, files the shapes and sizes that were trialed, notes whether or not the materials worked or not, and includes the characteristics seen from each tested material. This library could even aid with determining if there is any potential for a second product or next generation product. Companies have a better understanding of the product's manufacturing process and everything involved with the materials themselves by having this easy access to information collected on materials.

Example Scenarios

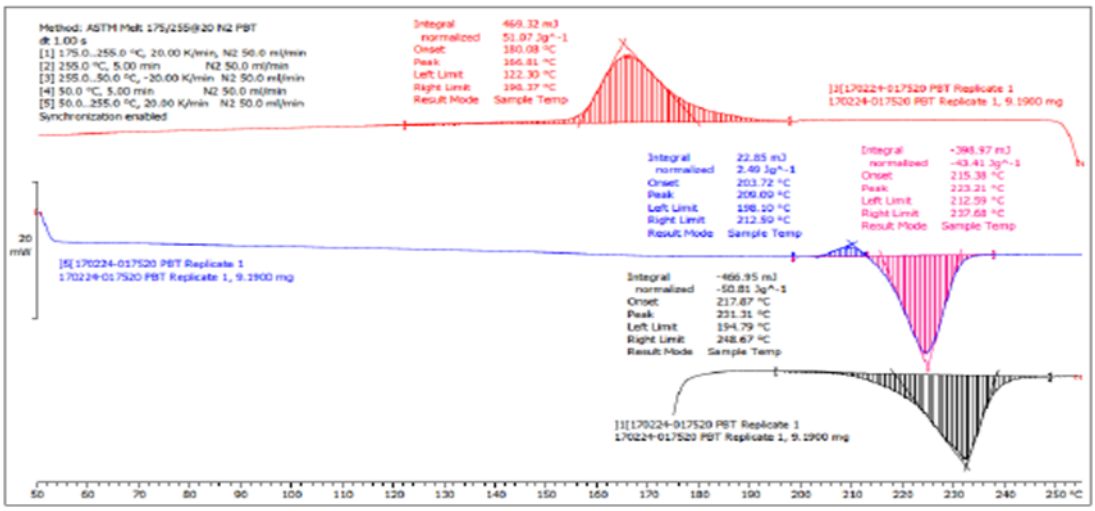
There are numerous potential situations in which testing a prototype is necessary. The scenario discussed in this paper involves a customer that was searching for an equivalent material for a product. When this occurs, ideally, the analysis on the initial product material would be conducted early in the prototyping stage. In many cases, the material supplier will not divulge the details about the material or the specific material may be unknown. The time and money invested in the research process for an equivalent material may be dramatically reduced, by using DSC, FT-IR, or TGA. Successfully completing the tests can determine what equivalent material could be used.

Stage 2: Development and Specification

This is where development of the product begins and individual specifications are finalized. Prototype trials have defined what production will entail and have determined how much of and what materials will be required. This stage looks at the individual characteristics that are required for proper function of a product. It can go as far as determining whether the product should be made on a smaller scale or not.

The second stage is the baseline for material testing. It is when you determine what thermal characteristic or processing variation occurs. Thermal variation can be through characteristics such as melting point, glass transitions, or crystallinity. It is also where the composition variation is determined including volatiles, moisture, polymer backbone, amount of carbon, and inorganics. This stage uses DSC and TGA for thermal and composition variation and FT-IR to establish a baseline spectrum for the material. Physical testing processes can assess the density variation of the materials, hardness, and tensile strength to name a few.

Figure 1



DSC Thermograms

This stage is also the stage in which special development is undertaken. Kinetics testing should be used to determine critical parameters such as shelf life, curing reactions, decomposition, evaporation, and oxidation resistance. Kinetics testing can be completed using DSC and TGA.

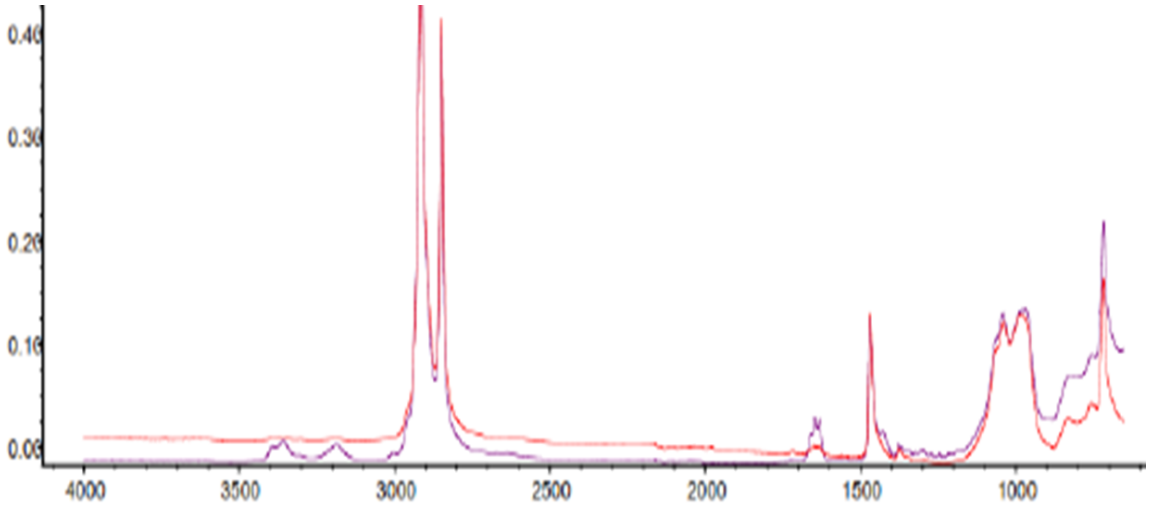
Benefits of Testing

There are numerous benefits to testing at the development and specification stage. It provides users with a better understanding of the variations that can be expected. It can be critical for ruling out material as the root cause of future issues. Referencing baseline FT-IR spectra can be a quick and easy tool for determining contamination levels if contamination is expected. Ultimately, the baseline results should reference an optimal product and are a quick guide on how to return to an optimal product.

Example Scenario

One scenario showing benefits for testing at this stage involved a customer with a colorant being loaded at the machine. They were in an ideal situation as the colorant was characterized during development. This allowed the same tests to be conducted; which enabled comparison between old and new colorant. The FT-IR analysis immediately revealed a difference between the colorant in question and the characterized spectra. That difference was caused by a higher concentration of an additive which was found to be the root cause of the processing issue. If the company did not have the material characterized during development, this problem would have likely required a lengthy root cause analysis.

Figure 2



FT-IR Spectra Comparison

Stage 3: Scaling

The third stage begins once the product has started market penetration. Scaling is when the amount of a production run and the price of the product are determined. The ideal situation will involve ramping up production numbers to meet increased demand.

The first test when scaling should be a quality control analysis. Ideally this includes three phases: a pre-production test, an in-process test, and a final product verification. The pre-production phase is when incoming raw material is verified. Tests carried out in this phase are for material ID, grade verification, and the compositional ID. The in-process verification phase is where the mechanical and chemical properties are continuously checked throughout the process. The last phase, final product verification, is where testing needed to generate a certificate of analysis allowing product release is completed.

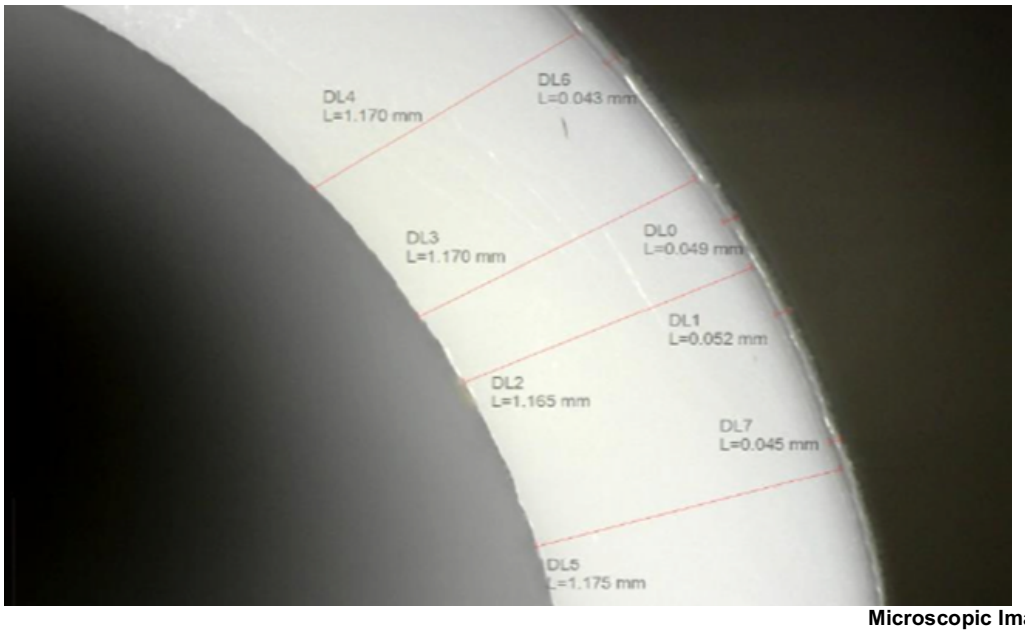
Benefits of Testing

There are a few benefits to testing at the scaling stage. In the pre-production phase, testing maintains product consistency from lot to lot by ensuring that the raw materials are equivalent. Testing enables early detection and avoidance of production with a material that would compromise the product's integrity and present an unnecessary expense. In the in-process phase, testing maintains confidence in the product throughout long production runs. There will be early detection if there is a change in production. In the final product phase, testing adds value to the product being sent to a customer, especially when accompanied with a certification. This testing will support the production team if the product's integrity is at all questioned.

Example Scenario

One beneficial scenario occurred with a customer receiving complaints for brittle parts from the end user. The customer first placed the root cause in the manufacturing plant. However, records of the manufacturing parameters show production ran well. The records included measurements, temperatures, clean outs, and equipment verification. There was also laboratory data on the raw material and final parts. All records showed the product met the necessary specifications and all parameters were within normal variations because the analysis had been conducted throughout the product's lifecycle. The root cause analysis then shifted to the customer to determine variations in their process.

Figure 3



Microscopic Image

Summary

Regardless of which stage a product is in, there are numerous tests available to analyze any potential issues and address any concerns. Properly applied analytical testing can offer significant benefits, including faster development, higher quality product, higher confidence in production, and savings in time and money if an issue arises. The most important analytical approaches are to start early in development and test methodically to make discoveries. Once the process of analysis is undertaken, companies can not only guarantee that their products will achieve a higher success rate, but the entire product development team will have a better understanding of the process.

For more information, please contact dan.clark@teel.com