Crisp And Fresh - The Material Way!

by Bill Newton

The humble packet of crisps (or chips for the US reader) may retail for pocket money prices but the small price tag belies the level of testing that is required to ensure that the product satisfies the requirements of the buying public. In particular, testing plays a vital role in the development of the product. Since it takes just about 20 minutes from the time a potato enters the factory until the finished packet is ready, it is clear that the entire production process must be honed to perfection in order to guarantee a high quality product. A staggering array of tests will have been carried out on the materials used in the product from the cooked crisps to the plastic used for the bag and even the delivery carton for the finished product.

Texture analysis and materials testing

Texture testing is a well established technique for evaluating the mechanical and physical properties of raw ingredients, food structure and designs, and for pre- and post- Quality Control checks. In materials testing, typical material test capabilities include; tensile strength (pull), compression or crush, flexural or bend, creep and relaxation, friction or slip, adhesion or peel, cyclic fatigue, tear, snap on and off, shear, ductility and insertion. Comparison of the results from mechanical texture analysis with trained human sensory panels has shown that the measurements have a high correlation with the various sensory attributes associated with textural quality. In many instances, a universal testing instrument such as the LFPlus or the TAPlus texture analyzer from a UK manufacturer shown in Figure 1 can be used to carry out the majority of tests simply by equipping it with the appropriate fixtures and grips for the particular application. In particular, texture analysis can be carried out using dedicated food testing probes and fixtures. With powerful application and analysis software available, such as the NEXYGEN™ MT software which features a vast library of international standard tests for many different applications, a single instrument can be used in a multitude of applications. Some testing, such as melt flow indexing, requires the use of dedicated equipment.

Figure 1: TAPlus texture analyzer

Crisp testing

Many texture tests can be performed on the crisps themselves. Crispiness is a key characteristic and can greatly affect consumer acceptability - a departure from the expected texture is considered to be a quality defect. Measurement of the crispiness and fracturability of crisps can be made using a penetration test with a texture analyser or universal testing machine equipped with a crisp fracture support jig (Figure 2). This jig consists of a ball probe and a round hollow support mounted to the base table. The ball probe is driven down to apply a bending force to the crisp. The measurement is generally made for the first significant break in the crisp during the first compression cycle and is usually taken as the first peak force

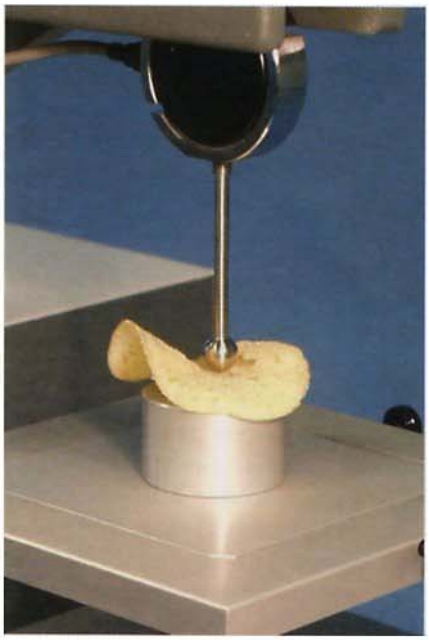

Figure 2: Crisp fracture support jig

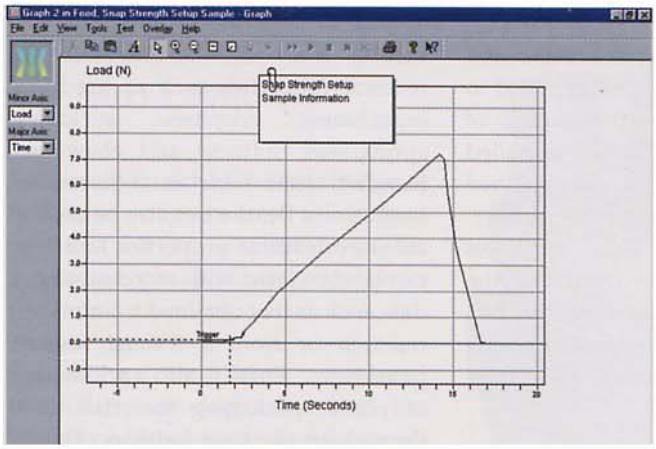

Figure 3:. Typical curve showing crisp fracture

prior to the force dropping by at least 5%. Figure 3 shows a typical curve of crisp fracture.In this way, the crispiness of the product can be evaluated to help develop the optimum cooking process. This test is also important in testing shelf life, by comparing crispiness of the "just-cooked" product to predict 'sell by' and 'use by' dates.

Plastic and the crisp packet

Materials testing is carried out not only on the raw materials used in the crisp packet but also on all the facets that make up the bag itself. Burst strength, opening strength, seam strength, tear and peel are all parameters that can be measured using materials testing systems. The packet must be strong enough to prevent accidental tearing or bursting and to ensure that there is no ingress of air or moisture, which will adversely affect shelf life producing the unacceptable 'soggy crisp'. Peel tests determine how easy it is to open the packet. Consumers require a durable packet that will not shed crisps over the rest of the shopping or in a lunch box, yet do not want to have to wrestle with the packet to open it, or indeed have the packet suddenly tear on opening because excessive force is required to open it. Seam testing can be carried out on a low force universal testing machine. Industry standard tests are available for measuring opening strength, seam strength and peel strength, but individual manufacturers often set their own pass and fail tolerances.

The majority of crisp packets are manufactured from polypropylene, which is hygienic, lightweight and durable. "Metallized" film, used in some packets, is manufactured using two layers of polypropylene. One layer is printed and the other one is metallized and the two are sandwiched together.

Melt flow tests are carried out on the raw material by the film manufacturers prior to manufacture using a dedicated instrument such as the MFI-10 (Figure 4). Measuring the melt flow index gives an indication of the average molecular weight in the polymer and is commonly used as a material-acceptance specification by processors. Once the film has been manufactured, it can be subjected to a falling dart impact test, which tests the impact resistance and also can be related to the burst properties of the bag. A "pull-to break" test measures the tensile strength of the plastic film, whilst elongation tests

Figure 4.: MFI-10 melt flow indexer

measure the percent age extension of the film, which indicates how much it will stretch before it will break.

A crucial parameter to be measured is the coefficient of friction of the plastic film. High speed, high volume packaging machines utilize large rolls of plastic film. The coefficient of friction determines how easily the plastic passes over the rollers in the packaging machines. If the film does not move at the correct speed, the process can get out of synchronisation, leading to slowed production and possible damage and wastage. Friction must be tested both on as-manufactured films and on printed films, since the amount of ink on the film influences the coefficient of friction. Static and kinetic friction measurements can be made using a universal materials testing machine, such as a 1 kN LFPlus tester fitted with a coefficient of sliding friction fixture. The plastic film can be tested to ASTM D1894 (2001), ISO 8295 (2004) and TAPPI T549 (2001) standards by holding it on the horizontal bed and exerting a known force using a sled to which is attached a further sample of the same material. The sled is pulled across the bed either at rates defined by the required standards or at user-selectable speeds. This measures the force required to overcome the frictional resistance between the two imposed surfaces, when one surfaces is moved relative to the other along their plane of contact.

Getting the crisps to the retailer

Crisp packets are transported to the retailer in cartons and it is important that the cartons are tested to ensure that they can withstand the both the rigours of transit and stacking in the warehouse, A universal testing machine can be equipped with a specially designed compression cage to perform crush tests on cartons ranging from small packets to boxes up to 1.5 m3. For larger cartons, the rugged compression assembly is mounted below the testing machine. Boxes, cartons, crates and other containers can be tested safely inside the cage where controlled compressive forces are applied either for crush tests or constant loading tests. This helps identify the top loading capabilities of containers and any weak spots in the packaging design.

The bigger picture

The potato crisp provides an excellent illustration of the use of texture analysis and materials testing equipment in the food processing and packaging industries. Other snack products and a host of other foodstuffs can also benefit from the measurement of textural properties such as hardness, crunchiness, crispiness, stickiness, springiness, softness and chewiness. Standard tests such as compression, tension and flexure can also be used to measure textural properties and they can be correlated with more subjective data such as that obtained from market research or from a trained sensory panel team. There is also a wide range of plastic packaging materials used throughout the food industry. One of the primary aims of packaging is to contain and protect the goods being carried and materials testing is an integral part of packaging development. For example, carbonated drinks bottles need to withstand internal pressures of up to 100 psi and being dropped from a height of approximately 1m when full. Similarly other plastic containers, eg freezer to microwave food trays need to protect the contents from damage in transit as well as providing a container in which to store and heat them. Packaging is generally designed to minimize the amount of waste to keep costs down and thorough testing is essential to ensure that it still meets all of its functional requirements.

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